A STUDY OF ENGINEERING STUDENTS COLLABORATIVE PROJECT DEVELOPMENT SKILLS IN THE UNDERGRADUATE ENGINEERING CURRICULUM

by

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ABSTRACT

In recent years, there has been a rapid increase in the use of technologies by educational institutions and students. Use of technologies for educational purpose have taken different dimensions to improve student learning and success. More specifically, engineering education focusses on methodologies that aid development of Industry4.0 skills in students. Engineering design and manufacturing industries are shifting more towards computational tools and are operating in a global sector. With this shift, students should learn to integrate their technical skills with computer skills and also learn to work in a collaborative environment.

The use of software tools to aid teamwork and effectively carry out group projects are becoming integral part of engineering curriculum. Due to factors such as conflicting schedules, geographic separation, different learning styles, and different backgrounds, students have always struggled working on group projects. Establishing strong communication channels and thereby building strong teams to work on group projects has been a challenge for faculty members and instructors teaching those courses. Recent technologies have led to the invention of virtual communication that can be enabled through online collaboration tools. These online collaboration tools help students build a working model of working towards the successful completion of their projects. This thesis conducts a state of art analysis of how present day engineering education addresses the computational needs and incorporates Industry 4.0 skills. A conceptual study on the use and impact of computational tools and the use of online collaboration tools in the engineering education was studied. Students and Instructors from different engineering and computer science students were administered in the study and the data obtained from the research was analyzed.

Keywords: computational tools, online collaboration tools, engineering education, Industry 4.0 skills.

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CHAPTER I

1. INTRODUCTION

1.1 Background

Education plays a very important role in preparing students to operate well within their professional and personal worlds. Industry 4.0 (the fourth industrial revolution) encompasses future industry development trends that aimed at achieving more intelligent manufacturing processes, such as dependence on Cyber Physical Systems (CPS) and the implementation and operation of smart factories. The notion of "Industrial 4.0" was initially introduced in a German government article published in November 2011 as a high-tech plan for the year 2020. The term "Industry 4.0" reappeared in April 2013 at a German industrial expo in Hannover, and swiftly became the German national plan. In this research effort Industry 4.0 skill sets are analyzed to see their applicability and implementation within the undergraduate engineering education.

Along with the technical skills sets, teamwork and group projects are important components of the learning experience student get during their time in school. To effectively work in a team is a skill set that has to be inculcated in students before they graduate and face the real world. Often, employers have reported that students who are technically strong fail at being good team players.

1.2 Industry 4.0

Industry 4.0 aims to create a highly flexible manufacturing model for customized and digitized goods and services, with real-time interactions between people, goods, and devices throughout the manufacturing process. Humans saw and produced mechanical, electrical, and information technologies throughout the first three industrial revolutions, all of which were aimed at increasing the productivity of industrial operations. CPS technology is leading the fourth industrial revolution, which will combine the real world with the computer age for future industrial development. Figure 1 displays the timeline of the four stages of the industrial revolution [1].

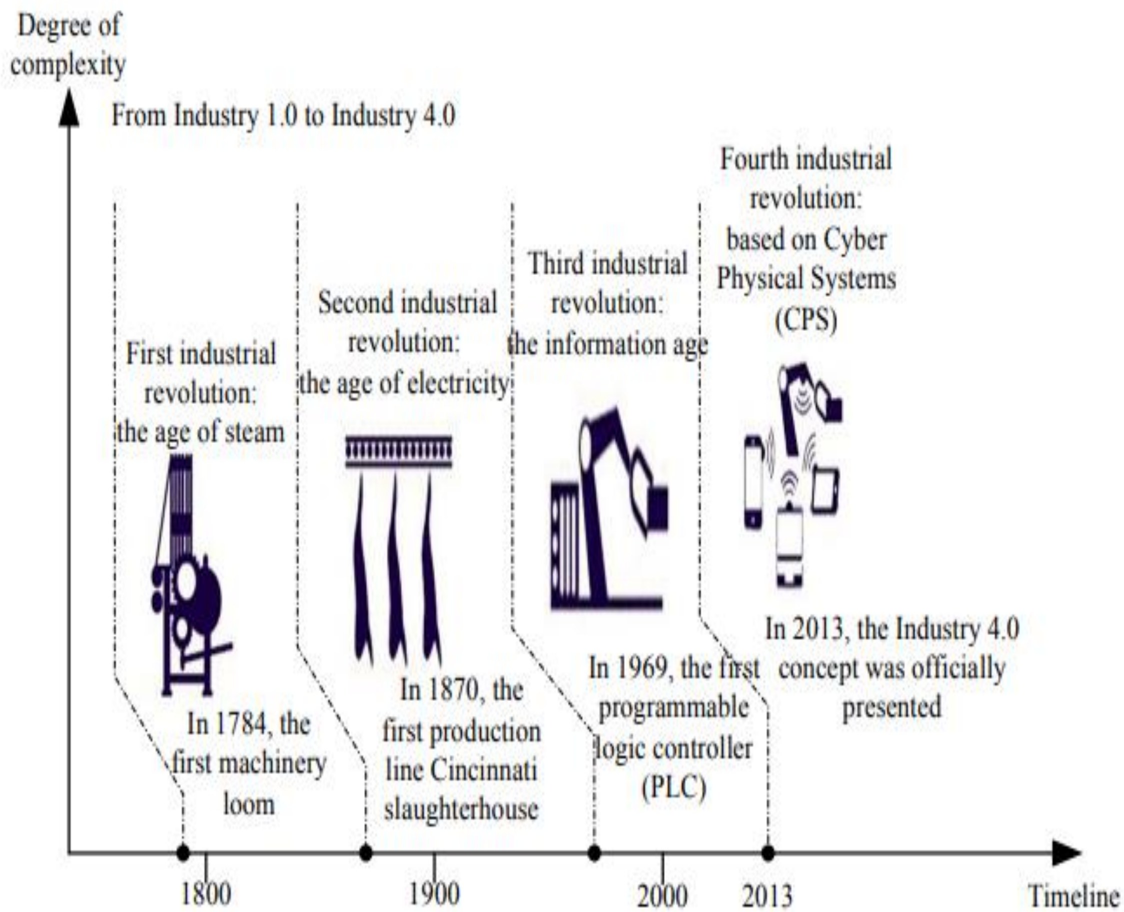


Figure 1: The four stages of the industrial revolution [1]

1.2.1 Industry 4.0 Key Concepts

Industry 4.0 aims to give IT-enabled mass customization of manufactured products, to automate and adapt the production chain, to track parts and products, to facilitate communication between parts, products, and machines, to apply human–machine interaction techniques, and to accomplish IoT-enabled production optimization in smart factories and to equip new types of services and business models of interaction in the value chain. When Industry 4.0 was initially proposed, it included nine pillars: cyber-physical systems, the Internet of Things, Big data, 3D printing, robotics, simulation, augmented reality, cloud computing, and cyber security [2]. The author in [3] states that “the principles of Industry 4.0 are interoperability, virtualization, decentralization, real-time capability, service orientation, and modularity”.

1.2.2 Issues and Challenges in Industry 4.0

Some of the issues in Industry 4.0 are as follows:

1) Many current systems lack autonomy, which will stymie industry' efforts to move toward smart manufacturing.
2) In the majority of present network protocols, a shortage of bandwidth might constitute a bottleneck that takes decades to fix.
3) Many industries are still working to assure the quality and integrity of their data. There isn't a standardized way to data entity annotations.
4) Complex system modeling and analysis are still insufficient for practical reasons.

5) There are several challenges in adapting present manufacturing routes to accommodate a big dynamical reconfiguration for personalized and customized items.

6) It's still unclear how various sectors (e.g., small and medium-sized businesses vs. Fortune 500 companies) should invest and what kind of support each country should provide.

One major concern in the long run is cyber security. In the previous five years, cyber-attacks like WannaCry, Petya, and NotPetya have been witnessed. Even though there are common techniques to improve cyber security, such as end-to-end encryptions, intrusion detection and prevention systems, and virtual private networks, the growing digitalization still has flaws. Another crucial concern is data security. Data privacy, unlike being attached, emphasizes the risk of our data being exploited or that the purpose of use was not revealed at the outset. On social media, there is a growing discussion over who owns data and what they may do with it. A problem would necessitate international cooperation in terms of legislation and regulation [2].

1.2.3 International Efforts

Government policies and assistance are critical to Industry 4.0's continued growth and practical uses. Simultaneously, it is to the interest of governments to materialize the outputs of diverse Industry 4.0 activities. What is apparent is that, after Germany, several other countries swiftly followed suit and launched their own versions of Industry 4.0. We are seeing a global response from key governments recognizing Industry 4.0 and, in many cases, a rivalry to achieve this aim. Connectivity, Human Capital, Internet Use, Digital Technology Integration, and Digital Public Services are the five categories. There are five categories: Connectivity, Human Capital, Use of Internet, Integration of Digital Technology and Digital Public Services. These indicators have a significant impact on motivating each country to develop and implement cutting-edge technology. Figure 2 shows some of the key countries and their Industry 4.0 initiatives [2].

Countries (alph.)	Iconic industrial plan
Australia	Industry 4.0 Testlabs
Belgium	Made Different
Denmark	Manufacturing Academy of Denmark (MADE)
France	Industrie du Futur
Germany	Germany: Industrie 4.0
Italy	Impresa 4.0
Japan	Society 5.0
The Netherlands	Smart Industry
People's Republic of China	Made in China 2025
Portugal	Indústria 4.0
Singapore	Research, Innovation and Enterprise 2020 Plan
South Korea	Manufacturing Industry Innovation 3.0
Spain	Industria Conectada 4.0
The United Kingdom	The Future of Manufacturing
The United States of America	Advanced Manufacturing Partnership

Figure 2: Major countries and their Industry 4.0 strategies [2]

1.2.4 Key Technology Enablers for Industry 4.0

1.2.4.1 Internet of Things (IoT)

The Internet of Things (IoT) is a network of physical items that are embedded with sensors, actuators, Radio Frequency Identification (RFIDs), software, and connection to allow them to communicate with humans and other connected devices in order to achieve shared goals. In the IoT, a cloud is critical for processing the massive amounts of data created and servicing a large number of users. The IoT's ability to accommodate a large number of diverse resource-constrained devices attracts the interest of the academic community. Figure 3 depicts a typical IoT architecture. The entire architecture is divided into two tiers: edge and platform. End devices (sensors, RFID, cameras, and so on), gateways, and sensor networks, all of which are connected to the core through access networks, make up the edge layer of IoT. The middleware, server and storage tiers, as well as essential services for device management, data management, real-time processing, analytics engines, and so on, make up the platform tier [4].

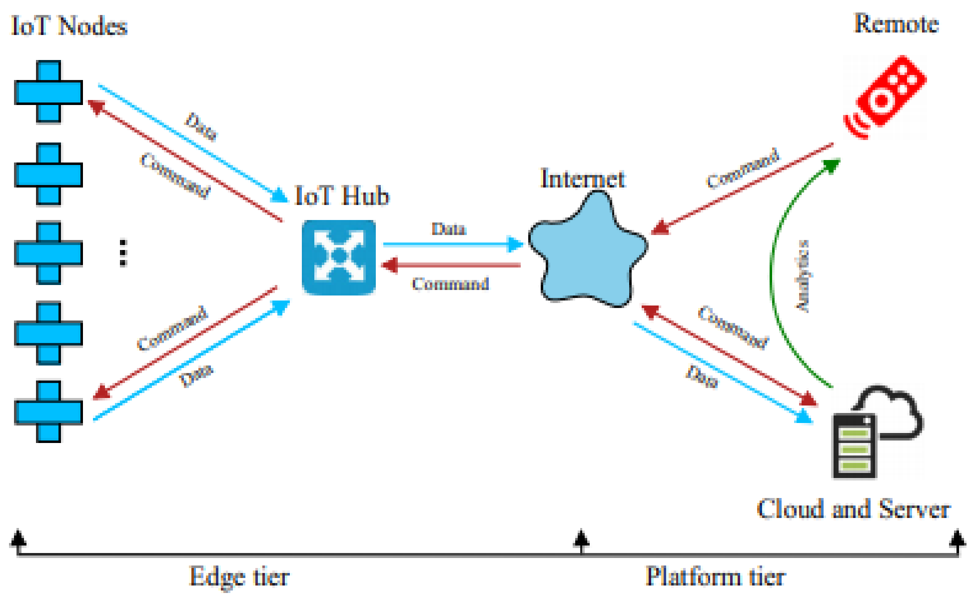


Figure 3: Architecture of IoT [4]

A network of networks was the concept used to characterize the Internet in its early days, when it was primarily focused on computers. Everything appears to be connected in the Internet of Things, including clothes, shoes, shirts, refrigerators, glasses, washing machines, plants, pets, automobiles, aircraft, towns, and so on. The term "network of networks" can still be used to describe the Internet of Things. What's different is that linked networks are no longer confined to IP-linked devices and networks in the traditional sense. Instead, multiple network technologies are used to connect islands of networks. To do anything, the user must manage a variety of programs while also going from one to the next in order to handle a smart gadget. Instead of reaching a holistic vision of IoT, it is risked to establish isolated islands of IoT technology. By linking multiple applications, the IoT has the ability to shape how we consume energy, increase resource efficiency such as food and water, and enhance supported living, healthcare access, and much more.

As a result, important problems such as creating interoperability across the various IoT enabling technologies and devices were discovered for the fulfillment of a genuine vision of the IoT. Furthermore, the key problem is not only to create an IoT system that links multiple IoT devices, but also to maintain scalable, private, secure, and trustworthy IoT operations. As a result, it is stated that there is a need to adapt technological variances across diverse IoT sectors.

It is consequently critical to establish a diverse technical approach to IoT security, interoperability, administration, and privacy for the IoT's future progress. The Internet of Things' internetworking methods, Wireless Sensor Network (WSNs), and traditional computing equipment are critical for standardizing Internet communications. In the IoT, it's also critical to have lightweight, scalable, and adaptable security solutions in place to protect users' data and maintain their privacy [7].

There are a variety of Industry 4.0-related systems and technologies (e.g. cloud, IoT, augmented reality, mobile devices) that have the potential to be incorporated into commercial supply chain management solutions. Businesses must develop Industry 4.0 transition strategies that incorporate the needs of the supply chain, including suppliers, partners, and customers.

Production decentralization poses new hurdles for real-time business process integration. Furthermore, the rise of digital ecosystems, which include cyber-physical systems, has the potential to dramatically alter supply chain arrangements in a short amount of time.

Decentralization and additive manufacturing make it possible to create "temporary supply chains" for certain items (ultimate a single product), continuously changing business partners, and information management needs. In digital marketplaces, mobile technology and mobile Supply Chain Management Systems (mSCM) management will be critical. The global supply chains that necessitate digital end-to-end integration might erect hurdles to emerging rivals that take advantage of technology advances. With mobile technology, there are also chances to modify or "stretch" existing supply chains. For example, in the pharmaceutical business, a mix of smartphone applications, cloud platforms, and IoT may be utilized to construct mSCM systems that enable the integration of many distinct processes such as:

1) Begin with the providers of medicinal compounds (raw materials used to produce medicines),
2) Coordinating production across many partners (e.g. medicine production and package production in a different company),
3) Provide mobile logistics assistance to retail pharmacies, including digital information to medication users through smartphone and QR code, and
4) Collecting data using special wearable technology (IoT) to track the impact of medications in daily life.

This case exemplifies the significant influence of mSCM in the era of Industry 4.0, as well as the need of promptly pursuing the elicited research opportunities [8].

The key IoT influences on supply chain delivery procedures and the technology involved are listed in Table 1. It is found that transportation received the most attention, followed by inventory management and warehousing. More research on the effects on order management and the interface between different stakeholders in the supply chain is needed [9].

Table 1: Impact of IoT on supply chain delivery process [9]

Delivery function	IoT impact	IoT technology
Warehousing	Enabler of Joint Ordering Time savings in the order of 81 to 99%	Smart things RFID tags
	More than 1000% savings in processing times	RFID Tags and Temperature sensors
	Collaborative warehousing	Smart things and multi-agent systems
	Warehouse and yard management	Smart things
	Safety and security	Smart things and multi-agents
Order management	Information sharing	EPCglobal
Inventory Management	Enabler of VMI through real time visibility	Smart things
	Inventory shrinkage	RFID tags
	Inventory misplacement	RFID tags
	Shelf replenishment	RFID tags
	Inventory accuracy and out-of-stocks	RFID tags
Transportation	Positive benefits to shipper, receiver and customer, with higher benefits going to shipper	Wireless networks
	Autonomous decision-making	Sensor Networks
	Product condition	Sensor-enabled RFID tags
	Quality monitoring, real-time responsiveness and price optimisation	Sensor Networks
	Visibility, theft reduction	Smart items, multi-agent systems
	Real-time visibility and joint shipping	Smart things
	Intermodal shipping	Smart containers
	Rerouting based on quality level	Sensors, information fusion and cloud computing
	Accurate and timely delivery	Sensor-enabled RFID networks
	More than 300% savings in scanning and recording times	RFID tags and smartphones
	Fleet management, dynamic route optimisation	Smart things
	Quality control	Time-Temperature Indicator wireless sensor
	Quality-controlled logistics	Smart packaging

1.2.4.2 Cyber Physical Systems (CPS)

CPS are interdisciplinary systems that use a mixture of compute, communication, and control technologies to conduct feedback control on globally dispersed embedded computer systems. Existing network systems and conventional embedded systems are being transformed and integrated. CPS can provide real-time, safe, reliable, and dynamic cooperation with physical systems represented by embedded systems through integration.

Data is acquired by distributed field devices in the CPS system via physical system data acquisition modules, which provide real-time capability and accuracy. Digital medical devices and systems that use automated acquisition and control technology, distributed energy systems, aerospace and aircraft control, and industrial control are only some of the uses for CPS. It has the potential to provide significant economic advantages as well as fundamental changes in the function of existing engineering physical systems [5]. Figure 4 below shows the general architecture of CPS.

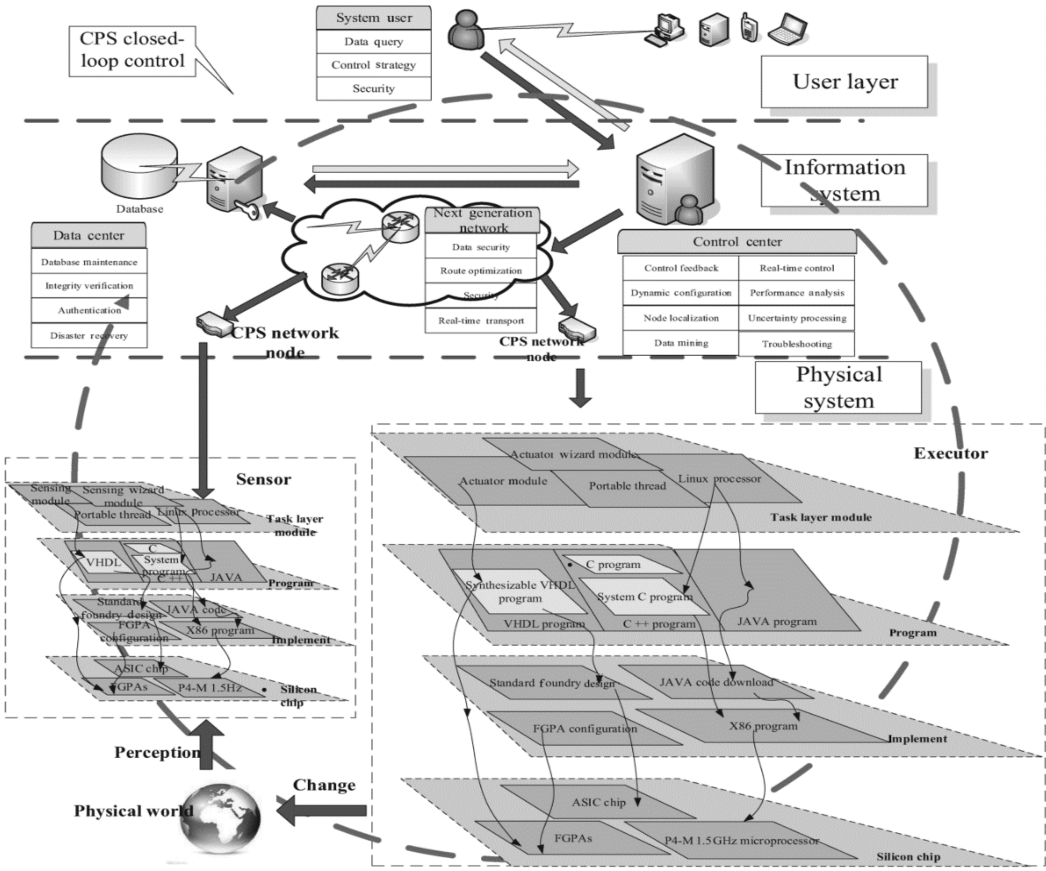


Figure 4 : Architecture of CPS [5]

1.2.5 Industry 4.0 Implementation in the Context of Sustainability

The importance of Industrial 4.0-related opportunities and constraints as drivers for Industry 4.0 implementation in the context of sustainability, with a distinct focus on different business sizes, industry sectors, and the firm's role as an Industry 4.0 supplier or user. The Triple Bottom Line of sustainability, comprises of the following:

1) Strategic, operational, environmental, and social potential associated to Industry 4.0
2) Threats to competitiveness and long-term viability,
3) A good match in terms of organization and output

4) Employee competencies and acceptability as important preconditions for Industry 4.0 adoption

Various business sizes, industrial sectors, and firms' responsibilities as Industry 4.0 suppliers or users are examined. It discovers that for major organizations, mechanical and plant engineering manufacturers, as well as Industry 4.0 suppliers, strategic possibilities are the key antecedents of Industry 4.0 deployment. Small and medium-sized businesses, automotive, chemical, and plastics industries, as well as Industry 4.0 customers, all benefit from operational potential.

Environmental and social opportunities are important for all firm sizes, industrial sectors (excluding the automobile industry), and jobs in Industry 4.0, with an influence that is significantly stronger for Industry 4.0. Also, despite their size, mechanical and plant engineering businesses are unable to apply Industry 4.0 due to the difficulty of competitiveness and future viability. Large firms, automotive, electrical engineering, and steel manufacturing have the most organizational and production obstacles while implementing Industry 4.0.

The empirical study shows that challenging competitiveness and future viability have a negative impact on new technology and innovation implementation in the Industry 4.0 scenario, but that this must be analyzed case by case, since past research have shown the contrary. Because the current scenario demonstrates an unexpectedly good association between staff credentials and acceptability for Industry 4.0 deployment, more research should be done [6].

1.2.6 Impacts of Industry 4.0

Industry 4.0 has the potential to bring about significant changes in a number of fields outside of the industrial sector. Its consequences and influence may be divided into six categories: (1) Industry, (2) Products and Services, (3) Business Models and Markets, (4) Economy, (5) Workplace, and (6) Skill Development.

1) Industry will be the first to feel the effects of Industry 4.0. This new industrial paradigm will usher in a vision of manufacturing that is decentralized and digitalized, with production parts that can autonomously govern themselves, trigger operations, and adapt to changes in their surroundings. Furthermore, the new paradigm suggests completely integrating goods and processes, moving the industrial perspective from mass manufacturing to mass customization, resulting in increased complexity.

As a result, technology advancements and the formation of smart factories will have a significant impact on production processes and operations, providing for more operational flexibility and more effective resource allocation. Industry 4.0 will have a significant impact on production systems, supply chains, and industrial processes.

This new paradigm is changing the present industrial environment in three ways: (1) production digitalization, (2) automation, and (3) integrating the manufacturing site to a larger supply chain. As a result, Industry 4.0 entails complete network integration and real-time data sharing. Productivity growth is at the heart of every industrial revolution. The fourth industrial revolution, on the other hand, will affect the whole supply chain, from product creation and engineering to outbound logistics, in addition to enhancing productivity.

2) This new industrial paradigm has a significant impact on products and services. Rapid changes in the economic environment and changing market demands have resulted in an increasing demand for the creation of increasingly complicated and intelligent goods in recent years.

The products will become increasingly modular and flexible, allowing for mass customization to satisfy unique consumer needs. As a result, Industry 4.0 is defined by the introduction of new goods and services as embedded systems that can become responsive and interactive, be controlled and tracked in real-time, optimize the whole value chain, and provide pertinent information about their status throughout their existence.

3) In the previous several years, company models and markets have swiftly altered, and new inventive business models will emerge. In the context of Industry 4.0, the introduction of new disruptive technologies has altered the way products and services are marketed and delivered, disrupting existing enterprises and introducing new business prospects and models. As a result, value chains are becoming more responsive, as Industry 4.0 encourages the integration of producers and customers, allowing for tighter consumer connection and business model adaption to market demands.

The rising digitalization of industrial production, together with system integration and complexity, will result in the establishment of more sophisticated and digital market models, boosting competitiveness by removing barriers between information and physical structures.

4) The new paradigm and developing technical breakthroughs can have an impact on the economy. The merging of the real and virtual worlds is known as digitization, and it will affect every economic sector.

This will be the primary driving force behind innovation, which will be crucial to productivity and competitiveness.

5) Technological breakthroughs are rapidly changing the work environment, and Industry 4.0 is redefining employment and necessary skills. The most major shift is in the human-machine interface, which encompasses worker contact as well as a set of new collaborative work methods.

The number of robots and smart devices is growing, and the real and virtual worlds are combining, implying that the existing work environment is undergoing a considerable transition. The rising importance of human-machine interfaces will encourage interaction between production aspects as well as the necessary communication between smart machines, smart goods, and employees, which will be aided by CPS' vision of IoT and IoS.

As a result, ergonomic concerns should be considered in the context of Industry 4.0, and future systems should emphasize the value of employees. Job profiles, as well as work management, organization, and planning, will be affected by the integration of Industry 4.0 in industrial systems and the rising deployment of new technologies. The major task is to avoid technological unemployment by reframing existing occupations and taking steps to prepare the workforce for the new ones that will be generated.

6) One of the most significant critical factors for a successful acceptance and implementation of the Industry 4.0 framework is skill development, which will lead to demographic and societal changes. New competences will be required in the future work vision, and it will be vital to develop possibilities for the development of such abilities through high-quality training.

This new industrial paradigm will have a significant influence on the labor market and professional positions, and it will be critical to guarantee that more jobs are generated than are lost. Because interdisciplinary thinking will play a major role and strong abilities in social and technological domains will be needed, the new needed competency sectors must be incorporated in education.

As a result of Industry 4.0's rising automation of jobs, workers must be prepared to take on new responsibilities. The same can be said for engineering education, which has a lot of promise in terms of training future professionals and informing them about new technical trends and possibilities, as well as managers who need to adapt their management strategies to meet changing market demands. Furthermore, in order to meet the demands of Industry 4.0, more qualified personnel will be required in technological sectors.

In summary, Industry 4.0 has enormous potential in many areas, and its implementation will have an impact across the entire value chain, improving production and engineering processes, improving product and service quality, optimizing customer-organization relationships, bringing new business opportunities and economic benefits, and changing education requirements and pathways [10].

1.3 Teamwork and Collaboration Tools

Teamwork is an essential skill required for engineering and computer science jobs. Efficient team management skills and their effective operation is key to successful completion of the group project.

Students come in with varying interoperable skill sets and are required to learn the importance of being responsible team players. Some of the proven methods of helping students to work efficiently in teams include: effective team formation, practice of recording team meeting minutes, maintaining an anonymous online team resolution center where students can report team problems and get solutions, having 2-3 teamwork assessments done during the course of project development, and having a percentage of the grade assigned for effectively working in teams.

The 21st century students who are all technology equipped, are inclined towards work cooperatively in a virtual manner. When used effectively, technology innovations can support higher-level thinking by engaging students in authentic, complex tasks within collaborative learning contexts. To facilitate effective teamwork, one of recent advancement in technology are the online collaboration tools.

These online collaboration tools are software systems that allows students (customers) to work together on common projects regardless of their physical location. Inside academic programs such as engineering and computer science, students have started to extensively make use of these online collaboration tools for effective learning and completion of group projects.

In this thesis effort, Industry 4.0 framework will be analyzed in detail with its vision of globalization of industries that share resources along their product lifecycle development [11]. Software applications used in engineering undergraduate curriculum that aim at Industry 4.0 skills [12-16] will be studied in this research. More specifically, set of features that the software applications offers to promote project based collaborative engineering learning environment will be studied and reported in this thesis.

Surveys will be administered to study the impact and use of software tools to develop Industry 4.0 skills sets in undergraduate students. Also, a detailed analysis of Industry 4.0 different online collaboration tools frequently used by engineering and computer science students for working on their group projects will be studied in this research effort.

Different feature sets will be taken into consideration for analyzing the pros and cons of various tools. Also, an online anonymous survey will be built and administered as a part of this research effort to study the potential benefits of using online collaboration tools.

1.4 Statement of the Problem

This section describes the problem and the justification to solve such a problem within the scope of this research effort. Industry 4.0 is a slowly emerging concept, and the current engineering industry sector is already navigating towards the adoption of such skills sets. Concepts like smart supply chain, cyber-physical systems, integration of IoT devices, and big data predictions are becoming more popular among manufacturing companies.

Industry 4.0 skill sets mainly focus on bringing together Information Technology with Industrial Technology. When it comes to undergraduate engineering education, it is the prime responsibility of every academic institution to build a workforce that serves the needs of the community and the growing industry sectors.

In addition to increasing demand of Industry 4.0 skill sets, team work also plays an important role when it comes to success of any project. More specifically team work plays a vital role in every engineer's career. Employers have reported that students in engineering disciplines perform well on the technical aspects but fall short of expectations when it comes to be good team players. When it comes to team work, communication plays an important role. Without proper communication and communication channels, we cannot establish effective teams. When it comes to communication and communication channels, in earlier days, face to face communication was easy to achieve. But these days, face to face communications are becoming very challenging for students and most of the time it has to be online or virtual form of communication.

Students use online collaborative tools to facilitate teamwork. In an engineering curriculum, different courses have team project assignments and the choice of such online tools is up to the students to decide. There are many free open-source online collaboration tools available for students in the market and the choice of right ones is essential for students to be successful. Unlike other disciplines that involve mostly standard files like word, excel, power point, etc.., engineering discipline is very diverse and the used different file formats during communication. For example, engineers deal with design diagrams, mathematical formulas, programming language specific code, etc… when they are working on their team projects/assignments. Collaboration tools out there in the market should enable students to effectively use different file formats during their communication.

The main question one needs to ask is “Does the current curriculum sufficiently cover the topics and concepts of Industry 4.0 and collaborative project development to get the students prepared for the current job market?”

In this research effort, the problem of identifying the current gap in undergraduate engineering education when it comes to addressing the Industry 4.0 and the soft skills within the existing curriculum has been taken into study. Results from this study will enable educators to think of ways to close the gap and address the needed concepts within the undergraduate engineering curriculum sufficiently to get the student body prepared for the current job market.

The findings from this research effort will also lead to the identification of the adjustments that need to be made within the existing curriculum and the adoption challenges when it comes to teaching industry 4.0 skills along with the soft skills to undergraduate students.

1.5 Research Challenges

The major challenges identified in this research effort are as follows:

1) Since Industry 4.0 skill set involves many complex technologies, identifying the existing curriculum gap is not an easy task.
2) Involving the different engineering disciplines that have different objectives and curriculum needs in the study increases the complexity when it comes to data analysis.
3) Creating a survey tool that can be used with the student body and instructors to address the research questions is challenging.
4) Since this research study is more qualitative in nature, choice of right experimental procedure using tools such as surveys with right questions will be a challenge.
5) Assessing the validity of the data collected without biases and the analyses of data to determine results will also be a challenge due to the subjective nature of this research.
6) Online collaboration tools are not mandated in many courses but still students tend to use them on their own interest. To qualitatively assess the use and impact of currently used software applications by students that have helped them to build their soft skills will be a challenge in this research.

1.6 Research Objectives

The objectives of this research efforts are:

1. To conduct an analysis and documentation of the literature related to this research, more specifically:

   a. Industry 4.0 concepts, skill sets, the need, issues and challenges in Industry 4.0, international effort to address industry 4.0, key technology enablers for Industry 4.0, Industry 4.0 implementation in the context of sustainability, impacts of Industry 4.0, teamwork, and online project collaboration

   b. Adoption of Industry 4.0 and soft skills within the engineering curriculum at different academic institutions, challenges faced, and adjustment techniques recommended

2. To collect data and information thorough an online survey tool to identify the existing curriculum gap when it comes to addressing Industry 4.0 and soft skills.

   a. Understanding the digital presence of instructors and students

   b. Student's and instructor's exposure of Industry 4.0 concepts

   c. The extent to which Industry 4.0 subject areas are covered within the existing curriculum

   d. Student's and instructor's exposure to software tools that specifically support Industry 4.0 concepts

   e. Student's involvement in collaborative project development

   f. Student's exposure to software tools to aid in collaborative project development

3. To analyze the gathered information from Research Objective 2, more specifically:

a. Identify groupings of commonalities amongst the responses received,

b. Visually interpret and present information in the form of table and charts to address Research Objectives 1 and 2, and

c. Use additional statistical analysis to identify any useful information.

4. To present key findings that addresses the results obtained through this research effort.

5. To recommend sensible follow-up work related to the work in this thesis which may be pursued in future.

CHAPTER II

2. LITERATURE REVIEW

In this chapter, the different benefits of incorporating Industry 4.0 skills have been discussed. The methodologies adopted by different academic institutions to adopt Industry 4.0 skills into their curriculum has also been discussed in this chapter. The importance of collaborative project development along with the need of good teamwork among engineering students is also discussed in this chapter.

The advantages of incorporating 3D printing and Industry 4.0 into engineering undergraduate programs has been discussed by Chong [17]. Surveys and interviews were conducted to obtain evaluations based on the impacts of incorporating 3D printing and Industry 4.0 into a curriculum on engineering teaching and learning. Surveys (using Qualtrics software and emailed to all engineering students) were conducted to aggregate the feedbacks and views from faculty and students. Industry 4.0 has been known by roughly 75% of the students and 86% of the lecturers, respectively.

Students can benefit considerably from improved 3D sketching abilities and speedy 3D-printed prototypes when studying common processing equipment, manufacturing, maintenance, logistics, and operations. As illustrated in Fig 1, the author suggests a blended learning paradigm for incorporating Industry 4.0 into engineering education, which includes traditional, online, and flipped classroom approaches.

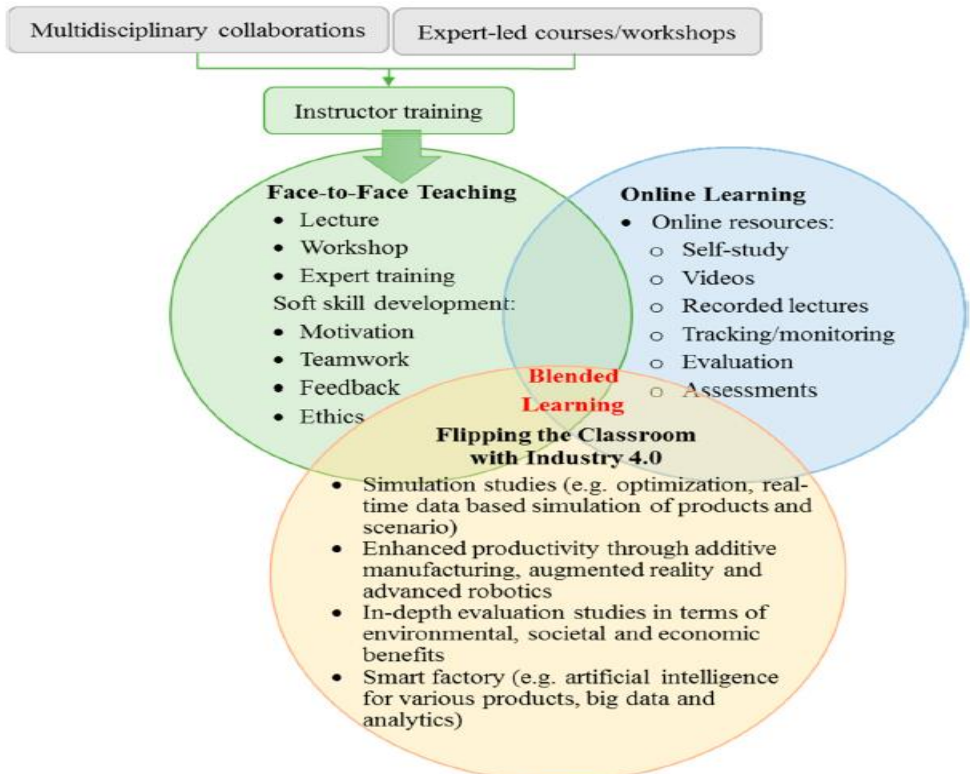


Figure 5: Blended learning model for Industry 4.0 [17]

The model's implementation can begin with cross-disciplinary partnerships or expert-led teacher training, followed by traditional face-to-face teaching and online learning. The flipped classroom is an important part of the paradigm since it promotes learning-by-doing approaches like "bring your own device" and "do it yourself.

Integrating Industry 4.0 into engineering education can help to establish a student-centered learning environment in which students are educated to become proactive, lifelong learners who are more environmentally and economically sensitive. Based on the research conducted and results obtained, it tis inferred that students that are exposed to Industry 4.0 will be able to conduct self-directed research and get expertise in product design, technology development, smart manufacturing, detecting and fixing problems in order to create a more sustainable future.

Based on the context of the fourth industrial revolution, Ray [18] has discussed the potential benefits of integrating Artificial Intelligence (AI) methods and digital technologies like learning analytics to improve undergraduate student education and graduate employment. Integration and implementation of learning analytics approaches with the results of earlier research projects in self-regulated learning and personal learning environments are among the project's goals. To guarantee comprehensive student participation in the planning and development process, a student-centered reflective and participatory technique was implemented. The author advocates utilizing a free open-source learning management system to collect and capture learning analytics data from student activities as a bottom-up method to building such systems. It is envisaged that by combining this approach with a tried-and-true user-centered methodology for improving personalized learning, a practical, standardized, and affordable solution to the challenge of bringing successful enhanced learning analytics systems into institutions would be developed.

The findings and analyses from this study are said to have the potential to assist the higher education industry as a whole in overcoming infrastructural and data sharing constraints.

The transformation of a training-oriented manufacturing workshop into a Learning Factory (LF) for the production engineering program is described by the author [19]. The proposed changes were based on the formulation of three pillars for the development of an LF (didactic, integrative, and engineering). The research suggest that a thorough transformation process can help to ease the transition to new manufacturing trends like Industry 4.0 into an academic setting that strengthens engineering education. A research method has been designed with the goal of implementing a model that directs efforts to convert production engineering methods in the direction of an LF. It is composed by two stages:

- First Stage: Identification of LF's relevant features (thematic, objective group, educational purpose, teaching-learning strategies, and technological infrastructure in various LF proposals). The following research steps were completed in order to recognize the major elements of the LF: Identification of literature, quantitative text analysis, and qualitative text analysis are all techniques used to analyze texts.
- Second stage: Consists of the model's structure, which is built on three pillars. The properties that must be obtained in the planned alterations are referred to as these pillars. The concept is divided into four phases, each of which is supposed to interfere in the infrastructure and didactics of production engineering processes in order to create a learning factory.

This approach could serve as a framework for implementing a Learning Factory in stages. The research study suggest that a thorough transformation process can help to simplify the transition to new manufacturing trends like Industry 4.0 in an academic framework that promotes engineering education. In [20] the author describes the goal of the article as to examine the key technologies of Education 4.0 (as shown in Fig. 2), which are critical to the success of Industry 4.0 and have a substantial impact on engineering education. The idea behind Education 4.0 is to create a symbiotic relationship between all educational actors, including students, teachers, education managers, and administrators, in order to improve educational processes. Education 4.0 refers to educational contexts in which several players collaborate to create value at various levels. In order to implement the Education 4.0 concept, it is critical to encourage the creation and use of intelligent educational infrastructure.

The following are the core elements of Industry 4.0: prioritization of future challenges in terms of prosperity and quality of life, resource consolidation, improvement of innovation transfer and networking, strengthening of industry dynamism, development of favorable conditions for innovation, and transparency and participation through an innovation policy.

Table 2: Main technologies in sustaining Industry 4.0 [20]

Area of application	Technological approach
Self-learning and interactions	Remote and virtual laboratories
Improving the learning accessibility for students with disabilities	
Education using robots	Educational robots
Language learning	3D virtual worlds
Active Worlds 20	
Consumer psychology and behavior	Augmented reality
Science Learning (Chemistry, Medicine etc.)	
Interactive learning	
Visualization of educational data	Complex data visualizations
Mechanical engineering formulas; view, edit, and share DWG drawing file format	Mobile computing
Practicing engineering laboratory experiment Creative engineering	
Unlimited stream of data Linked open data	Linked open data
Data publication, consumption and reuse	
Catalyst in Science, Technology, Engineering, and Mathematics (STEM) Education	Cloud computing
Chemical Engineering	
Enhance engineering communication and math skills	Gamification
Software engineering and cyber-security	

Practice simulator for engineering students	Computer-based simulation
Battery basics in laboratories	
Adapting higher education to the requirements of Industry 4.0 vision	

The research signifies that technology, as well as their unique methodologies for improving learning in engineering education, represent a significant advancement in the educational process.

Some of the experiences with applying few techniques to study programs at the University of Novi Sad and China Agricultural University are presented by the author in [21]. Changes in Mechatronics and Identification Technology provided ideal conditions for introducing the concept of Industry 4.0. Because of the fact that concept of Industry 4.0 has gained widespread acceptance, we must quickly alter our engineering education curricula. Also, keeping in mind that when the 5G mobile network becomes more widely adopted, the utilization of the Industry 4.0 idea will also grow considerably. As a result, it is critical that engineers be educated in Mechatronics and Identification technologies. The fourth revolution necessitates transdisciplinary knowledge and competence (as in the case of Mechatronics). Multidisciplinary abilities will be required. In the industrial and service industries, real-time collaboration will be more important than ever.

Recent advancements (as shown in Fig 3) in computer science, such as cloud computing, edge computing, big data, data mining, blockchain, artificial intelligence, and many others, will be implemented in sensors, actuators, robots, control valves, control applications, and SCADA (Supervisory Control And Data Acquisition) applications to add new value to next-generation manufacturing processes.

Figure 6: Connections in Industry 4.0 [21]

The author emphasis the fact that, given the rapid pace of change in Industry 4.0, it is critical that study programs in Universities that train future employees have excellent solutions to all difficulties.

The fourth phase of technical progress: industrial advancement of new digital technologies, the innovations of new digital industrial technologies collectively known as Industry 4.0, is on the advent [22], posing a new threat/challenge to employment.

The organizational culture such as Universities must supports the requirement to adjust human resource performance to the demands of Industry 4.0. Current psychological evaluation methods only take into account a subset of these needed talents, which aren't necessarily the most important.

This study aims to identify and examine what is thought to be at the heart of the complex set of skills required to tackle this problem. The use of a psychological instrument to measure transversal competencies was the subject of this research. After assessment on a series of students from the University POLITEHNICA of Bucharest, the capabilities map needed for the evaluation and selection of human resources suited to operate in an industry 4.0 setting was created.

Then it was put to test using the ABCD-M psychological evaluation tool. Third-year students (90 pupils in total (Machine-tools 38, Logistics 19 and Robotics 33) in three areas were given this psychological evaluation test: robotics, machine tools, and logistics.

Manufacturers will be able to boost their competitiveness as a result of adopting Industry 4.0, allowing them to expand their industrial workforce at the same time as productivity rises. These soft-skills may be cultivated through academic studies and are the foundation for the development of a complex set of competences, such as teamwork and networking capacity, communication ability, personal effectiveness, self-improvement, creative and inventive thinking, and leadership skills.

Technology plays a very important role when it comes to enabling online communication. Hamid et al. [23] in their paper discuss the benefits of using Online Social Networking (OSN) tools to enable student to student and student to lecture communications. The study concluded that OSN helps students to effectively interact with each other and with their professors. The study collected data from two different universities at Malaysia and Australia. The research methodology used by Hamid et al. was qualitative study involving focus group discussions with a small group of students.

The use of online and offline collaboration between students using asynchronous tools was discussed by Wang [24]. Blended learning strategies use online discussion into classrooms to increase student learning and participation. This study analyzed the collaborative learning experience among students from two different colleges using different online and offline interactions. Different pedagogical implications as a results of student's online collaboration and offline interaction experience were presented in this paper. The study involved group of students working on a project and were given different activities that involved online and offline interactions among students. The findings from the research concluded that ICT (Information and Communication) tools increased the social interaction among students. The study also concluded that the integrated e-learning elements resulted in a more learner-centered learning environment.

With Computer Science majors GitHub has become a very popular online collaboration tools for software development. Zagalsky et al. [25] in their paper discussed the pros and cons of using GitHub an emerging collaborative platform for managing software projects in academia. GitHub is heavily used by software engineering professionals by allowing them to create repositories, version control, and other features to improve the group project development experience. In this paper, the authors conducted a qualitative study focusing on how GitHub gets used in education and what benefits it brings to the students and educators. The targeted lecturers and professors were from higher education who have already used or using GitHub to support teaching and learning. The study aimed at investigating diverse populations as well as GitHub's usefulness in non-technical courses. The research conducted in this paper found that GitHub can be a powerful learning management tool and a collaborative social learning platform for students working on group software projects.

Ku et al. [26] in their paper analyzed the collaboration factors, teamwork satisfaction, and student attitudes towards online collaborative learning. The authors took into study the online courses with collaborative learning components from 197 graduate students across three consecutive academic years. The study consisted of a student attitude survey with open-ended and satisfaction scale questions. The survey was administered to the students during the final week of each semester. The research findings concluded that the three extracted online collaboration factors (Team Dynamics, Team Acquaintance, and Instructor Support) from the student attitude survey had moderate to high degrees of correlation with teamwork satisfaction. Results from this research effort also revealed the fact that three collaboration factors accounted for 53% of the variance in online teamwork satisfaction. Also the results from the survey and open-ended questions revealed that the students favored working collaboratively in an online environment.

Lingard and Barkataki [27] in their paper, discuss the importance of teamwork in engineering and computer science. Teamwork is an important skill for students in engineering and computer science disciplines. Employers from these professions are expecting students to have strong communication skills to perform well in their respective jobs. Students are expected to gain proficiency in teamwork skills along with their technical skills. Projects that are teamwork based help the students to apply the technical knowledge in a meaningful way. When it comes to team work and team projects factors such as planning, estimating, tracking progress, taking corrective actions, managing change, controlling and managing risks, maintaining ethical and professional conduct, communicating complex ideas clearly and concisely, using design automation tools, leveraging web-based tools for team collaboration, and most importantly participating effectively as team members are all very essential and important. In this paper, the authors have conducted their study by using student team projects in both undergraduate and graduate classes. The research findings concluded that there was a greater level of student participation in teamwork projects while providing faculty with an insight into the team progress, and the degree collaboration among the team members. Such tools even helped self-organizing teams to work on complex project tasks without getting overwhelmed by tasks associated with managing the teams.

Uhomoibhi [28] in his paper describes the resources used for sharing and collaboration in engineering education and also analyzes the influence of online technology to enhance education. He also discusses the challenges faced by educational institutions to bring in a collaborative approach to prepare students towards global engineering education.

CHAPTER III

3. RESEARCH METHODOLOGY

In this chapter the overall research design methodology is discussed. The subsections detail the sample size collected, the period of study, and the different methods employed to collect data. The tools used in this research to perform data analysis along with the statistical methods employed to perform data analysis is also discussed in this paper. The limitation of the research is also discussed in one of the subsections.

3.1. Research Design

This section will discuss the plan to address the research objectives stated in this thesis effort. The sample size, methods of data collection, survey tools developed, period of data collection, and methods of data analysis used will all be discussed in this chapter.

The kind of research applied in the study is ***Descriptive, Quantitative and Qualitative Research***

Descriptive research uses a set of scientific methods and procedures to collect raw data and create data structures that describe the existing characteristics of a defined target population. The data and information generated through the descriptive designs can provide the decision makers with evidence that can lead to a course of action.

Although quantitative research is frequently connected with positivism, it is also employed in interpretive, realist, and pragmatist philosophies. In most cases, deductive reasoning is used in quantitative research.

Qualitative research is frequently utilized in interpretive philosophy, although it is also employed in realism and pragmatist philosophy on occasion. Qualitative research, on the other hand, is almost certainly interpretive since researchers must evaluate subjective meanings expressed about the research object. To develop theory, qualitative research usually takes an inductive approach.

The three research designs that have been presented often result in a mixed methods research design. Mixed method research designs combine quantitative and qualitative data collection techniques and analysis tools.

This research effort has employed a mixed methods research design. A mixed methods research design is frequently the consequence of the three research designs that have been discussed above. Descriptive, quantitative, and qualitative data gathering approaches and analytic tools are combined in mixed method research designs.

3.2. Sample Size

The online survey was conducted at College of Engineering, West Texas A&M University (WTAMU). The respondents were course instructors and undergraduate students in the discipline of engineering and computer science, Total of 6 course instructors and 23 students took part in the survey. Hence the sample size is 29.

3.3. Period of Study

The period of the research study is 1.3 years, starting from spring 2020 and ending in summer 2021. The researcher took first six months to collect the review of literature and identify the research gap. Another three months were spent to draft the research design, to prepare data collection instrument and to conduct the pilot study. After finalizing the questionnaire, three months have been spent to collect the data from the target respondents. The researcher took two months to analyze and interpret the collected data and to prepare the thesis.

3.4 Methods of Data Collection

This thesis effort employed surveys as research method in-order to conduct an in-depth study of the given problem and the surrounding factors. Survey allow researchers to collect quantitative and qualitative data that can be analyzed using descriptive and inferential statistics. Surveys commonly use questionnaires to collect data, however, structured observations and structured interviews can also be considered as data collection methods for surveys [29].

3.4.1 Primary Data

Primary data needed for conducting this research work was collected by online survey:

The research survey was developed in Qualtrics survey software. The online survey link was emailed to course instructors in different disciplines and requested instructors to pass on their class students, followed by two email reminder. The online survey was closed at the end of April 2021 and resulted in to total of 29 responses, in which 6 of them were instructors and 23 of them are undergraduate engineering and computer sciences students.

3.4.2. Secondary Data

Secondary data needed for conducting the study was collected from various journals, conference proceedings, online websites, and previous thesis work.

3.4.3 Pilot Study

After the formulation of the questionnaire, pilot study was conducted. A very small sample from the population was selected. Based on the answering of the questionnaires and also based on the suggestions of the respondents, relevant modifications were done to the instrument. Then the questionnaire was finalized.

3.5. Data Analysis

The data after collection has to processed and analyzed in accordance with the outline laid down for the purpose at the time of developing the research plan. This is essential for a scientific study and processing implies editing, coding, classification and tabulation of collected data. So that they acquiescent to analyze.

The term analysis refers to the computation of certain measures along with searching for patterns of relationships that exists among data groups. Thus, relationships or differences that support or contradict the original or new hypothesis should be subjected to statistical tests of significance during the analysis process to establish whether the validity data can be claimed to imply any conclusion.

Analysis of data in general way involves a number of closely related operations that performed with the purpose of summarizing.

3.6. Statistical Tools Used in Analysis

For assessing correlations between categorical data, the Chi Square statistic is used in this research effort. Qualtrics [30] inbuilt statistical analysis tools have been used in this research effort. The null hypothesis of the Chi-Square test is that the categorical variables in the population have no association; they are independent. A Chi-Square analysis might be used to address the following research question:

Is there a link between a specific engineering program and the extent to which they have been exposed to Industry 4.0 concepts?

The Chi-Square statistic can be calculated in a number of ways, all of which are simple and intuitive:

$$\chi^2 = \sum \frac{(f_o - f_e)^2}{f_e} \tag{1}$$

where f_o is the observed frequency (the counts in the cells) and f_e is the predicted frequency if the variables had no relationship.

A p-value is calculated using the chi-square test statistics and the confidence level. The statistical significance of the relationship between the two variables is determined by the p-value. A low p-value indicates that the observed table relationship would arise with a very low chance, indicating that the two variables are related. A p-value of less than 0.5 is generally considered a low p-value.

3.7. Limitation of the Study:

The study has the following limitations.

- The Universe being large, the study was restricted to College of Engineering at West Texas A&M University (WTAMU) only. So, the sample may not be true representative of the population.
- The data were collected only from small numbers instructor and student at College of Engineering at WTAMU.
- The target respondents were scattered in the study area. Meeting them and collecting data were difficult task.

CHAPTER IV

4. ANALYSIS OF RESULTS

This chapter discusses how the data obtained from the surveys were analyzed using Qualtrics and the results obtained are presented. With the help of Qualtrics Data and Analysis tab, I was able to filter, classify, merge, clean, and statistically analyze the data that was collected.

4.1. Visual Chart and Table Analysis

Instructor Response

Table 3: Major of the program Discipline (Instructor) – Percentage Analysis

#	Answer	%	Count
1	Mechanical Engineering	33.33%	2
2	Civil Engineering	16.67%	1
3	Electrical Engineering	50.00%	3
4	Environmental Engineering	0.00%	0
5	Engineering Technology	0.00%	0
6	Computer Science	0.00%	0
7	Math	0.00%	0
8	Others specify	0.00%	0
	Total	100%	6

Sources: Primary Data

Table 4: Major of the program Discipline (Instructor) – Statistical Analysis

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Choose your discipline: - Selected Choice	1.00	3.00	2.17	0.90	0.81	6

Sources: Primary Data

Student Response

Table 5: Major of the program Discipline (Student) – Percentage Analysis

#	Answer	%	Count
1	Mechanical Engineering	13.04%	3
2	Civil Engineering	0.00%	0
3	Electrical Engineering	8.70%	2
4	Environmental Engineering	13.04%	3
5	Engineering Technology	0.00%	0
6	Computer Science	52.17%	12
7	Math	13.04%	3
8	Others specify	0.00%	0
	Total	100%	23

Sources: Primary Data

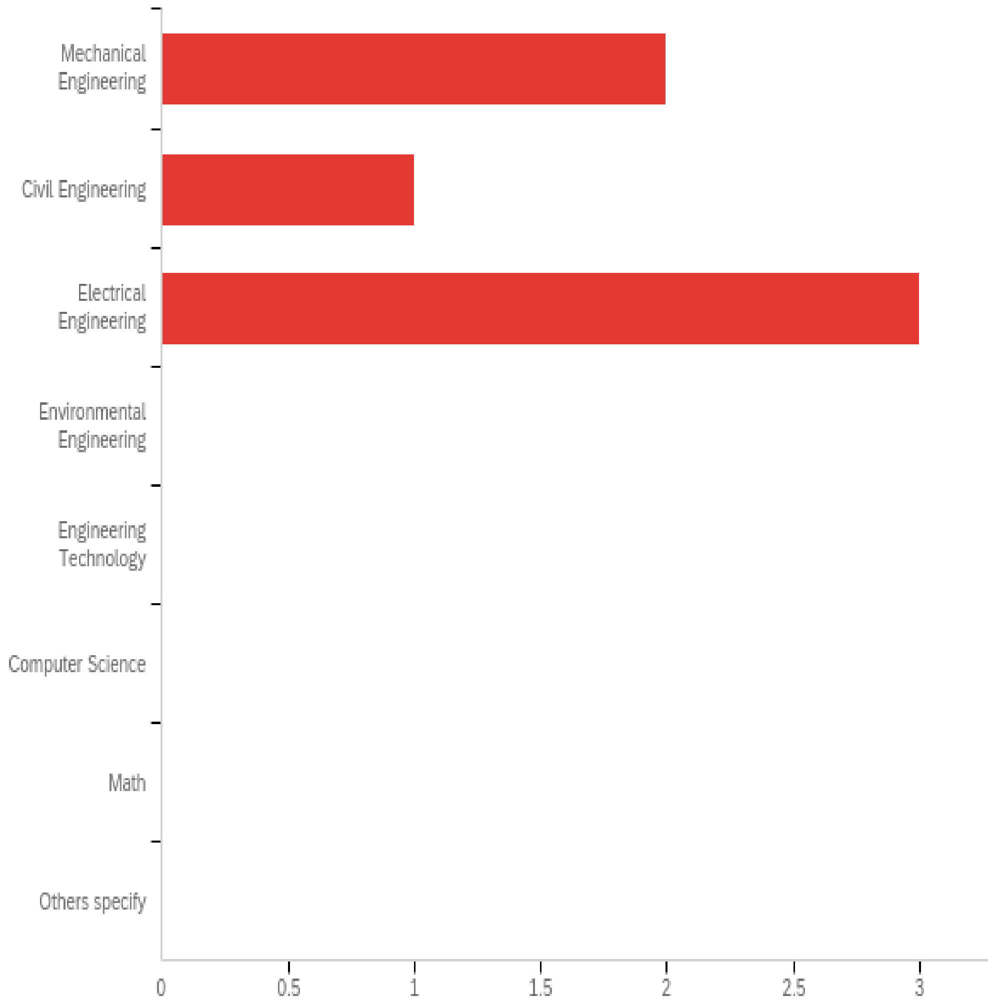
Table 6: Major of the program Discipline (Student) – Statistical Analysis

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Choose your major: - Selected Choice	1.00	7.00	4.96	1.90	3.61	23

Sources: Primary Data

Instructor Response

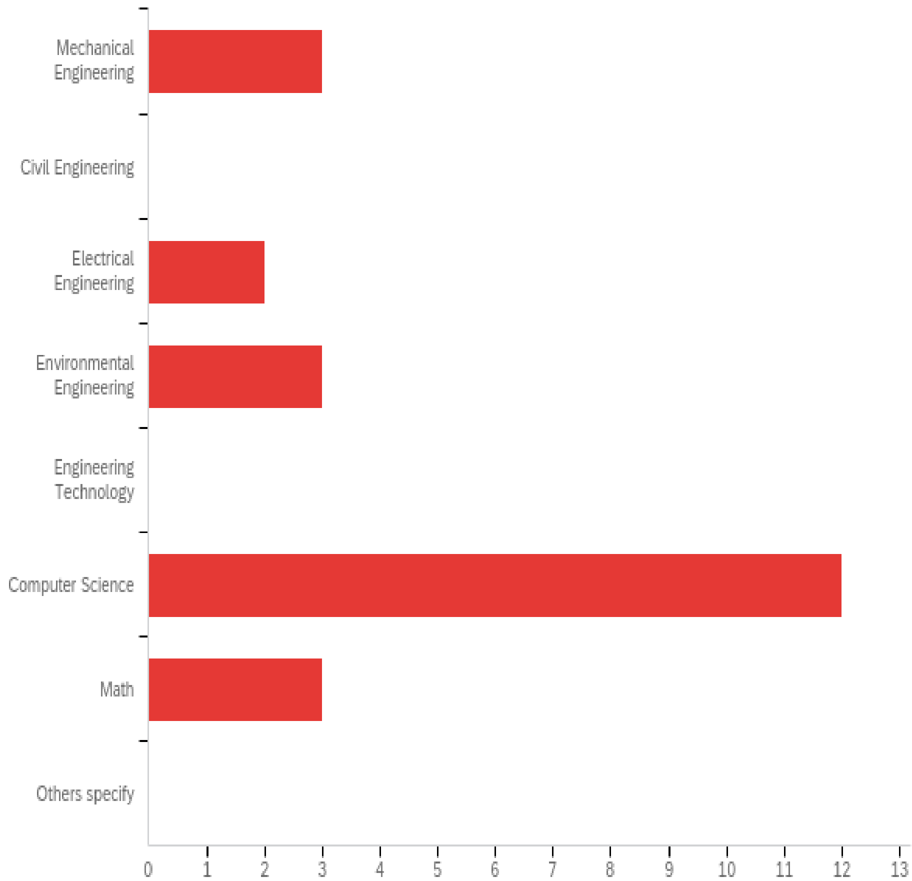
Chart 1: Major of the program Discipline – Instructor



Sources: Primary Data

Student Response

Chart 2: Major of the program Discipline – Student



Sources: Primary Data

From the above table and chart it can be inferred that out of 6 instructor respondents, 2 were from mechanical, 1 from civil and 3 from electrical engineering program. Out of 23 student respondents, 3 were from mechanical, 2 from electrical, 3 from environmental, 12 from computer science, and 3 from math program.

It is concluded that, majority of the instructor respondents were from electrical engineering and majority of the student respondents were from the computer science program.

Instructor Response

Table 7: Respondents Categories (Instructor) – Percentage Analysis

#	Answer	%	Count
1	Assistant Professor	83.33%	5
2	Associate Professor	0.00%	0
3	Professor	16.67%	1
4	Full-time Instructor	0.00%	0
5	Part-time Instructor	0.00%	0
6	Other	0.00%	0
	Total	100%	6

Sources: Primary Data

*T*able 8: Respondents Categories (Instructor) – Statistical Analysis

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Are you a ---------------? - Selected Choice	1.00	3.00	1.33	0.75	0.56	6

Sources: Primary Data

Student Response

Table 9: Respondents Categories (Student) – Percentage Analysis

#	Answer	%	Count
1	Undergraduate – Freshman	4.35%	1
2	Undergraduate – Sophomore	13.04%	3
3	Undergraduate – Junior	30.43%	7
4	Undergraduate – Senior	47.83%	11
5	Masters	4.35%	1
	Total	100%	23

Sources: Primary Data

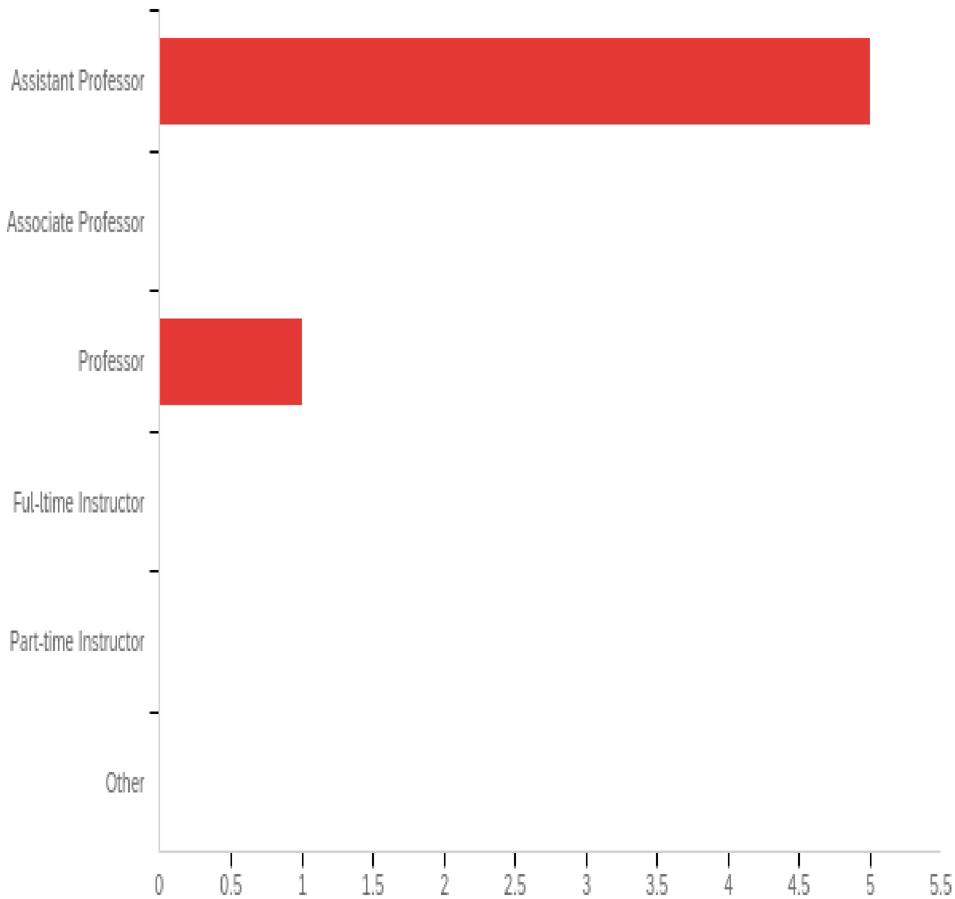
Table 10:Respondents Categories (Student)– Statistical Analysis

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Are you a ---------------?	1.00	5.00	3.35	0.91	0.84	23

Sources: Primary Data

Instructor Response

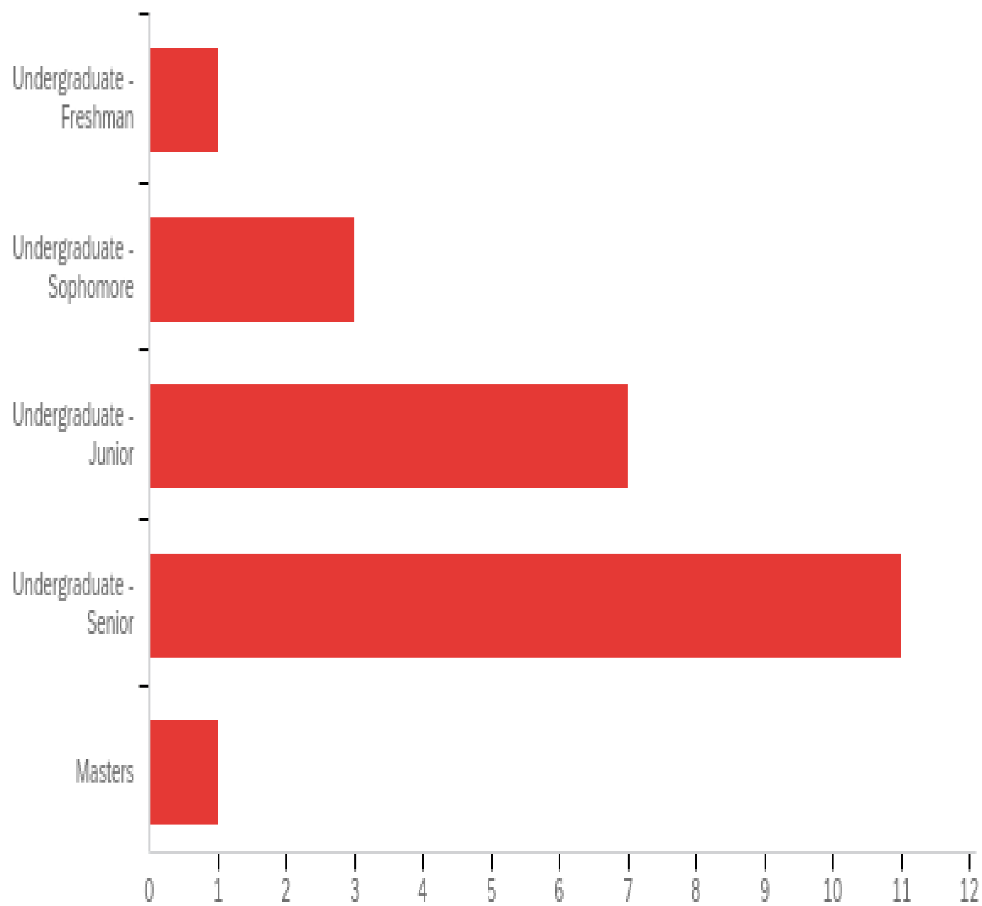
Chart 3: Respondents Categories- Instructor



Sources: Primary Data

Student Response

Chart 4: Respondents Categories- Student



Sources: Primary Data

From the above table and chart it can be inferred that out of 6 instructor respondents, 5 were Assistant Professor and 1 Professor from the engineering program. Out of the 23 student respondents, 1 was freshman, 3 were sophomores, 7 were junior, 11 were seniors and 1 graduate student from the College of Engineering.

It is concluded that, majority of the instructor respondents were Assistant Professors from the Engineering program and majority of the student respondents were undergraduate senior students.

Student Response

Table 11: Respondents Gender (Student)– Percentage Analysis

#	Answer	%	Count
1	Male	47.83%	11
2	Female	47.83%	11
3	Non-binary / third gender	4.35%	1
4	Prefer not to say	0.00%	0
	Total	100%	23

Sources: Primary Data

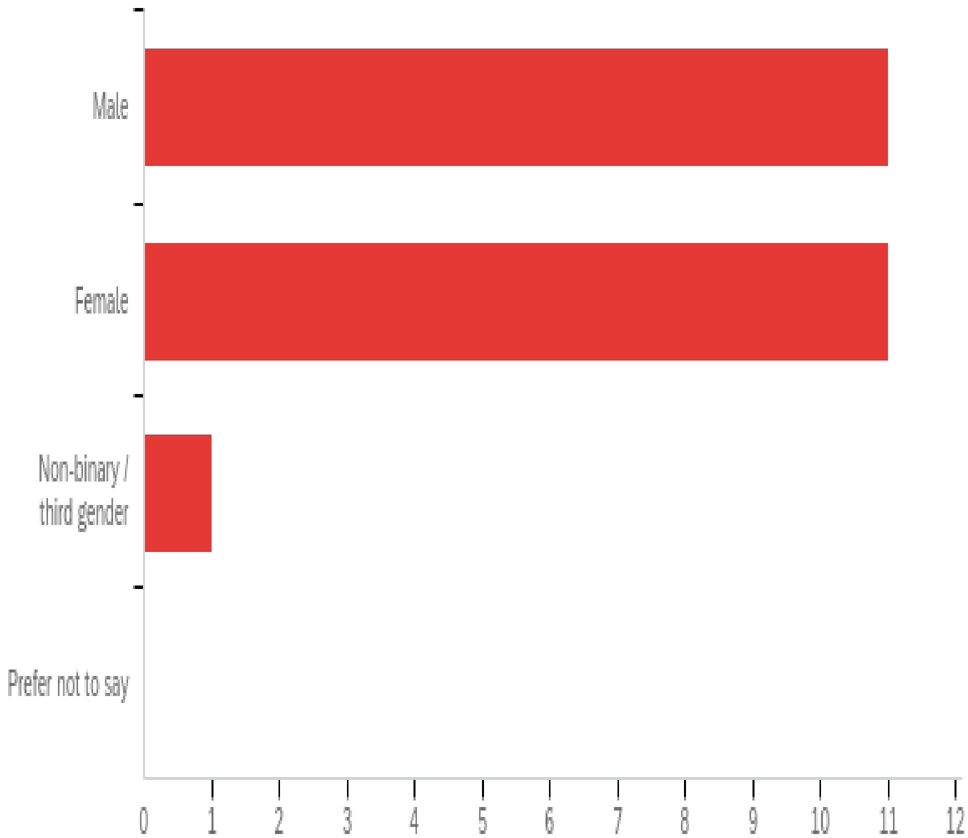
Table 12: Respondents Gender (Student) – Statistical Analysis

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Select your gender:	1.00	3.00	1.57	0.58	0.33	23

Sources: Primary Data

Student Response

Chart 5: Respondents Gender-Student



Sources: Primary Data

From the above table and chart, it can be inferred that out of 23 student respondents, 11 were male, 11 were female, and 1 non-binary/ third gender from the College of Engineering.

Also, the representation of male and female students respondents were found out to be distributed equally.

Instructor Response

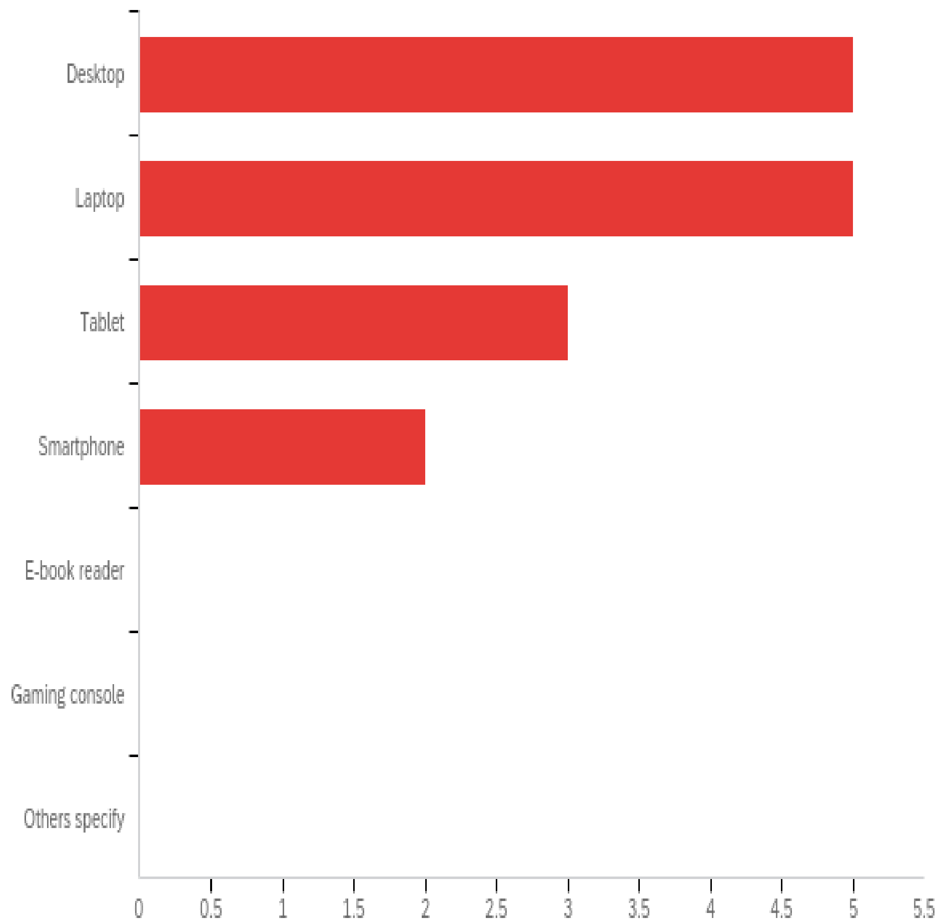
Table 13: The digital device use for educational purpose (Instructor) – Percentage Analysis

#	Answer	%	Count
1	Desktop	33.33%	5
2	Laptop	33.33%	5
3	Tablet	20.00%	3
4	Smartphone	13.33%	2
5	E-book reader	0.00%	0
6	Gaming console	0.00%	0
7	Others specify	0.00%	0
	Total	100%	15

Sources: Primary Data

Instructor Response

Chart 6: The digital device use for educational purpose- Instructor



Sources: Primary Data

From the above table and chart, instructor's use of digital devices for educational purpose was studied. 33.3% of them use laptop as well as desktop, 20% of them use tablet and 13.3% of them use smart phone.

It was concluded that, majority of the instructor respondents use laptop and desktop for educational purpose.

Student Response

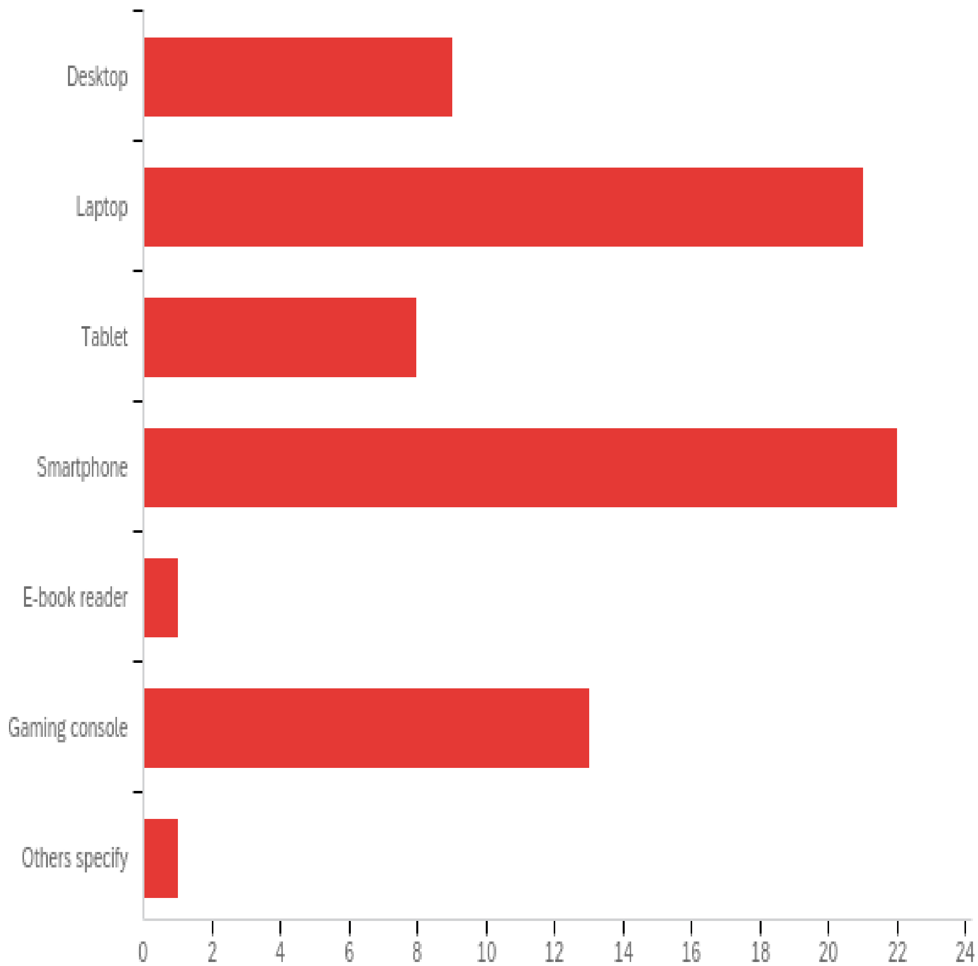
Table 14: The Digital Device own / Use for educational purpose (Student) – Percentage Analysis

#	Answer	%	Count
1	Desktop	12.00%	9
2	Laptop	28.00%	21
3	Tablet	10.67%	8
4	Smartphone	29.33%	22
5	E-book reader	1.33%	1
6	Gaming console	17.33%	13
7	Others specify	1.33%	1
	Total	100%	75

Sources: Primary Data

Student Response

Chart 7: The Digital Device own / Use for educational purpose- Student



Sources: Primary Data

From the above table and chart it can be inferred that among the student respondents, 12 % of them use laptop, 28% of them use desktop, 10.6 % of them use tablet, 29.3% of them use smartphone,1.3% of the use e-book reader,17.7% of them use gaming console and 1.3% of them use other digital devices.

It is concluded that, majority of the student respondents own smartphone digital devices.

Student Response

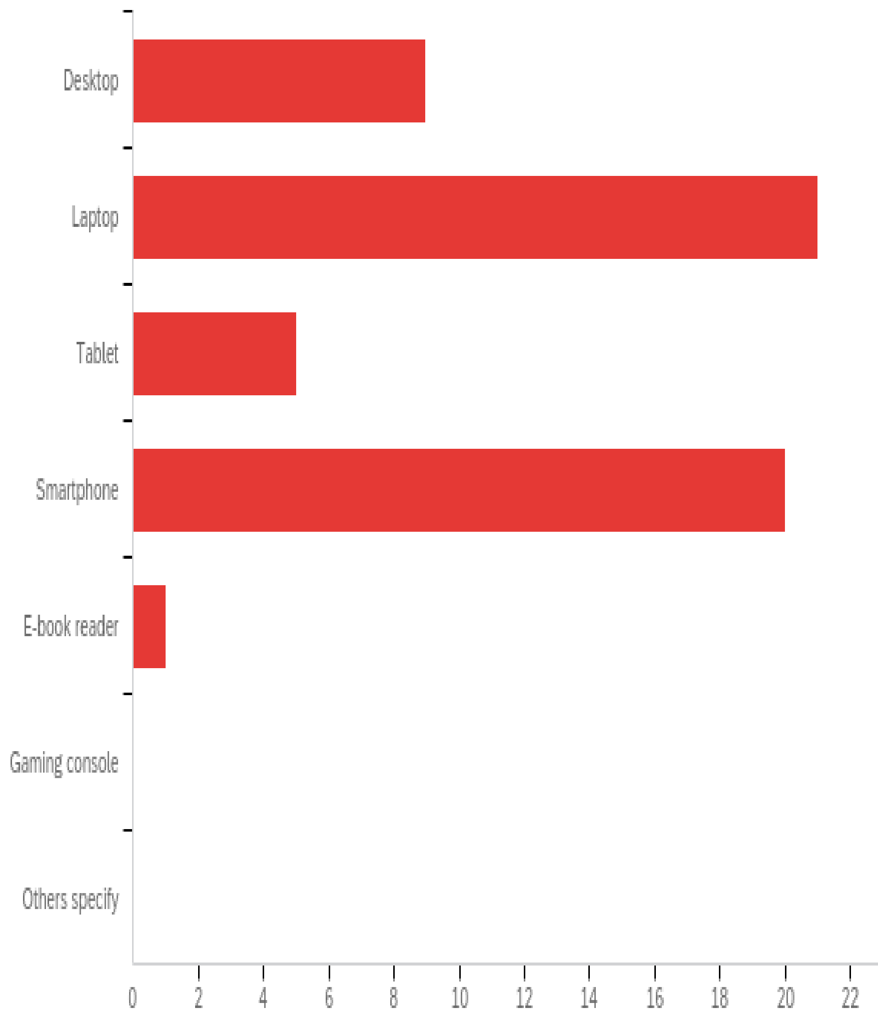
Table 15: The Digital Device use for educational Purpose (Student)-– Percentage Analysis

#	Answer	%	Count
1	Desktop	16.07%	9
2	Laptop	37.50%	21
3	Tablet	8.93%	5
4	Smartphone	35.71%	20
5	E-book reader	1.79%	1
6	Gaming console	0.00%	0
7	Others specify	0.00%	0
	Total	100%	56

Sources: Primary Data

Student Response

Chart 8: The Digital Device use for educational Purpose- Student



Sources: Primary Data

From the above table and chart, it can be inferred that among the student respondents, 16.07 % of them use laptop, 37.5% of them use desktop, 8.93 % of them use tablet, 35.71% of them use smartphone, and 1.79% of the use e-book reader.

It is concluded that, majority of the student respondents use laptop for educational purpose.

Instructor Response

Table 16: How would you rate yourself in terms of using technology for teaching purpose (Instructor) – Percentage Analysis

#	Answer	%	Count
1	Extremely comfortable	50.00%	3
2	Somewhat comfortable	50.00%	3
3	Neither comfortable nor uncomfortable	0.00%	0
4	Somewhat uncomfortable	0.00%	0
5	Extremely uncomfortable	0.00%	0
	Total	100%	6

Sources: Primary Data

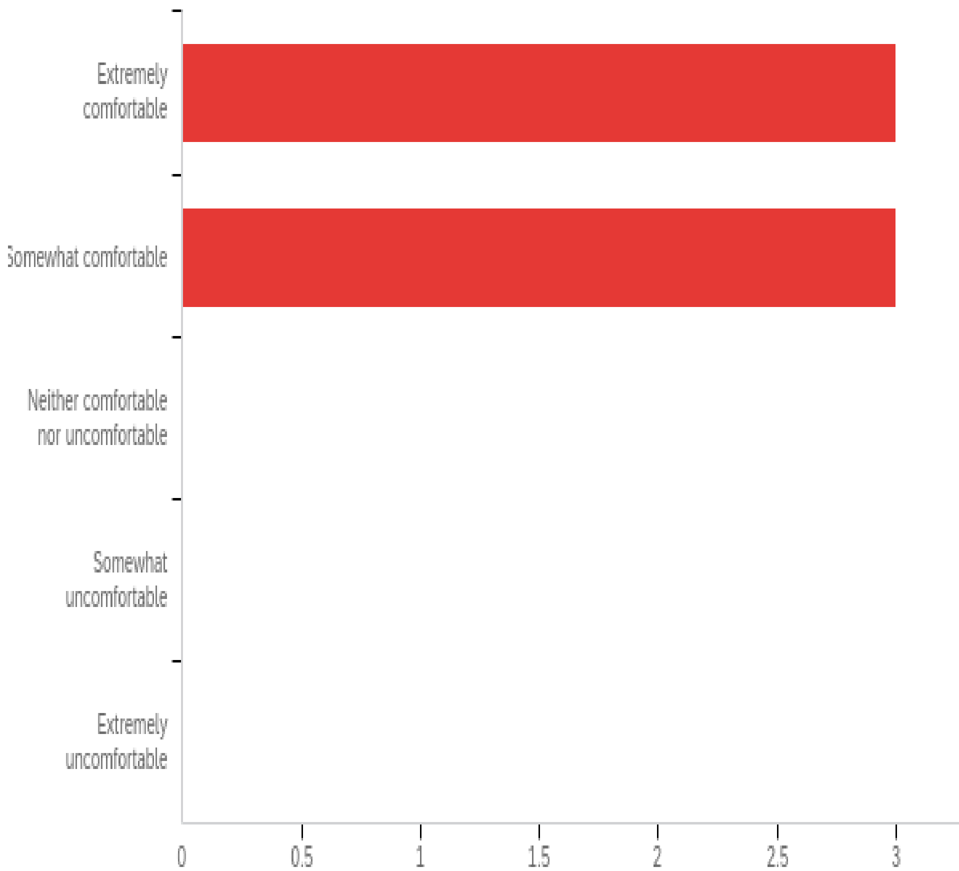
Table 17: How would you rate yourself in terms of using technology for teaching purpose (Instructor)- Statistical Analysis

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	How would you rate yourself in terms of using technology for teaching purpose?	1.00	2.00	1.50	0.50	0.25	6

Sources: Primary Data

Instructor Response

Chart 9: How would you rate yourself in terms of using technology for teaching purpose-Instructor



Sources: Primary Data

From the above table and chart, it can be inferred that among the instructor respondents, with respect to the level of comfort using technology for teaching purpose, 50% of them are extremely comfortable using technology and other 50% of them are somewhat comfortable using technology.

It is concluded that, the instructor respondents are neither extremely comfortable nor somewhat comfortable using technology for teaching purpose.

Student Response

Table 18: How frequently do you use the above-mentioned digital devices to do the following activities (Student)- Percentage Analysis

#	Question	Daily	No.	4-6 times a week	No.	2-3 times a week	No.	Once a week	No.	Never	No.	Total
1	To contact an instructor, student, and/or any individual within the WT system	69.57%	16	13.04%	3	8.70%	2	8.70%	2	0.00%	0	23
2	To complete course assignments and projects	73.91%	17	21.74%	5	4.35%	1	0.00%	0	0.00%	0	23
3	To collaborate with others students in the class	56.52%	13	13.04%	3	17.39%	4	8.70%	2	4.35%	1	23
4	To check the course postings in WTCLASS	82.61%	19	13.04%	3	4.35%	1	0.00%	0	0.00%	0	23
5	Others specify	57.14%	4	0.00%	0	14.29%	1	0.00%	0	28.57%	2	7

Sources: Primary Data

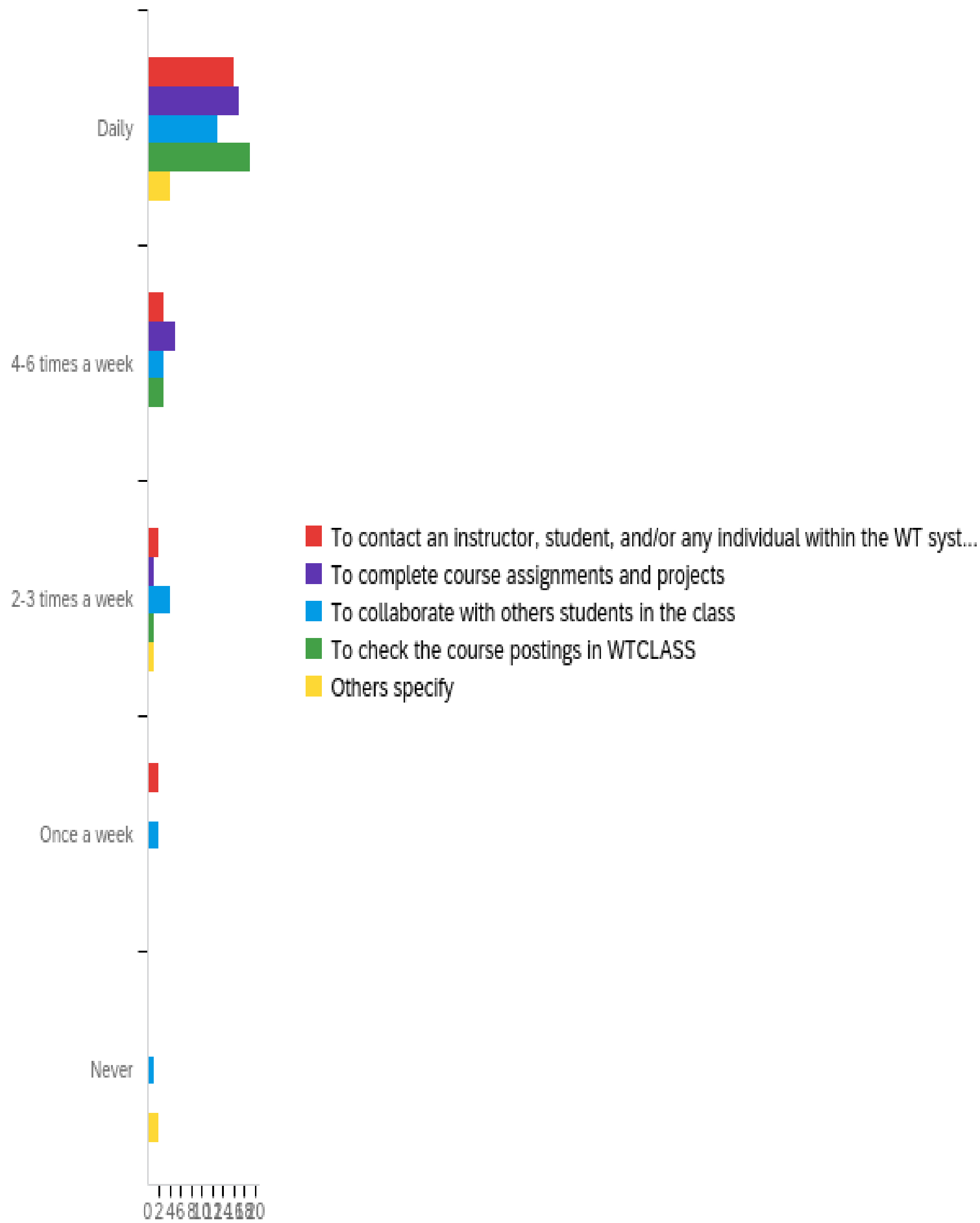
Table 19: How frequently do you use the above-mentioned digital devices to do the following activities (Student) - Statistical Analysis

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	To contact an instructor, student, and/or any individual within the WT system	1.00	4.00	1.57	0.97	0.94	23
2	To complete course assignments and projects	1.00	3.00	1.30	0.55	0.30	23
3	To collaborate with others students in the class	1.00	5.00	1.91	1.21	1.47	23
4	To check the course postings in WTCLASS	1.00	3.00	1.22	0.51	0.26	23
5	Others specify	1.00	5.00	2.43	1.76	3.10	7

Sources: Primary Data

Student Response

Chart 10: How frequently do you use the above-mentioned digital devices to do the following activities- Student



Sources: Primary Data

From the above table and chart it can be inferred that among the student respondents, with respect to how frequently they use digital device for educational purpose, 69.57 % of them use daily to contact an instructor, student, and/or any individual within the WT system, 73.91% of them use daily to complete course assignments and projects, 56.25% of them use daily to collaborate with others students in the class, and 82.61% of them use daily to check the course postings in WTCLASS.

It is concluded that, majority of the student respondents are using digital device to check the course postings in the WTCLASS.

Instructor Response

Table 20: Have you heard about Industry 4.0 (Instructor) - Percentage Analysis

#	Answer	%	Count
1	Yes	20.00%	1
2	Maybe	40.00%	2
3	No	40.00%	2
	Total	100%	5

Sources: Primary Data

Table 21: Have you heard about Industry 4.0(Instructor) - Statistical Analysis

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Have you heard about Industry 4.0?	1.00	3.00	2.20	0.75	0.56	5

Sources: Primary Data

Student Response

Table 22: Have you heard about Industry 4.0(Student) - Percentage Analysis

#	Answer	%	Count
1	Yes	6.25%	1
2	Maybe	6.25%	1
3	No	87.50%	14
	Total	100%	16

Sources: Primary Data

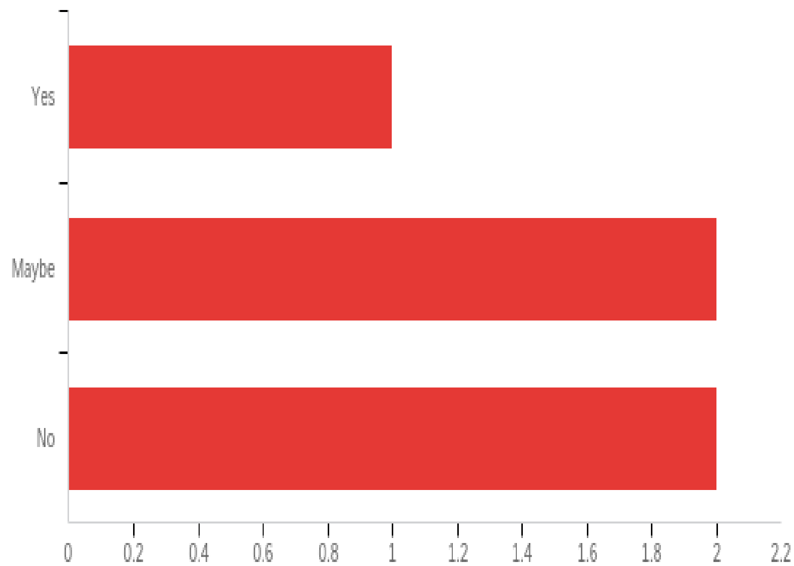
Table 23: Have you heard about Industry 4.0 (Student) - Statistical Analysis

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Have you heard about Industry 4.0?	1.00	3.00	2.81	0.53	0.28	16

Sources: Primary Data

Instructor Response

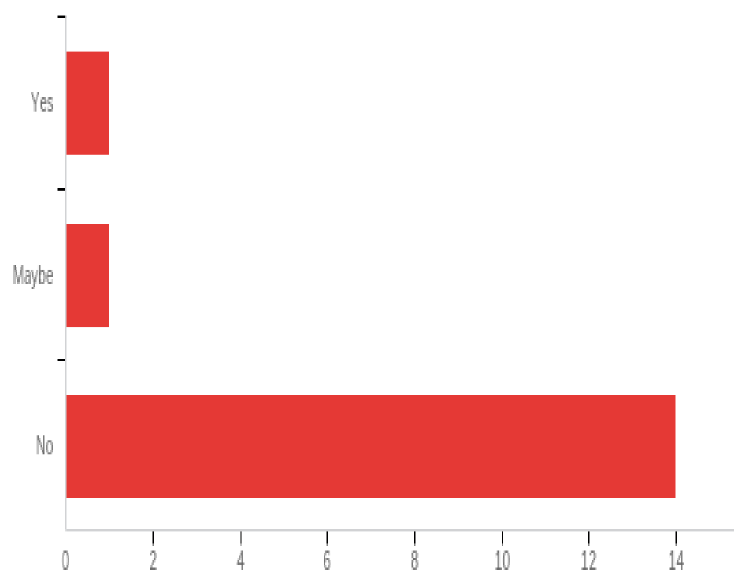
Chart 11: Have you heard about Industry 4.0 -Instructor



Sources: Primary Data

Student Response

Chart 12: Have you heard about Industry 4.0 -Student



Sources: Primary Data

From the above table and chart it can be inferred that among the instructor and student respondents, with respect to their exposure to industry 4.0 concepts, 20% of the instructors ahve heard about the Industry 4.0, 40% of the instructors have either heard little nor not heard about the industry 4.0, 6.2% of the students are either heard nor heard little about the industry 4.0 and 87.5% students are not heard about the industry 4.0.

It is concluded that, majority of the student respondents and insturctor respondents have not heard about the Industry 4.0 concepts.

Instructor Response

Table 24: To what extent the following Industry 4.0 pillars (topics/subject areas) get covered/included in the courses you teach? Please list the courses in the textbox provided below (Instructor) - Percentage Analysis

#	Question	Extremely well	#	2	#	3	#	4	#	Never covered this subject area in my courses	#	Total
1	Big Data	0.00%	0	20.00 %	1	0.00%	0	20.00 %	1	60.00%	3	5
2	Autonomous Robots	0.00%	0	0.00%	0	40.00 %	2	0.00%	0	60.00%	3	5
3	Simulation	20.00 %	1	60.00 %	3	0.00%	0	0.00%	0	20.00%	1	5
4	Universal System Integration	0.00%	0	20.00 %	1	0.00%	0	20.00 %	1	60.00%	3	5
5	Industrial IoT	20.00 %	1	20.00 %	1	20.00 %	1	0.00%	0	40.00%	2	5
6	Cybersecurity	0.00%	0	0.00%	0	0.00%	0	0.00%	0	100.00 %	5	5
7	Cloud Computing	0.00%	0	40.00 %	2	20.00 %	1	0.00%	0	40.00%	2	5
8	Additive Manufacturing	0.00%	0	40.00 %	2	0.00%	0	20.00 %	1	40.00%	2	5
9	Augmented Reality	0.00%	0	0.00%	0	0.00%	0	0.00%	0	100.00 %	5	5

Sources: Primary Data

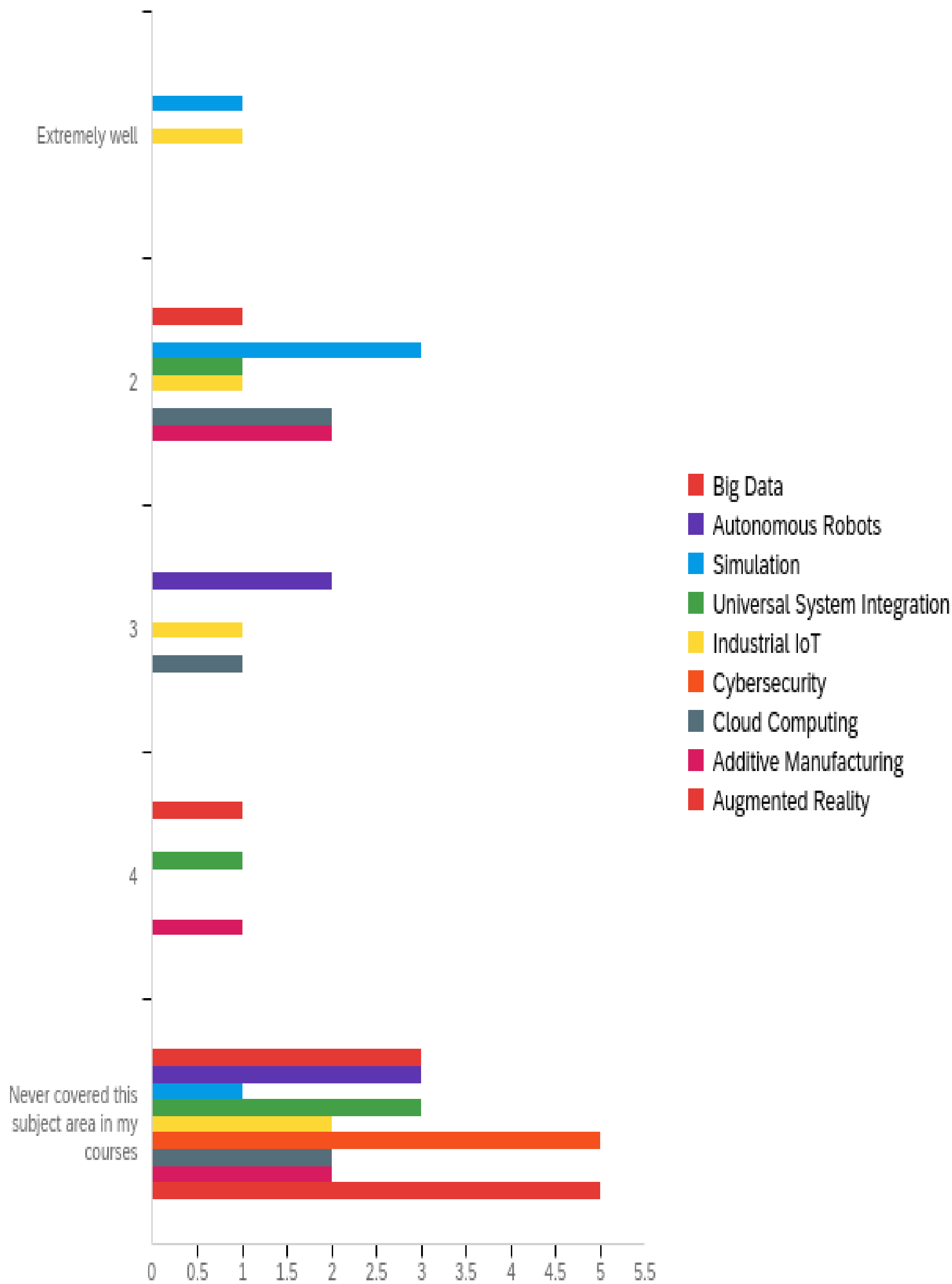
Table 25: To what extent the following Industry 4.0 pillars (topics/subject areas) get covered/included in the courses you teach? Please list the courses in the textbox provided below (Instructor) - Statistical Analysis

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Big Data	2.00	5.00	4.20	1.17	1.36	5
2	Autonomous Robots	3.00	5.00	4.20	0.98	0.96	5
3	Simulation	1.00	5.00	2.40	1.36	1.84	5
4	Universal System Integration	2.00	5.00	4.20	1.17	1.36	5
5	Industrial IoT	1.00	5.00	3.20	1.60	2.56	5
6	Cybersecurity	5.00	5.00	5.00	0.00	0.00	5
7	Cloud Computing	2.00	5.00	3.40	1.36	1.84	5
8	Additive Manufacturing	2.00	5.00	3.60	1.36	1.84	5
9	Augmented Reality	5.00	5.00	5.00	0.00	0.00	5

Sources: Primary Data

Instructor Response

Chart 13: To what extent the following Industry 4.0 pillars (topics/subject areas) get covered/included in the courses you teach? Please list the courses in the textbox provided below – Instructor



Sources: Primary Data

From the above table and chart it can be inferred that among the insturctor respondents with respect to what extent they may have used the industry 4.0 pillars on their subject area, instructors agree that the 9 pillars of the industry 4.0. namely, bigdata, autonomous robots, simulation, universalsystem integration, induatrial IoT, cybersecurity, cloud computing,additive manufacturing and augmented reality were used on a modreate level on their subject area / courses.

Student Response

Table 26: To what extent have you been exposed to the following Industry 4.0 pillars (topics) in your courses (Student) - Percentage Analysis

#	Question	Extremely well	#	2	#	3	#	4	#	I have not heard about this topic	#	Total
1	Big Data	0.00%	0	0.00%	0	18.75%	3	31.25%	5	50.00%	8	16
2	Autonomous Robots	0.00%	0	6.25%	1	18.75%	3	18.75%	3	56.25%	9	16
3	Simulation	0.00%	0	6.25%	1	12.50%	2	18.75%	3	62.50%	10	16
4	Universal System Integration	0.00%	0	0.00%	0	6.25%	1	25.00%	4	68.75%	11	16
5	Industrial IoT	0.00%	0	0.00%	0	6.25%	1	37.50%	6	56.25%	9	16
6	Cybersecurity	0.00%	0	18.75%	3	18.75%	3	12.50%	2	50.00%	8	16
7	Cloud Computing	0.00%	0	6.25%	1	12.50%	2	25.00%	4	56.25%	9	16
8	Additive Manufacturing	0.00%	0	0.00%	0	12.50%	2	18.75%	3	68.75%	11	16
9	Augmented Reality	0.00%	0	12.50%	2	6.25%	1	25.00%	4	56.25%	9	16

Sources: Primary Data

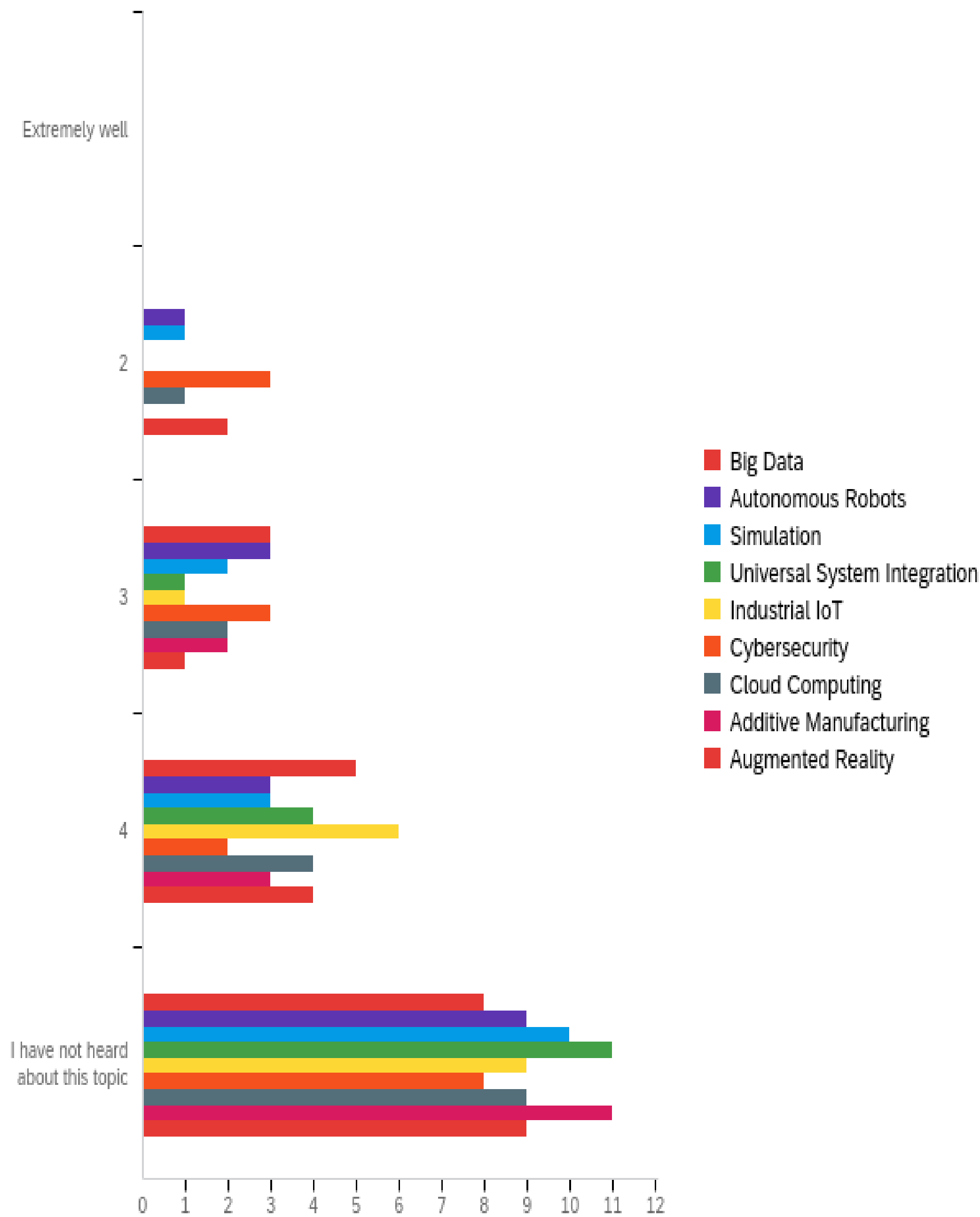
Table 27: To what extent have you been exposed to the following Industry 4.0 pillars (topics) in your courses (Student) - Statistical Analysis

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Big Data	3.00	5.00	4.31	0.77	0.59	16
2	Autonomous Robots	2.00	5.00	4.25	0.97	0.94	16
3	Simulation	2.00	5.00	4.38	0.93	0.86	16
4	Universal System Integration	3.00	5.00	4.63	0.60	0.36	16
5	Industrial IoT	3.00	5.00	4.50	0.61	0.38	16
6	Cybersecurity	2.00	5.00	3.94	1.20	1.43	16
7	Cloud Computing	2.00	5.00	4.31	0.92	0.84	16
8	Additive Manufacturing	3.00	5.00	4.56	0.70	0.50	16
9	Augmented Reality	2.00	5.00	4.25	1.03	1.06	16

Sources: Primary Data

Student Response

Chart 14: To what extent have you been exposed to the following Industry 4.0 pillars (topics) in your courses- Student



Sources: Primary Data

From the above table and chart it can be inferred that among the student respondents with respect to what extent they have been exposed to the Industry 4.0 pillars withing their courses, student respondensts agree that the 9 pillars of the Industry 4.0 namely, bigdata, autonomous robots, simulation, universalsystem integration, induatrial IoT, cybersecurity, cloud computing,additive manufacturing and augmented reality were used on a low modreate level within their courses.

Instructor Response

Table 28: Have you used any software tools that tie specific to the following Industry 4.0 pillars (topics) in your courses? If answered yes, please specify the software tools/technology used (Instructor) - Percentage Analysis

#	Question	Yes	#	No	#	Total
1	Big Data	0.00%	0	100.00%	5	5
2	Autonomous Robots	20.00%	1	80.00%	4	5
3	Simulation	60.00%	3	40.00%	2	5
4	Universal System Integration	0.00%	0	100.00%	5	5
5	Industrial IoT	40.00%	2	60.00%	3	5
6	Cybersecurity	0.00%	0	100.00%	5	5
7	Cloud Computing	20.00%	1	80.00%	4	5
8	Additive Manufacturing	20.00%	1	80.00%	4	5
9	Augmented Reality	0.00%	0	100.00%	5	5

Sources: Primary Data

Table 29: Have you used any software tools that tie specific to the following Industry 4.0 pillars (topics) in your courses? If answered yes, please specify the software tools/technology used (Instructor) - Statistical Analysis

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Big Data	2.00	2.00	2.00	0.00	0.00	5
2	Autonomous Robots	1.00	2.00	1.80	0.40	0.16	5
3	Simulation	1.00	2.00	1.40	0.49	0.24	5
4	Universal System Integration	2.00	2.00	2.00	0.00	0.00	5
5	Industrial IoT	1.00	2.00	1.60	0.49	0.24	5
6	Cybersecurity	2.00	2.00	2.00	0.00	0.00	5
7	Cloud Computing	1.00	2.00	1.80	0.40	0.16	5
8	Additive Manufacturing	1.00	2.00	1.80	0.40	0.16	5
9	Augmented Reality	2.00	2.00	2.00	0.00	0.00	5

Sources: Primary Data

Student Response

Table 30: Have you used any software tools that tie specific to the following Industry 4.0 pillars (topics) in your courses? If answered yes, please specify the software tools/technology used (Student) - Percentage Analysis

#	Question	Yes	#	No	#	Total
1	Big Data	6.25%	1	93.75%	15	16
2	Autonomous Robots	6.25%	1	93.75%	15	16
3	Simulation	18.75%	3	81.25%	13	16
4	Universal System Integration	0.00%	0	100.00%	16	16
5	Industrial IoT	0.00%	0	100.00%	16	16
6	Cybersecurity	25.00%	4	75.00%	12	16
7	Cloud Computing	6.25%	1	93.75%	15	16
8	Additive Manufacturing	0.00%	0	100.00%	16	16
9	Augmented Reality	0.00%	0	100.00%	16	16

Sources: Primary Data

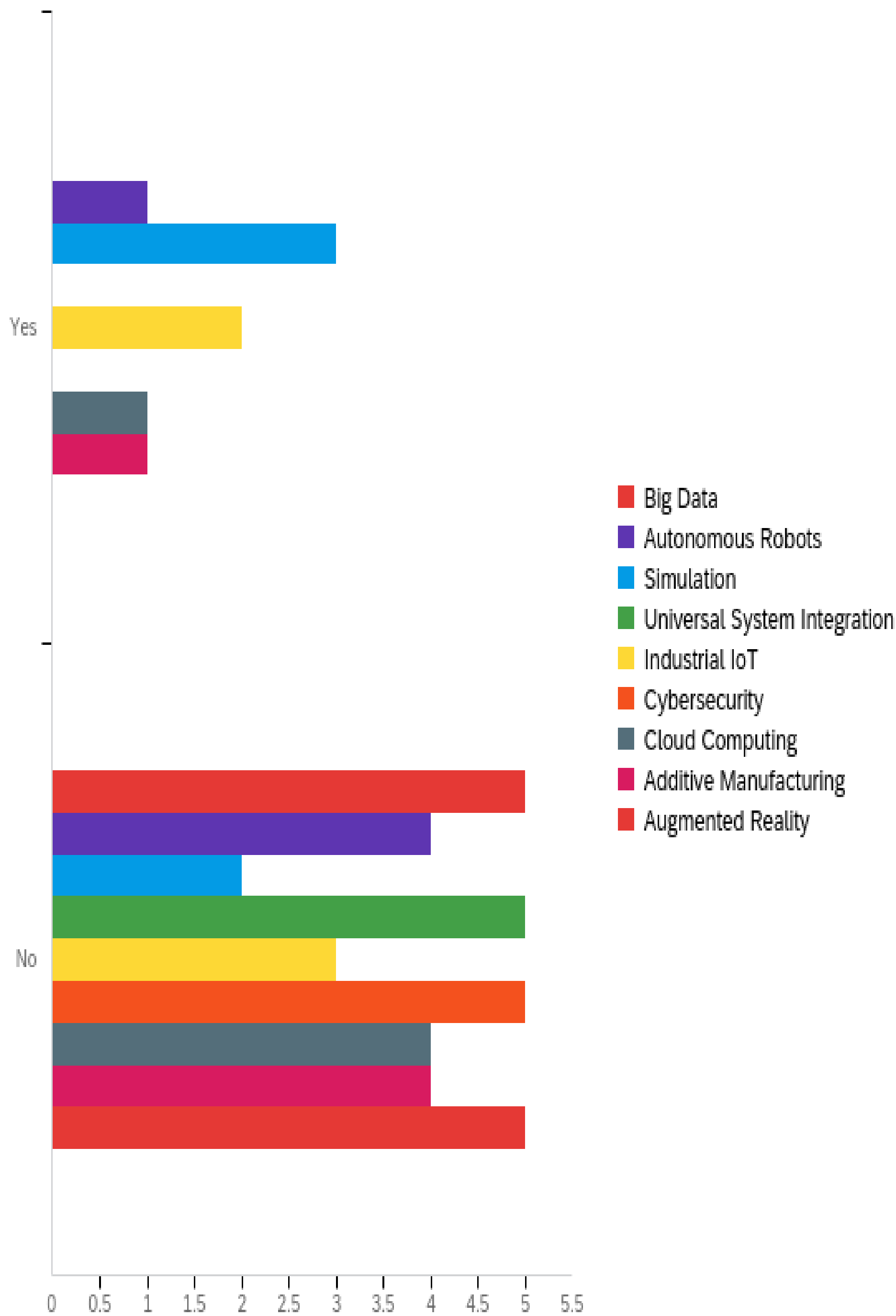
Table 31: Have you used any software tools that tie specific to the following Industry 4.0 pillars (topics) in your courses? If answered yes, please specify the software tools/technology used (Student) - Statistical Analysis

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Big Data	1.00	2.00	1.94	0.24	0.06	16
2	Autonomous Robots	1.00	2.00	1.94	0.24	0.06	16
3	Simulation	1.00	2.00	1.81	0.39	0.15	16
4	Universal System Integration	2.00	2.00	2.00	0.00	0.00	16
5	Industrial IoT	2.00	2.00	2.00	0.00	0.00	16
6	Cybersecurity	1.00	2.00	1.75	0.43	0.19	16
7	Cloud Computing	1.00	2.00	1.94	0.24	0.06	16
8	Additive Manufacturing	2.00	2.00	2.00	0.00	0.00	16
9	Augmented Reality	2.00	2.00	2.00	0.00	0.00	16

Sources: Primary Data

Instructor Response

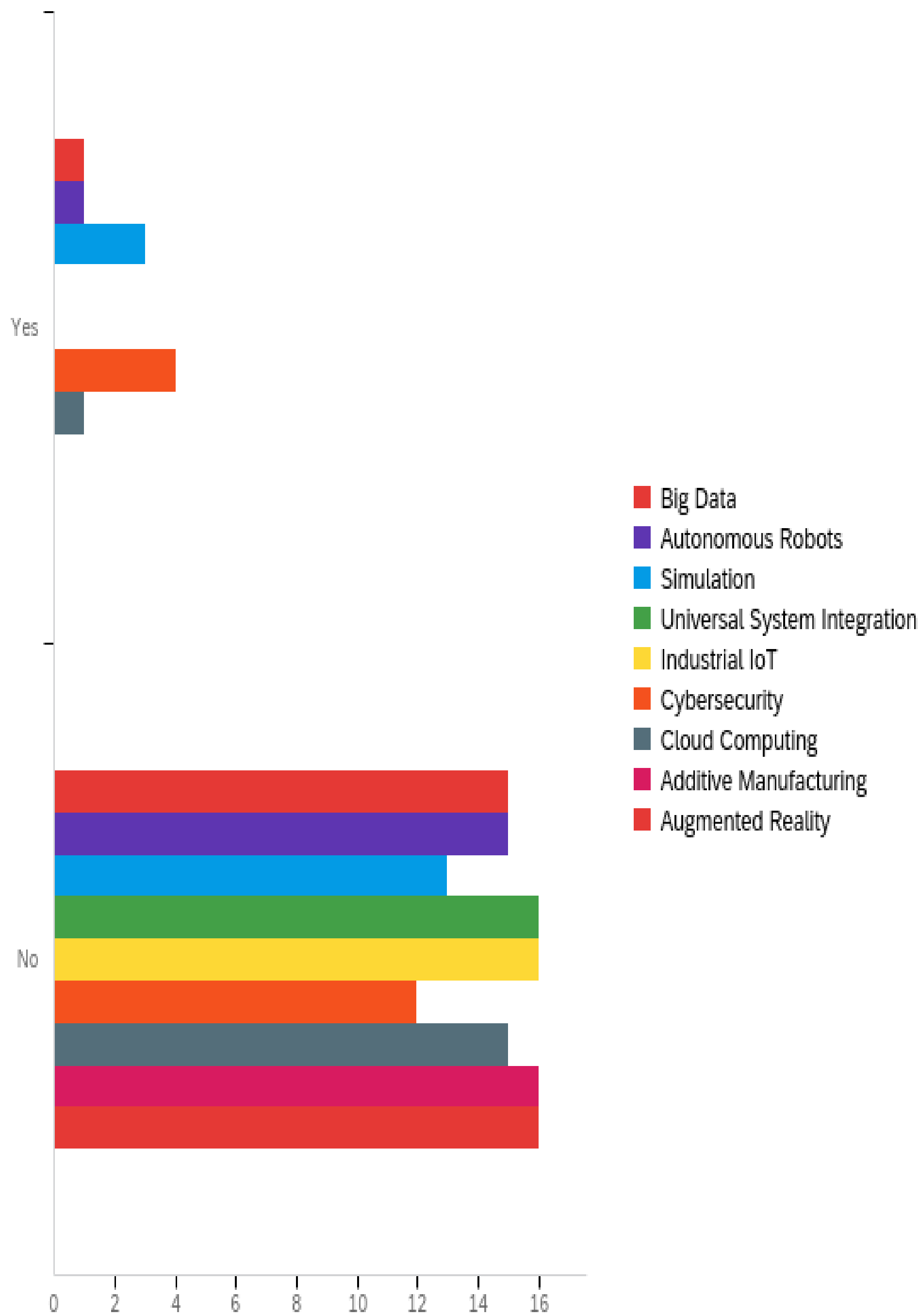
Chart 15: Have you used any software tools that tie specific to the following Industry 4.0 pillars (topics) in your courses? If answered yes, please specify the software tools/technology used- Instructor



Sources: Primary Data

Student Response

Chart 16: Have you used any software tools that tie specific to the following Industry 4.0 pillars (topics) in your courses? If answered yes, please specify the software tools/technology used- Student



Sources: Primary Data

From the above table and chart it can be inferred that among the insturctor and student respondents with regards to the usage of software tools that tie specific to the Industry 4.0 pillars within their course, both instructors and students agree that the software tools were used at a moderate level when it came to simulations, on the otherhand no software tools were used with regards to the following industry 4.0 pillars: bigdata, autonomous robots, universalsystem integration, induatrial IoT, cybersecurity, cloud computing,additive manufacturing, and augmented reality.

Instructor Response

Table 32: Have you involved students on any collaborative project development that tie specific to the following Industry 4.0 pillars (topics) in your courses? If answered yes, please specify the project title and course name (Instructor) -Percentage Analysis

#	Question	Yes	#	No	#	Total
1	Big Data	20.00%	1	80.00%	4	5
2	Autonomous Robots	20.00%	1	80.00%	4	5
3	Simulation	80.00%	4	20.00%	1	5
4	Universal System Integration	0.00%	0	100.00%	5	5
5	Industrial IoT	60.00%	3	40.00%	2	5
6	Cybersecurity	0.00%	0	100.00%	5	5
7	Cloud Computing	40.00%	2	60.00%	3	5
8	Additive Manufacturing	40.00%	2	60.00%	3	5
9	Augmented Reality	0.00%	0	100.00%	5	5

Sources: Primary Data

Table 33: Have you involved students on any collaborative project development that tie specific to the following Industry 4.0 pillars (topics) in your courses? If answered yes, please specify the project title and course name (Instructor) - Statistical Analysis

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Big Data	1.00	2.00	1.80	0.40	0.16	5
2	Autonomous Robots	1.00	2.00	1.80	0.40	0.16	5
3	Simulation	1.00	2.00	1.20	0.40	0.16	5
4	Universal System Integration	2.00	2.00	2.00	0.00	0.00	5
5	Industrial IoT	1.00	2.00	1.40	0.49	0.24	5
6	Cybersecurity	2.00	2.00	2.00	0.00	0.00	5
7	Cloud Computing	1.00	2.00	1.60	0.49	0.24	5
8	Additive Manufacturing	1.00	2.00	1.60	0.49	0.24	5
9	Augmented Reality	2.00	2.00	2.00	0.00	0.00	5

Sources: Primary Data

Student Response

Table 34: Have you involved students on any collaborative project development that tie specific to the following Industry 4.0 pillars (topics) in your courses? If answered yes, please specify the project title and course name (Student) - Percentage Analysis

#	Question	Yes		No		Total
1	Big Data	6.25%	1	93.75%	15	16
2	Autonomous Robots	6.67%	1	93.33%	14	15
3	Simulation	12.50%	2	87.50%	14	16
4	Universal System Integration	0.00%	0	100.00%	16	16
5	Industrial IoT	0.00%	0	100.00%	16	16
6	Cybersecurity	12.50%	2	87.50%	14	16
7	Cloud Computing	0.00%	0	100.00%	15	15
8	Additive Manufacturing	0.00%	0	100.00%	16	16
9	Augmented Reality	0.00%	0	100.00%	16	16

Sources: Primary Data

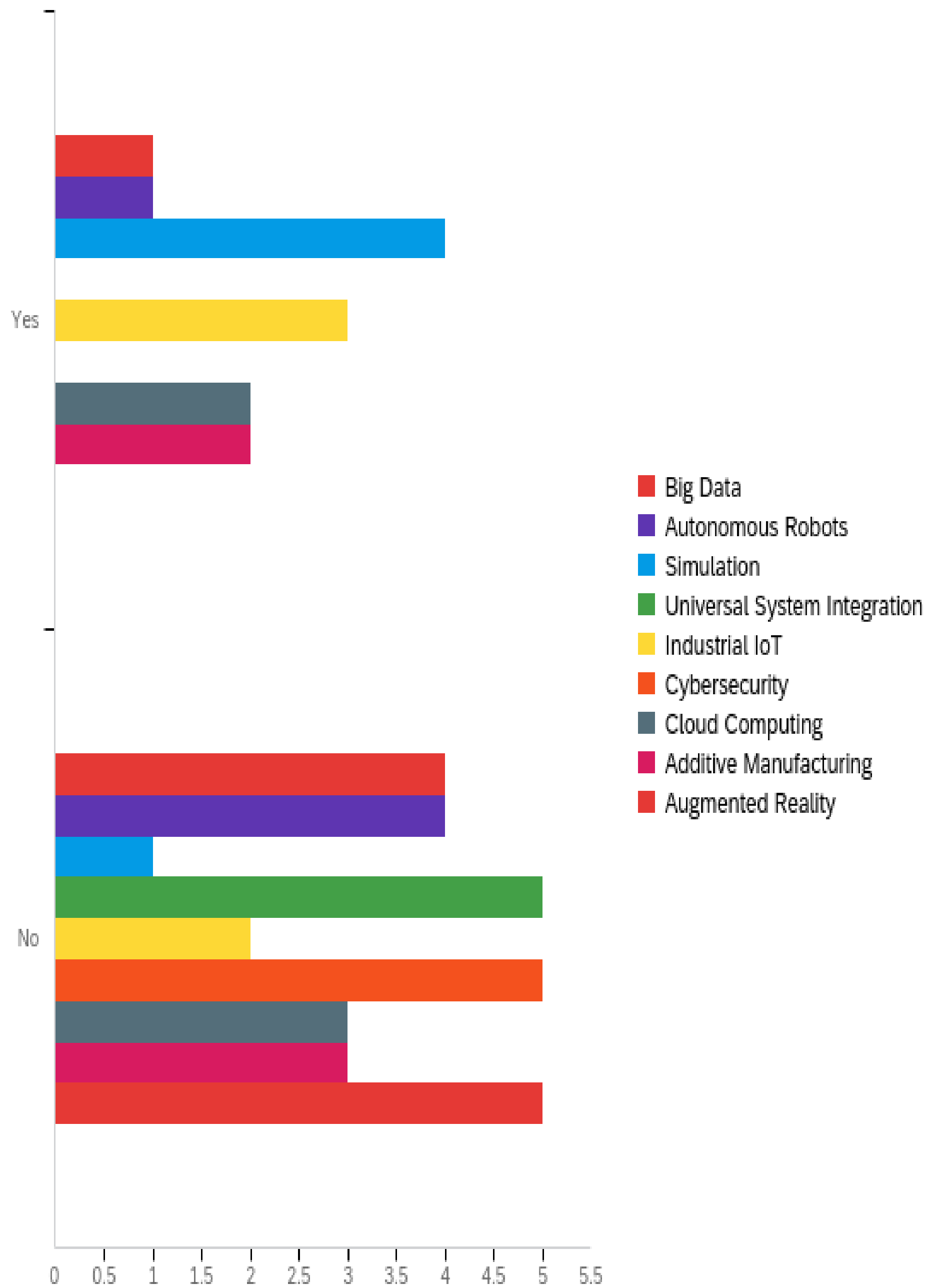
Table 35: Have you involved students on any collaborative project development that tie specific to the following Industry 4.0 pillars (topics) in your courses? If answered yes, please specify the project title and course name (Student) - Statistical Analysis

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Big Data	1.00	2.00	1.94	0.24	0.06	16
2	Autonomous Robots	1.00	2.00	1.93	0.25	0.06	15
3	Simulation	1.00	2.00	1.88	0.33	0.11	16
4	Universal System Integration	2.00	2.00	2.00	0.00	0.00	16
5	Industrial IoT	2.00	2.00	2.00	0.00	0.00	16
6	Cybersecurity	1.00	2.00	1.88	0.33	0.11	16
7	Cloud Computing	2.00	2.00	2.00	0.00	0.00	15
8	Additive Manufacturing	2.00	2.00	2.00	0.00	0.00	16
9	Augmented Reality	2.00	2.00	2.00	0.00	0.00	16

Sources: Primary Data

Instructor Response

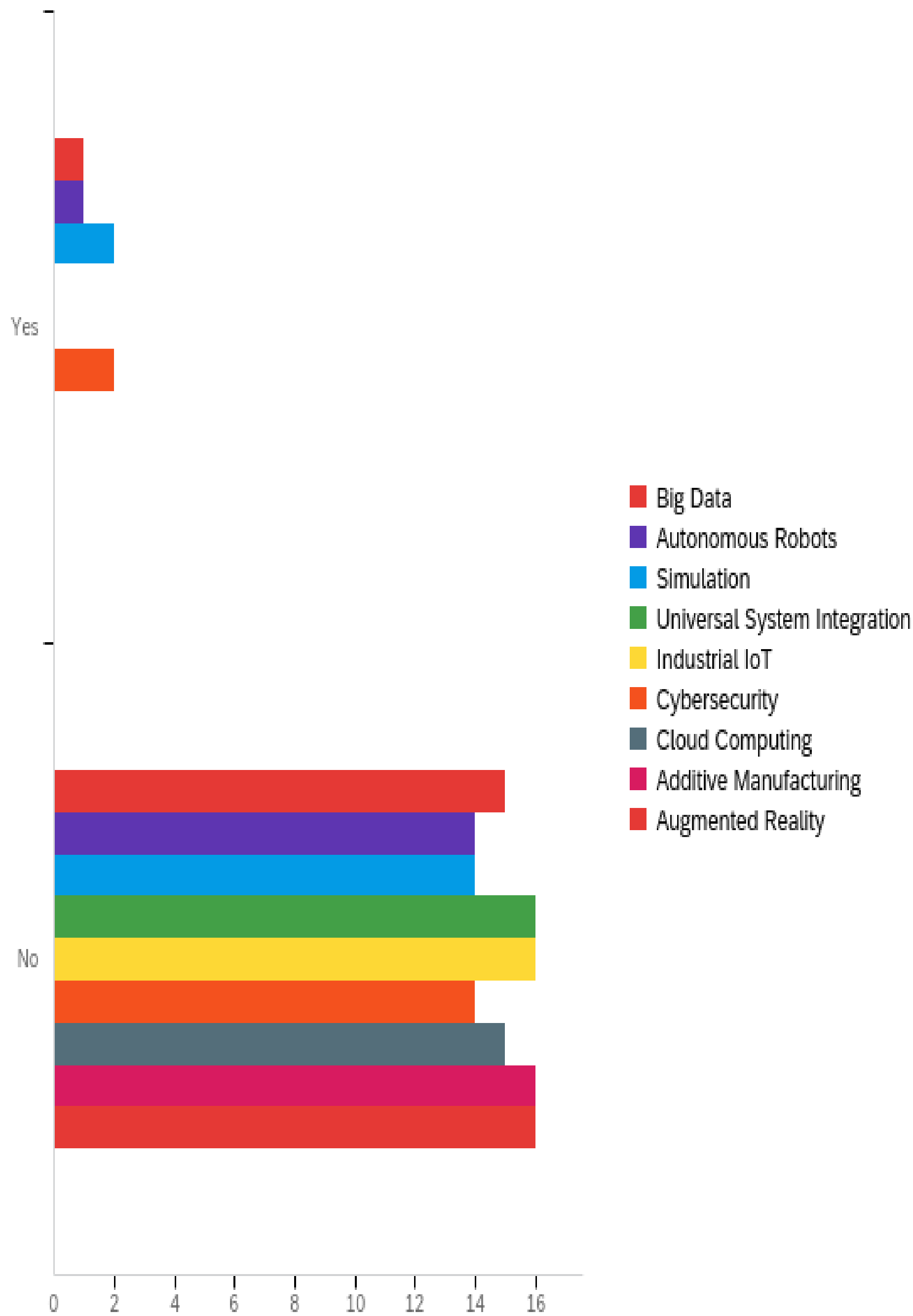
chart 17: Have you involved students on any collaborative project development that tie specific to the following Industry 4.0 pillars (topics) in your courses. If answered yes, please specify the project title and course name- Instructor



Sources: Primary Data

Student Response

Chart 18: Have you involved students on any collaborative project development that tie specific to the following Industry 4.0 pillars (topics) in your courses. If answered yes, please specify the project title and course name- Student



Sources: Primary Data

From the above table and chart it can be inferred that among the insturctor and student respondents, with respect to collobrative project development that tie specific to the Industry 4.0 pillars within their course, insturctor repondents felt that they have used the following Industry 4.0 pillars on some what moderate level within their courses, namely big data, autonomous robots, simulations, induatrial IoT, cloud computing and additive manufacturing. On the other hand, they have not used the following industry 4.0 pillars namely universal system integration, cybersecurity and augmented reality.

The student repondents says they have used the Industry 4.0 pillars namely big data, autonomous robots, simulations and cyber security on some what moderate level within the courses, On the other hand, they have not used the Industry 4.0 pillars namely universal system integration, induatrial IoT, cloud computing, additive manufacturing and augmented reality.

Instructor Response

Table 36: Mention the name of the software tool used in the textbox provided below each category. Also, select the level to which you have used the software tool in your courses (Instructor) – percentage Analysis

#	Question	Have not used any software tool	#	Used them for a specific assignment/project in my course(s)	#	Used them throughout the coursework	#	Total
1	System modeling	60.00%	3	0.00%	0	40.00%	2	5
2	Simulation	50.00%	2	25.00%	1	25.00%	1	4
3	Visualization	50.00%	2	25.00%	1	25.00%	1	4
4	Project planning	75.00%	3	25.00%	1	0.00%	0	4
5	Quality control	100.00%	4	0.00%	0	0.00%	0	4
6	System design	75.00%	3	25.00%	1	0.00%	0	4
7	System testing	75.00%	3	25.00%	1	0.00%	0	4
8	Creation of prototypes	80.00%	4	20.00%	1	0.00%	0	5
9	Project scheduling	100.00%	4	0.00%	0	0.00%	0	4
10	Manufacturing	75.00%	3	25.00%	1	0.00%	0	4
11	System development	100.00%	4	0.00%	0	0.00%	0	4
12	Optimization	75.00%	3	25.00%	1	0.00%	0	4
13	System optimization	75.00%	3	25.00%	1	0.00%	0	4
14	Documentation	25.00%	1	50.00%	2	25.00%	1	4
15	Others	100.00%	1	0.00%	0	0.00%	0	1

Sources: Primary Data

Student Response

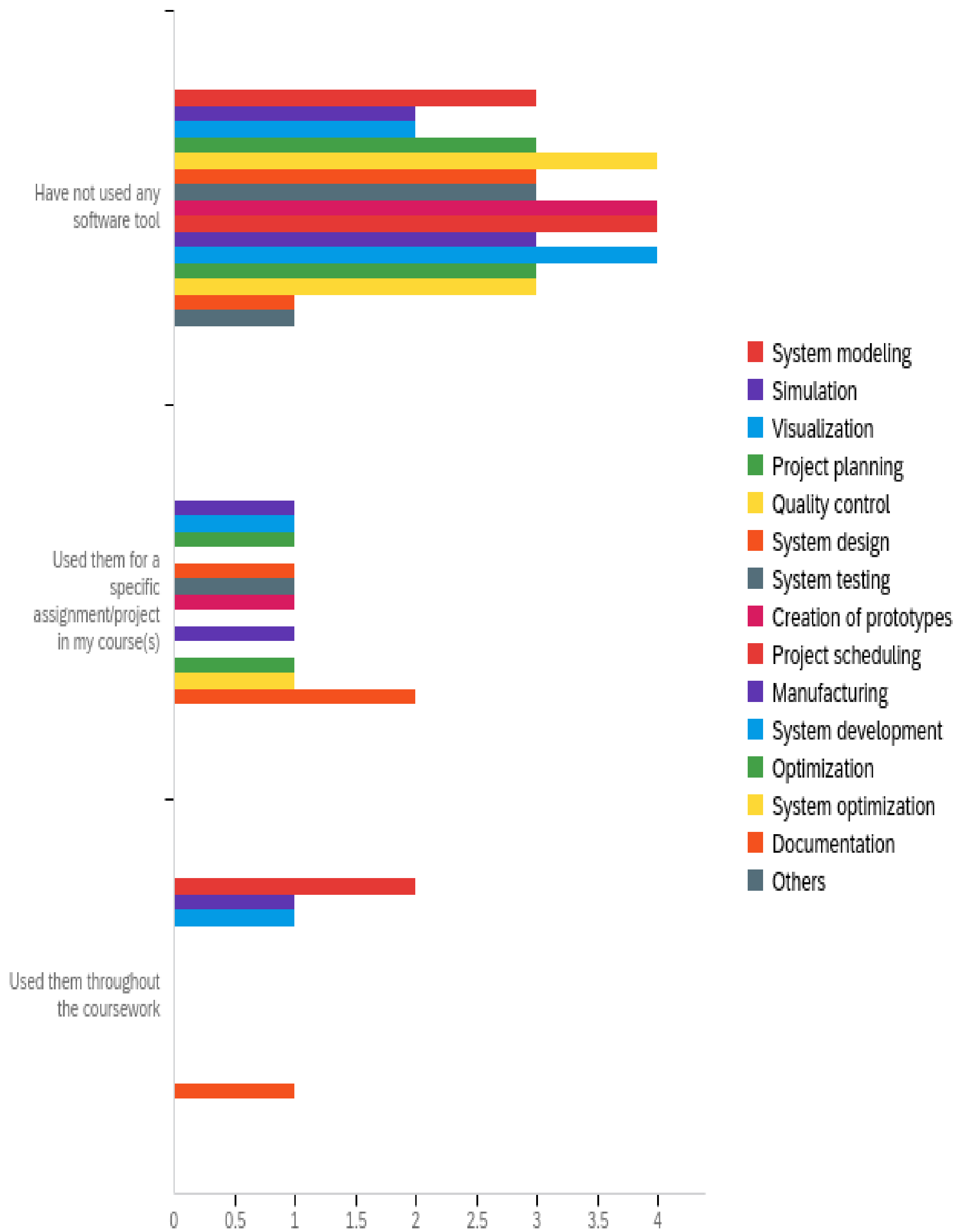
Table 37: Mention the name of the software tool used in the textbox provided below each category. Also, select the level to which you have used the software tool in your courses (Student) – percentage Analysis

#	Question	Have heard about them in at least one of my courses, but not used them	#	Used them for a specific assignment/project in my course(s)	#	Used them throughout the coursework	#	Have never heard about them or used them in any of my courses	#	Total
1	System modeling	25.00%	4	12.50%	2	0.00%	0	62.50%	10	16
2	Simulation	21.43%	3	21.43%	3	7.14%	1	50.00%	7	14
3	Visualization	14.29%	2	14.29%	2	21.43%	3	50.00%	7	14
4	Project planning	21.43%	3	7.14%	1	35.71%	5	35.71%	5	14
5	Quality control	14.29%	2	14.29%	2	0.00%	0	71.43%	10	14
6	System design	16.67%	2	25.00%	3	25.00%	3	33.33%	4	12
7	System testing	18.18%	2	18.18%	2	27.27%	3	36.36%	4	11
8	Creation of prototypes	18.18%	2	9.09%	1	27.27%	3	45.45%	5	11
9	Project scheduling	9.09%	1	9.09%	1	27.27%	3	54.55%	6	11
10	Manufacturing	36.36%	4	0.00%	0	0.00%	0	63.64%	7	11
11	System development	9.09%	1	27.27%	3	9.09%	1	54.55%	6	11
12	Optimization	18.18%	2	27.27%	3	9.09%	1	45.45%	5	11
13	System optimization	18.18%	2	18.18%	2	9.09%	1	54.55%	6	11
14	Documentation	18.18%	2	18.18%	2	54.55%	6	9.09%	1	11

Sources: Primary Data

Instructor Response

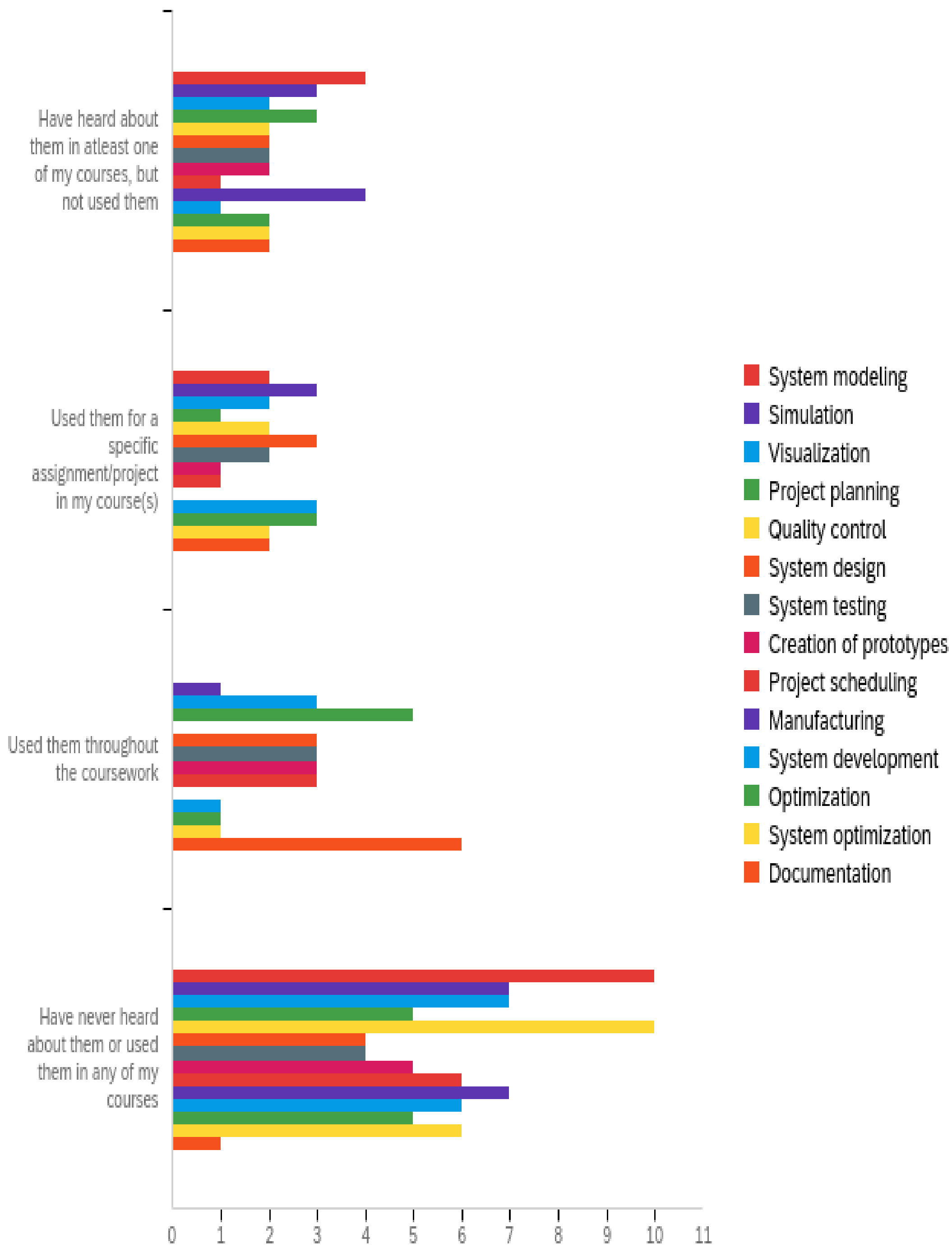
Chart 19: Mention the name of the software tool used in the textbox provided below each category. Also, select the level to which you have used the software tool in your courses- Instructor



Sources: Primary Data

Student Response

Chart 20: Mention the name of the software tool used in the textbox provided below each category. Also, select the level to which you have used the software tool in your courses-Student



Sources: Primary Data

From the above table and chart it can be inferred that the insturctor / Student respondents on the level of software tool that has been used in the courses. Insturctor repondents agree that they have used the following software tools such as system modeling, simulation, visualization,project planning, system design,system testing, creation of prototypes, project scheduling, manufacturing,optimization, system optimization and documentation on a modreate level on their course work. Where as the following software tools such as quality control, system development and project scheduling were not used in their course work.

The student repondents agree that they have used the following software tools such as system modeling, simulation, visualization,project planning, quality control, system design,system testing, creation of prototypes, manufacturing,optimization, system development, system optimization and documentation on a low modreate level on their course work.

Instructor Response

Table 38: How did the above specified software tools help you incorporate the Industry 4.0 skills into the coursework (instructor) - Percentage Analysis

#	Question	At least in one of my courses	#	Less than 10% of the courses I have taught so far	#	Between 10%and 50% of the courses I have taught so far	#	More than 50% of the courses I have taught so far	#	Total
1	I have involved students in interdisciplinary or multidisciplinary projects	40.00%	2	20.00%	1	20.00%	1	20.00%	1	5
2	I have involved students in team based projects	20.00%	1	20.00%	1	20.00%	1	40.00%	2	5
3	I have involved students in hands-on learning experience	20.00%	1	20.00%	1	20.00%	1	40.00%	2	5

Sources: Primary Data

Student Response

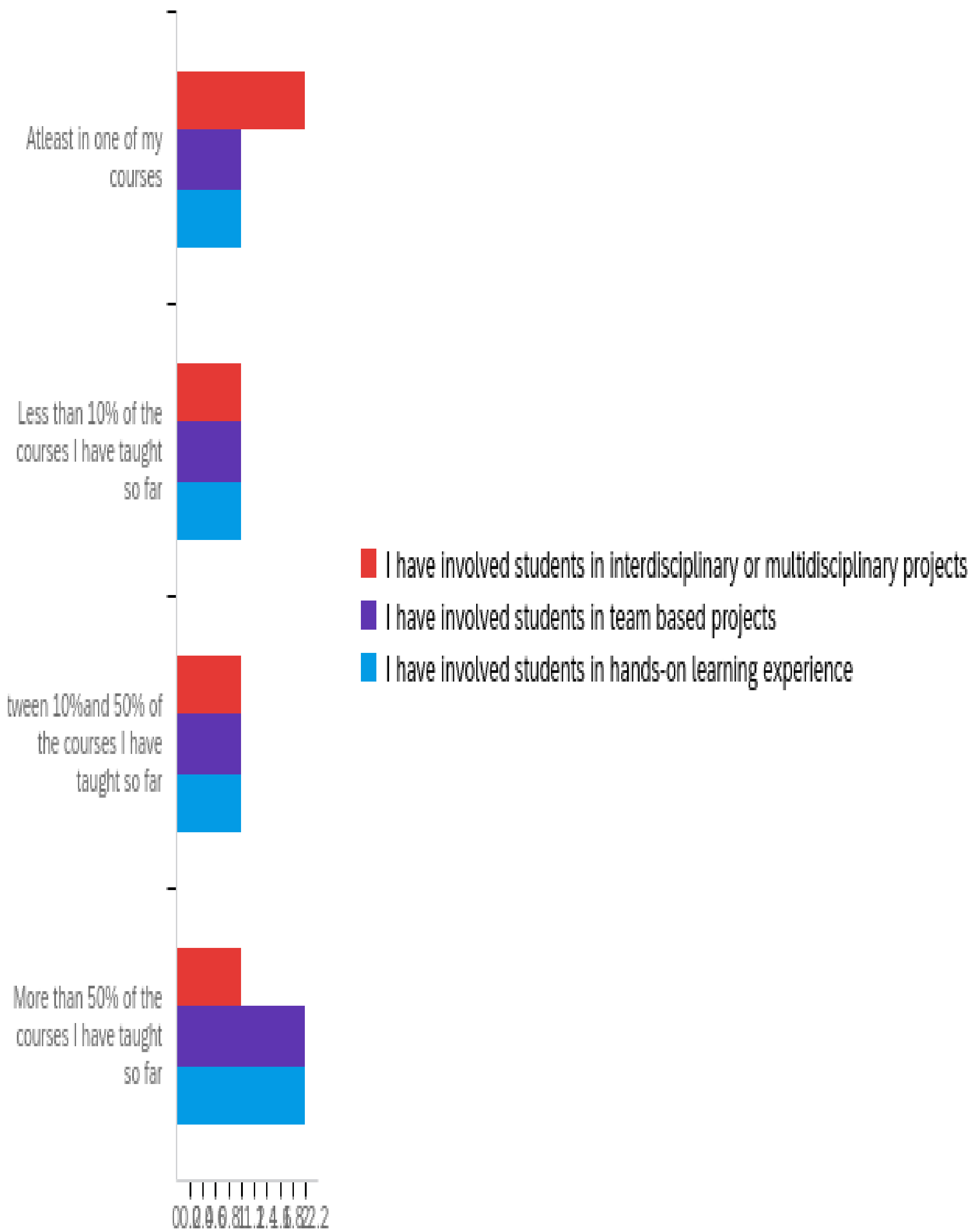
Table 39: How did the above specified software tools help you incorporate the Industry 4.0 skills into the coursework (Student) - Percentage Analysis

#	Question	At least in one of my courses	#	Less than 10% of the courses I have taken so far	#	Between 10%and 50% of the courses I have taken so far	#	More than 50% of the courses I have taken so far	#	Total
1	I have worked on interdisciplinary or multidisciplinary projects	46.67%	7	33.33%	5	20.00%	3	0.00%	0	15
2	I have worked on team based projects	13.33%	2	20.00%	3	33.33%	5	33.33%	5	15
3	I have had hands-on learning experience	13.33%	2	6.67%	1	40.00%	6	40.00%	6	15

Sources: Primary Data

Instructor Response

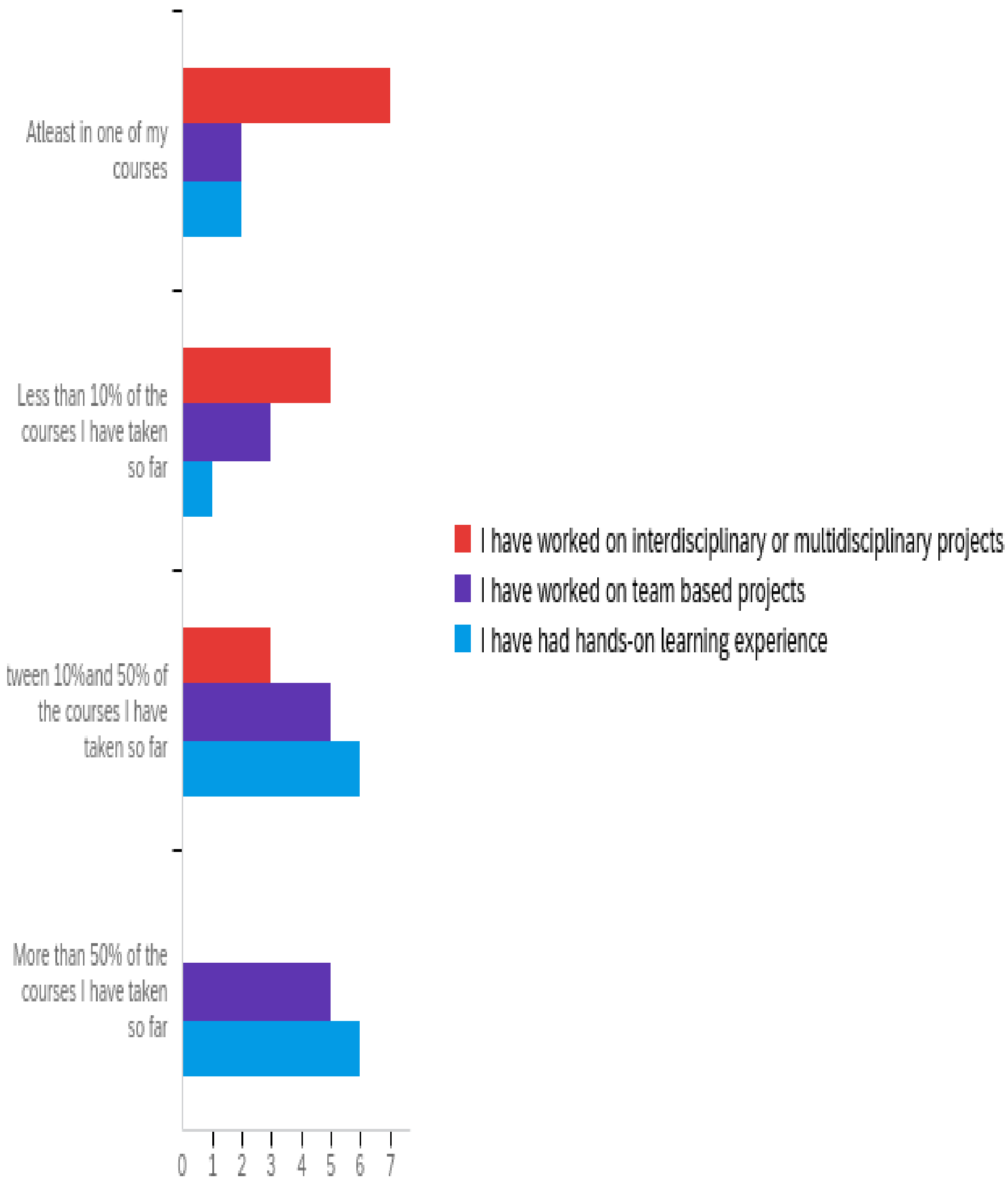
Chart 21: How did the above specified software tools help you incorporate the Industry 4.0 skills into the coursework- Instructor



Sources: Primary Data

Student Response

Chart 22: How did the above specified software tools help you incorporate the Industry 4.0 skills into the coursework- Student



Sources: Primary Data

From the above table and chart it can be inferred that among the insturctor respondents, with respect to spefic software tools that helped them to incorporate the industry 4.0 skills into their courses, insturctor repondents said that 40% of them used the software tool on interdisciplinary or multidisciplinary projects at least in one their courses, 40% of them used the software tools to encourage students to be involved in team based activities, and 40% of them used the software tools to encourage students to be involved in hands on learning experience.

The student respondents says that 46.67% of them used the software tool on interdisciplinary or multidisciplinary projects at least in one their courses, 33.3% of them say that software tool helped them to be involved in team based projects most them they have completed 50% the course at the time of suvey, and 40% of them say that the software tool helped them to be involved with hands on learning experience.

Instructor Response

Table 40: How well do you think the courses you have taken in your respective degree programs have prepared you with the following top rated soft skills that align closely with Industry 4.0 (Instructor) - Percentage Analysis

#	Question	Extremely competent	#	Some what competent	#	Neither competent nor incompetent	#	Some what incompetent	#	Extremely incompetent	#	Total
1	Complex problem solving	40.00%	2	40.00%	2	20.00%	1	0.00%	0	0.00%	0	5
2	Critical thinking	40.00%	2	60.00%	3	0.00%	0	0.00%	0	0.00%	0	5
3	Creativit y	40.00%	2	40.00%	2	20.00%	1	0.00%	0	0.00%	0	5
4	People manage ment	0.00%	0	40.00%	2	60.00%	3	0.00%	0	0.00%	0	5
5	Coordina ting with others	20.00%	1	80.00%	4	0.00%	0	0.00%	0	0.00%	0	5
6	Emotion al intelligen ce	0.00%	0	60.00%	3	40.00%	2	0.00%	0	0.00%	0	5
7	Judgmen t and decision-making	20.00%	1	60.00%	3	20.00%	1	0.00%	0	0.00%	0	5
8	Service orientati on	0.00%	0	80.00%	4	20.00%	1	0.00%	0	0.00%	0	5

Sources: Primary Data

Table 41: How well do you think the courses you have taken in your respective degree programs have prepared you with the following top rated soft skills that align closely with Industry 4.0(Instructor) - Statistical Analysis

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Complex problem solving	1.00	3.00	1.80	0.75	0.56	5
2	Critical thinking	1.00	2.00	1.60	0.49	0.24	5
3	Creativity	1.00	3.00	1.80	0.75	0.56	5
4	People management	2.00	3.00	2.60	0.49	0.24	5
5	Coordinating with others	1.00	2.00	1.80	0.40	0.16	5
6	Emotional intelligence	2.00	3.00	2.40	0.49	0.24	5
7	Judgment and decision-making	1.00	3.00	2.00	0.63	0.40	5
8	Service orientation	2.00	3.00	2.20	0.40	0.16	5

Sources: Primary Data

Student Response

Table 42: How well do you think the courses you have taken in your respective degree programs have prepared you with the following top rated soft skills that align closely with Industry 4.0 (Student) - Percentage Analysis

#	Question	Extremely competent	#	Some what competent	#	Neither competent nor incompetent	#	Some what incompetent	#	Extremely incompetent	#	Total
1	Complex problem solving	40.00%	6	33.33%	5	20.00 %	3	6.67%	1	0.00%	0	15
2	Critical thinking	40.00%	6	40.00%	6	20.00 %	3	0.00%	0	0.00%	0	15
3	Creativity	20.00%	3	66.67%	1 0	13.33 %	2	0.00%	0	0.00%	0	15
4	People management	13.33%	2	46.67%	7	33.33 %	5	6.67%	1	0.00%	0	15
5	Coordinating with others	20.00%	3	60.00%	9	20.00 %	3	0.00%	0	0.00%	0	15
6	Emotional intelligence	13.33%	2	46.67%	7	33.33 %	5	6.67%	1	0.00%	0	15
7	Judgment and decision-making	21.43%	3	57.14%	8	14.29 %	2	7.14%	1	0.00%	0	14
8	Service orientation	14.29%	2	35.71%	5	50.00 %	7	0.00%	0	0.00%	0	14

Sources: Primary Data

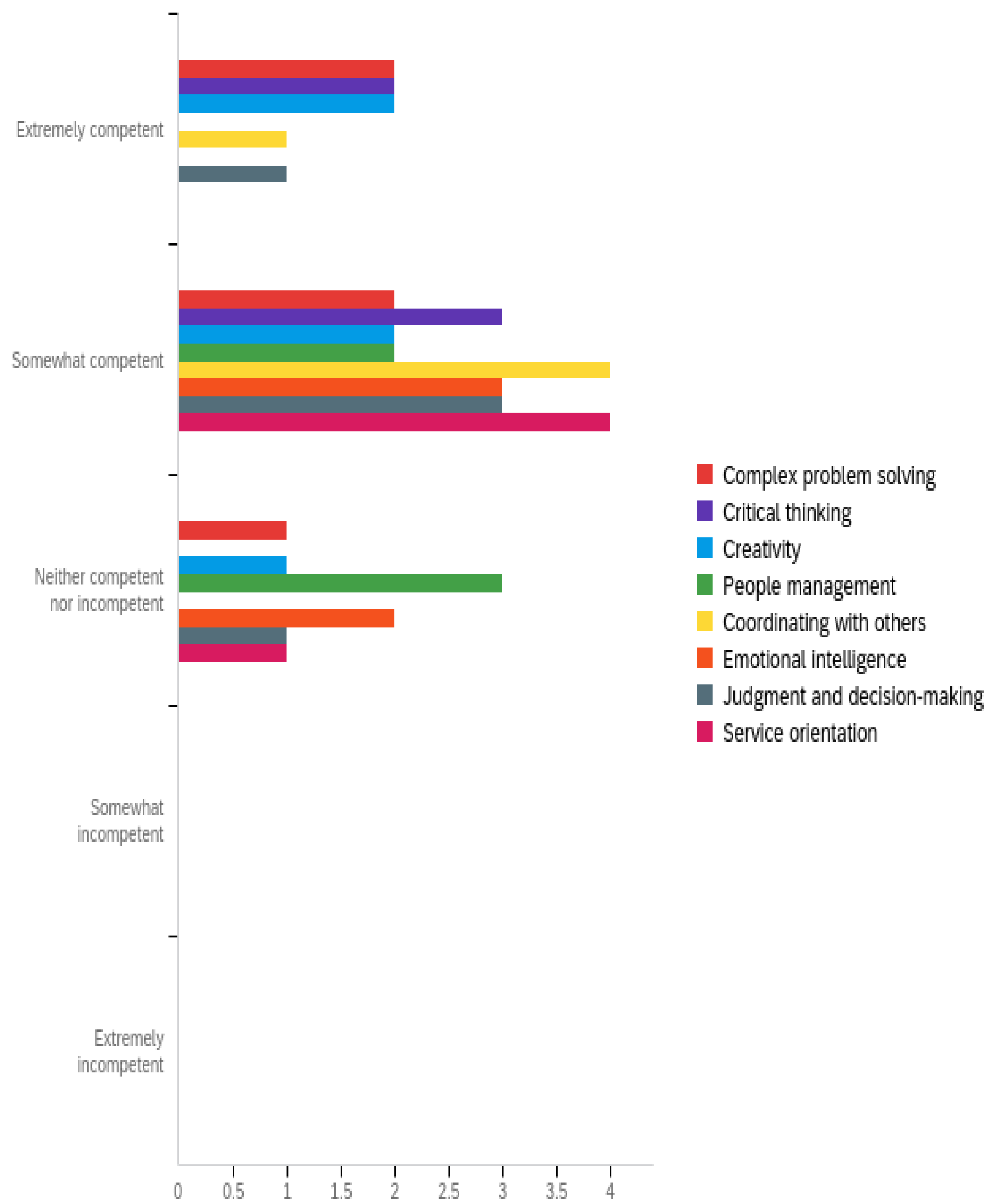
Table 43: How well do you think the courses you have taken in your respective degree programs have prepared you with the following top rated soft skills that align closely with Industry 4.0 (Student) - Statistical Analysis

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Complex problem solving	1.00	4.00	1.93	0.93	0.86	15
2	Critical thinking	1.00	3.00	1.80	0.75	0.56	15
3	Creativity	1.00	3.00	1.93	0.57	0.33	15
4	People management	1.00	4.00	2.33	0.79	0.62	15
5	Coordinating with others	1.00	3.00	2.00	0.63	0.40	15
6	Emotional intelligence	1.00	4.00	2.33	0.79	0.62	15
7	Judgment and decision-making	1.00	4.00	2.07	0.80	0.64	14
8	Service orientation	1.00	3.00	2.36	0.72	0.52	14

Sources: Primary Data

Instructor Response

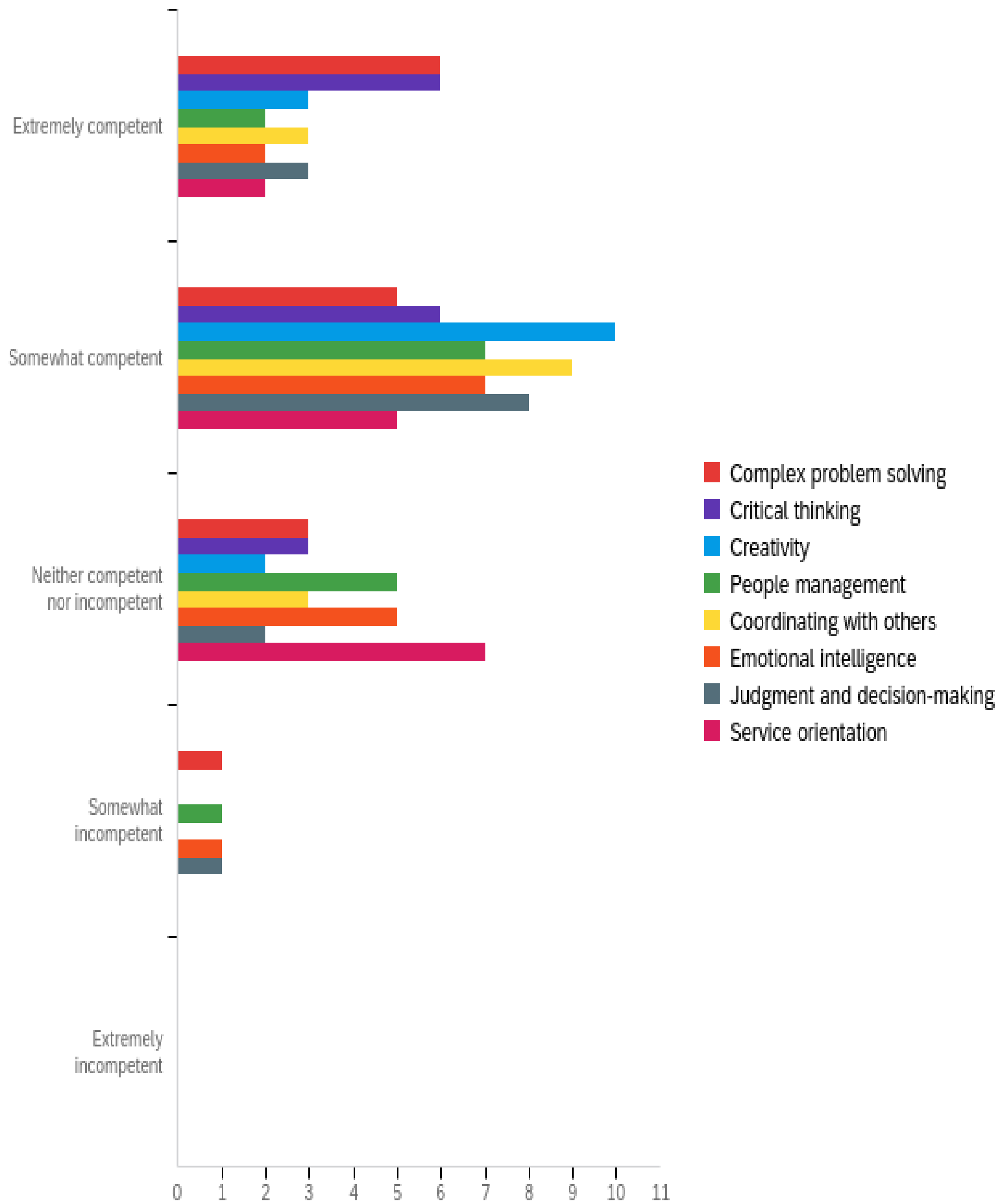
Chart 23: How well do you think the courses you have taken in your respective degree programs have prepared you with the following top rated soft skills that align closely with Industry 4.0- Instructor



Sources: Primary Data

Student Response

Chart 24: How well do you think the courses you have taken in your respective degree programs have prepared you with the following top rated soft skills that align closely with Industry 4.0- Student



Sources: Primary Data

From the above table and chart it can be inferred that, among the instructor and student respondents with respec to how well do they think the courses they have taken in their respetctive degree programm have prepard them with below top rated softskills that align closely with industry 4.0, both instructor and students repondents agree that they have used the following top rated skills on some what competent level within the courses they have taught or taken. The skills were complex problem solving, critical thinking, creativity, people mangement, coordinating with others, emotional intelligence,judgment and decision making and service orientation.

Instructor Response

Table 44: Have you encouraged students to use any software tools in particular to help them with collaborative project development? If yes, please specify (Instructor) - Percentage Analysis

#	Answer	%	Count
1	Yes	60.00%	3
2	No	40.00%	2
	Total	100%	5

Sources: Primary Data

Yes – Teams

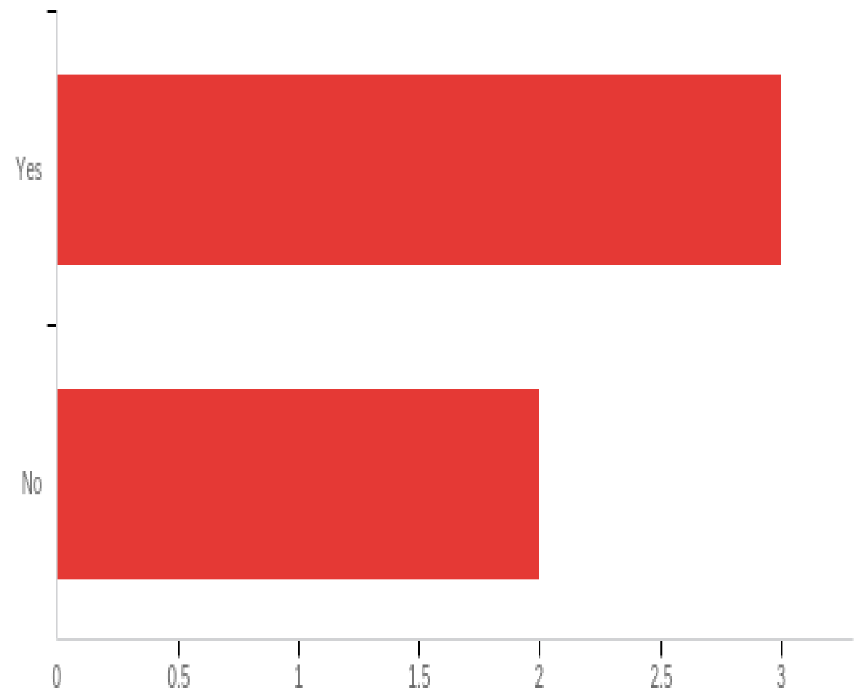
Table 45: Have you encouraged students to use any software tools in particular to help them with collaborative project development? If yes, please specify (Instructor) - Statistical Analysis

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Have you encouraged students to use any software tools in particular to help them with collaborative project development? If yes, please specify. - Selected Choice	1.00	2.00	1.40	0.49	0.24	5

Sources: Primary Data

Instructor Response

Chart 25: Have you encouraged students to use any software tools in particular to help them with collaborative project development? If yes, please specify- Instructor



Sources: Primary Data

From the above table and chart it can be inferred that among the instructor respondents with respect to how well they have encouraged their students to use any software tools in collabroative project development, 60% of them say that they have encouraged their students to use software tools in collabroative project development, 40% of them say they have not encouraged their students to use software tools in collabroative project development.

It is concluded that, majority of the insturctor respondents have encouraged their students to use software tools for collabroative project development.

Instructor Response

Table 46: Do you think we need to make changes to the existing curriculum in order to address the Industry 4.0 skills in our courses (Instructor)-Percentage Analysis

#	Answer	%	Count
1	Yes	60.00%	3
2	Maybe	40.00%	2
3	No	0.00%	0
	Total	100%	5

Sources: Primary Data

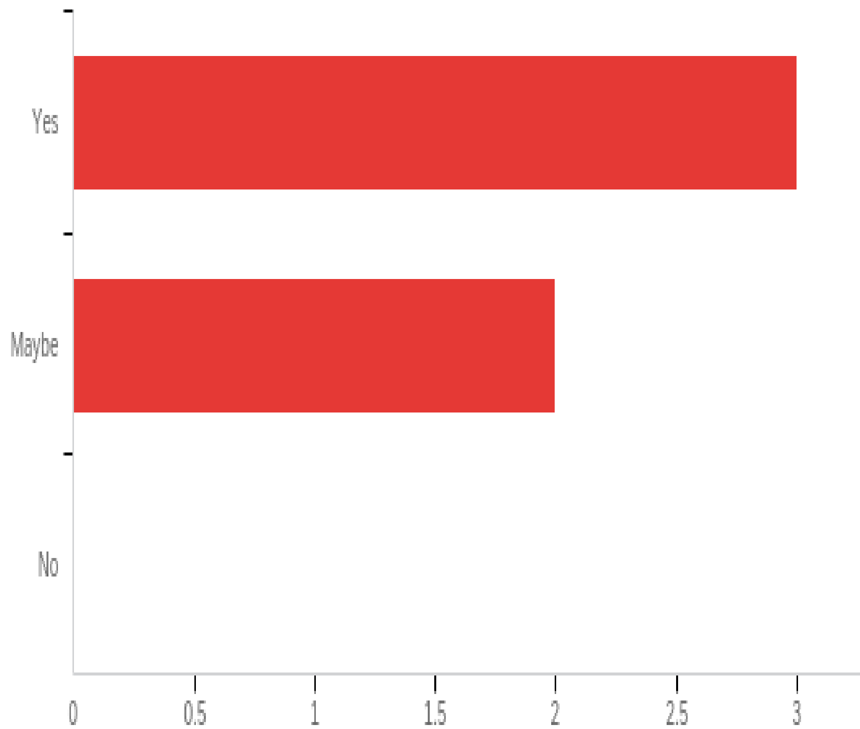
Table 47: Do you think we need to make changes to the existing curriculum in order to address the Industry 4.0 skills in our courses (Instructor) -Statistical Analysis

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Do you think we need to make changes to the existing curriculum in order to address the Industry 4.0 skills in our courses?	1.00	2.00	1.40	0.49	0.24	5

Sources: Primary Data

Instructor Response

Chart 26: Do you think we need to make changes to the existing curriculum in order to address the Industry 4.0 skills in our courses- Instructor



Sources: Primary Data

From the above table and chart it can be inferred among the instructor respondents, with respect to thoughts on changes that need to be made to the eixsting curriculm in order to address the Industry 4.0 skiils in their courses, 60% of them say they have to change the eixsting curriculm in order to address the industry 4.0 skiils in their courses, 40% of them say may be have to change the eixsting curriculm in order to address the Industry 4.0 skiils in their courses.

It is concluded that, majority of the insturctor respondents are in favor of making changes to the eixsting curriculm in order to address the Industry 4.0 skiils in their courses.

Instructor Response

Table 48: If you answered yes to the above question how significant will the changes have to be (Instructor) - Percentage Analysis

#	Answer	%	Count
1	Major	40.00%	2
2	Somewhere in-between	60.00%	3
3	Minor	0.00%	0
	Total	100%	5

Sources: Primary Data

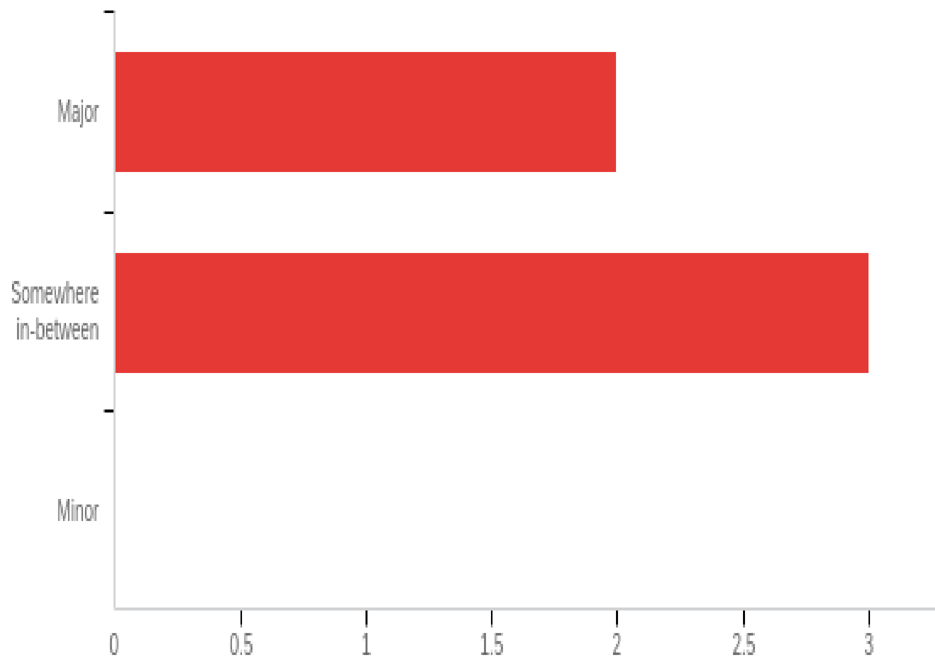
Table 49: If you answered yes to the above question how significant will the changes have to be (Instructor) - Statistical Analysis

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	If you answered yes to the above question how significant will the changes have to be?	1.00	2.00	1.60	0.49	0.24	5

Sources: Primary Data

Instructor Response

Chart 27: If you answered yes to the above question how significant will the changes have to be- Instructor



Sources: Primary Data

From the above table and chart it can be inferred that among the instructor respondents, with resepct to how significant will the changes have to be on their eixsting curriculm in order to address the Industry 4.0 skiils in their courses, 60% of them said some where in-between they need to change the eixsting curriculm in order to address the industry 4.0 skiils in their courses, 40% of them say that they need a major change with the eixsting curriculm in order to address the industry 4.0 skiils in their courses.

It is concluded that, majority of the insturctor respondents were somewhere in-between when it comes making significant changes to the eixsting curriculm in order to address the Industry 4.0 skiils in their courses.

Instructor Response

Table 50 :Are there any new software applications/technologies that you are considering on using in your courses in future that would fill the gap towards Industry 4.0?If yes/maybe, please specify the new applications/technologies that you are considering(Instructor)- Percentage analysis

#	Answer	%	Count
1	Yes	25.00%	1
2	Maybe	50.00%	2
3	No	25.00%	1
	Total	100%	4

Sources: Primary Data

Yes – MATLAB May be- Big data

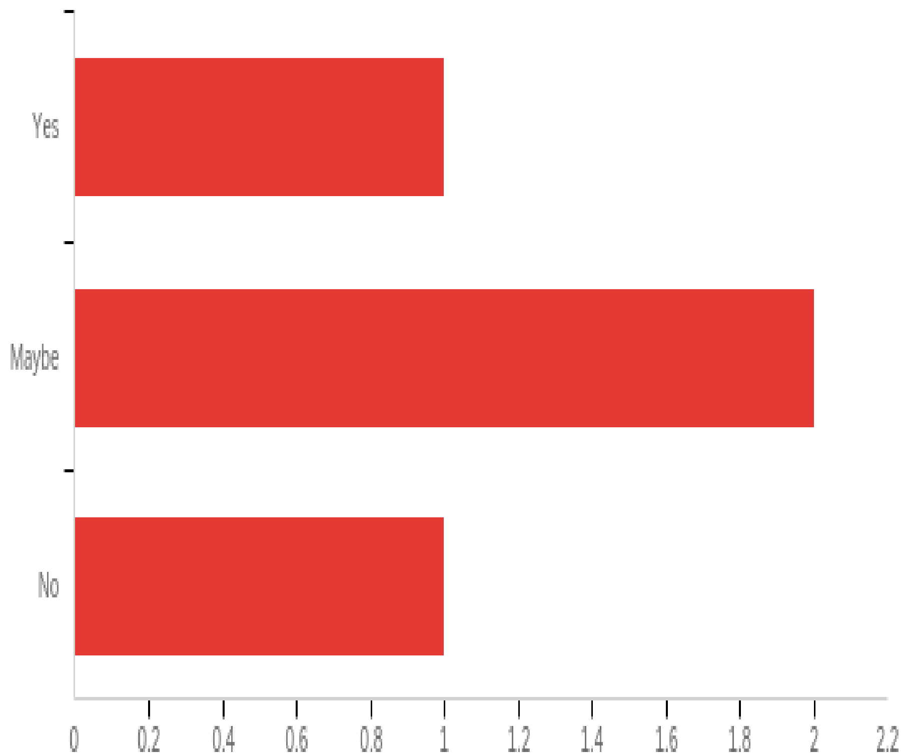
Table 51:Are there any new software applications/technologies that you are considering on using in your courses in future that would fill the gap towards Industry 4.0?If yes/maybe, please specify the new applications/technologies that you are considering (Instructor)- Statistical Analysis

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Are there any new software applications/technologies that you are considering on using in your courses in future that would fill the gap towards Industry 4.0?If yes/maybe, please specify the new applications/technologies that you are considering. - Selected Choice	1.00	3.00	2.00	0.71	0.50	4

Sources: Primary Data

Instructor Response

Chart 28: Are there any new software applications/technologies that you are considering on using in your courses in future that would fill the gap towards Industry 4.0?If yes/maybe, please specify the new applications/technologies that you are considering-Instructor



Sources: Primary Data

From the above table and chart it can be inferred that among the insturctor respondents, with respect to new software applications/ technologies that they considering on using their courses in future that would fill the gap towards industry 4.0 skill, 25% of them say they want for sure to use new software applications/ technologies that they considering on using their courses in future that would fill the gap towards industry 4.0 skill, 50 % of them say that they may be need to use new software applications/ technologies that they considering on using their courses in future that would fill the gap towards industry 4.0

skill, and 25 % of them say that they are not considering the use of new software applications/ technologies within their courses in future that would fill the gap towards industry 4.0 skill.

It is concluded that, majority of the insturctor respondents feel the need to use new software applications/ technologies within their courses in future that would fill the gap towards industry 4.0 skill.

Student Response

Table 52: Have you worked on collaborative project development or team-based project development in at least one of your courses (Student) - Percentage Analysis

#	Answer	%	Count
1	Yes	93.33%	14
2	No	6.67%	1
	Total	100%	15

Sources: Primary Data

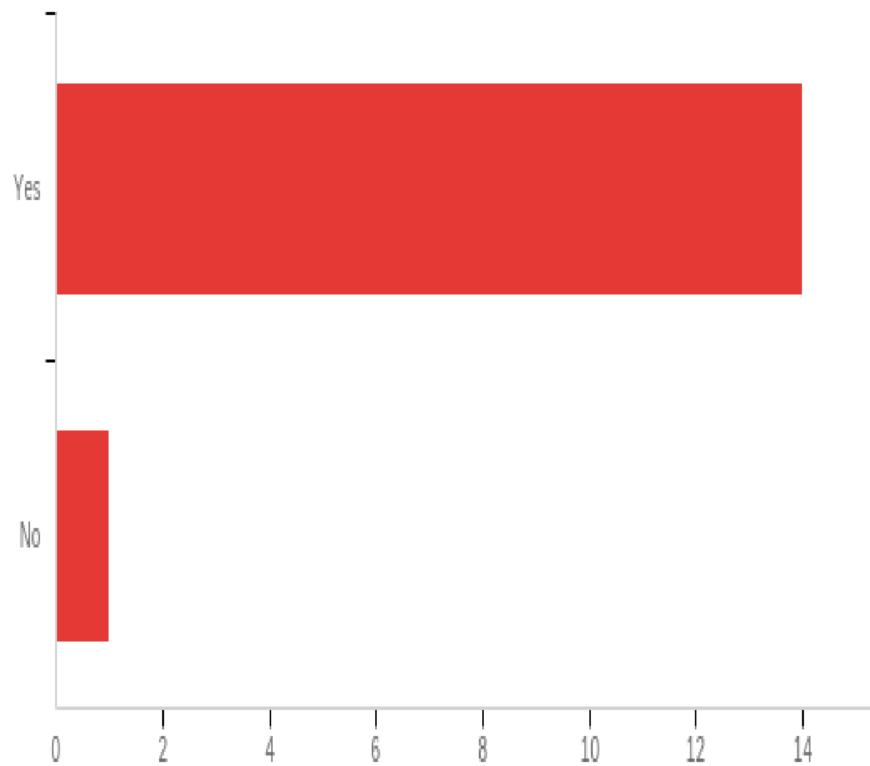
Table 53 : Have you worked on collaborative project development or team based project development in at least one of your courses(Student)- Statistical Analysis

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Have you worked on collaborative project development or team based project development in alteast one of your courses?	1.00	2.00	1.07	0.25	0.06	15

Sources: Primary Data

Student Response

Chart 29: Have you worked on collaborative project development or team based project development in at least one of your courses- Student



Sources: Primary Data

From the above table and chart it can be inferred that among the the student respondents with respect to percentage worked on collaborative project development or team based project development in at least one of their courses, 93.3 % of them says that they have worked on collaborative project development or team based project development in at least one of their courses and 6.7% of them have not worked on collaborative project development or team based project development in at least one of their courses.

It is concluded that, majority of the student respondents have worked on collaborative project development or team based project development in at least one of their courses.

Student Response

Table 54 : I have used the following communication apps to aid collaborative project development or team based project development (Student) - Percentage Analysis

#	Question	Always	#	Most of the time	#	About half the time	#	Sometimes	#	Never	#	Total
1	WTCLASS	33.33%	5	26.67%	4	13.33%	2	13.33%	2	13.33%	2	15
2	Microsoft Teams	6.67%	1	20.00%	3	6.67%	1	20.00%	3	46.67%	7	15
3	Slack	0.00%	0	0.00%	0	6.67%	1	20.00%	3	73.33%	11	15
4	Discord	20.00%	3	33.33%	5	6.67%	1	20.00%	3	20.00%	3	15
5	Join.me	0.00%	0	0.00%	0	0.00%	0	0.00%	0	100.00%	15	15
6	Skype	0.00%	0	0.00%	0	0.00%	0	13.33%	2	86.67%	13	15
7	Google Hangouts	0.00%	0	0.00%	0	7.14%	1	7.14%	1	85.71%	12	14
8	Zoom	26.67%	4	40.00%	6	6.67%	1	26.67%	4	0.00%	0	15
9	Others:	0.00%	0	12.50%	1	12.50%	1	0.00%	0	75.00%	6	8

Sources: Primary Data

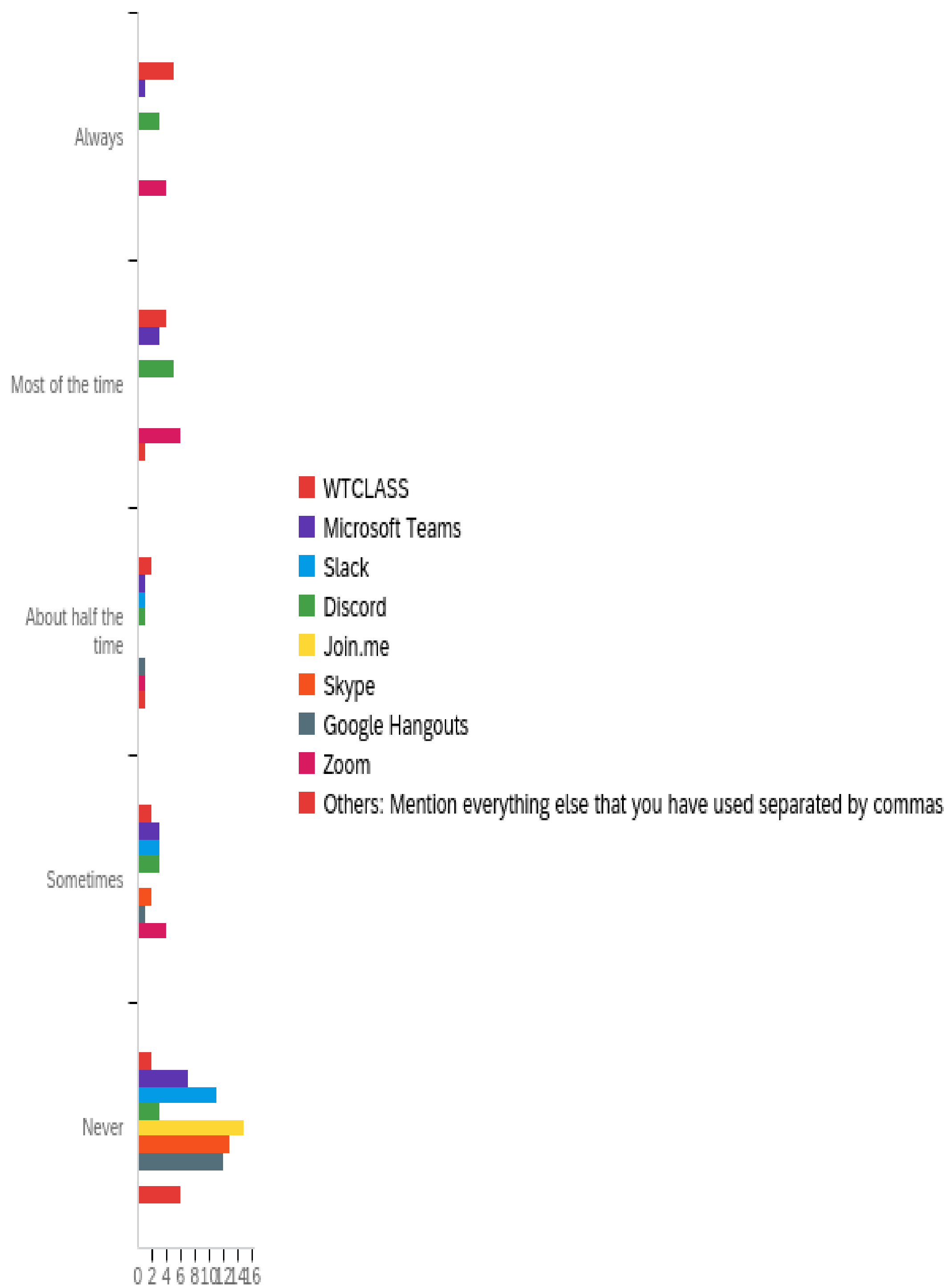
Table 55: I have used the following communication apps to aid collaborative project development or team based project development (Student) - Statistical Analysis

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	WTCLASS	1.00	5.00	2.47	1.41	1.98	15
2	Microsoft Teams	1.00	5.00	3.80	1.38	1.89	15
3	Slack	3.00	5.00	4.67	0.60	0.36	15
4	Discord	1.00	5.00	2.87	1.45	2.12	15
5	Join.me	5.00	5.00	5.00	0.00	0.00	15
6	Skype	4.00	5.00	4.87	0.34	0.12	15
7	Google Hangouts	3.00	5.00	4.79	0.56	0.31	14
8	Zoom	1.00	4.00	2.33	1.14	1.29	15
9	Others	2.00	5.00	4.38	1.11	1.23	8

Sources: Primary Data

Student Response

Chart 30: I have used the following communication apps to aid collaborative project development or team based project development- Student



Sources: Primary Data

From the above table and chart it can be inferred that among the student respondents with respect to the use of communication apps to aid collaborative project development or team based project development, they have used the following communication apps frequently to aid collaborative project development or team based project development: WT class, microsoft teams,discord and zoom. On the other hand slack, join.me,skype and google hangouts were used sparcely to aid collaborative project development or team based project development.

Student Response

Table 56 : I have used the following cloud storage platform to aid collaborative project development or team based project development (Student) - Percentage Analysis

#	Question	Always	#	Most of the time	#	About half the time	#	Sometimes	#	Never	#	Total
1	OneDrive	20.00%	3	0.00 %	0	26.67 %	4	46.67%	7	6.67%	1	15
2	Google Drive	46.67%	7	20.00 %	3	26.67 %	4	6.67%	1	0.00%	0	15
3	Dropbox	6.67 %	1	6.67 %	1	20.00 %	3	20.00%	3	46.67 %	7	15
4	Others:	0.00 %	0	0.00 %	0	0.00%	0	12.50%	1	87.50 %	7	8

Sources: Primary Data

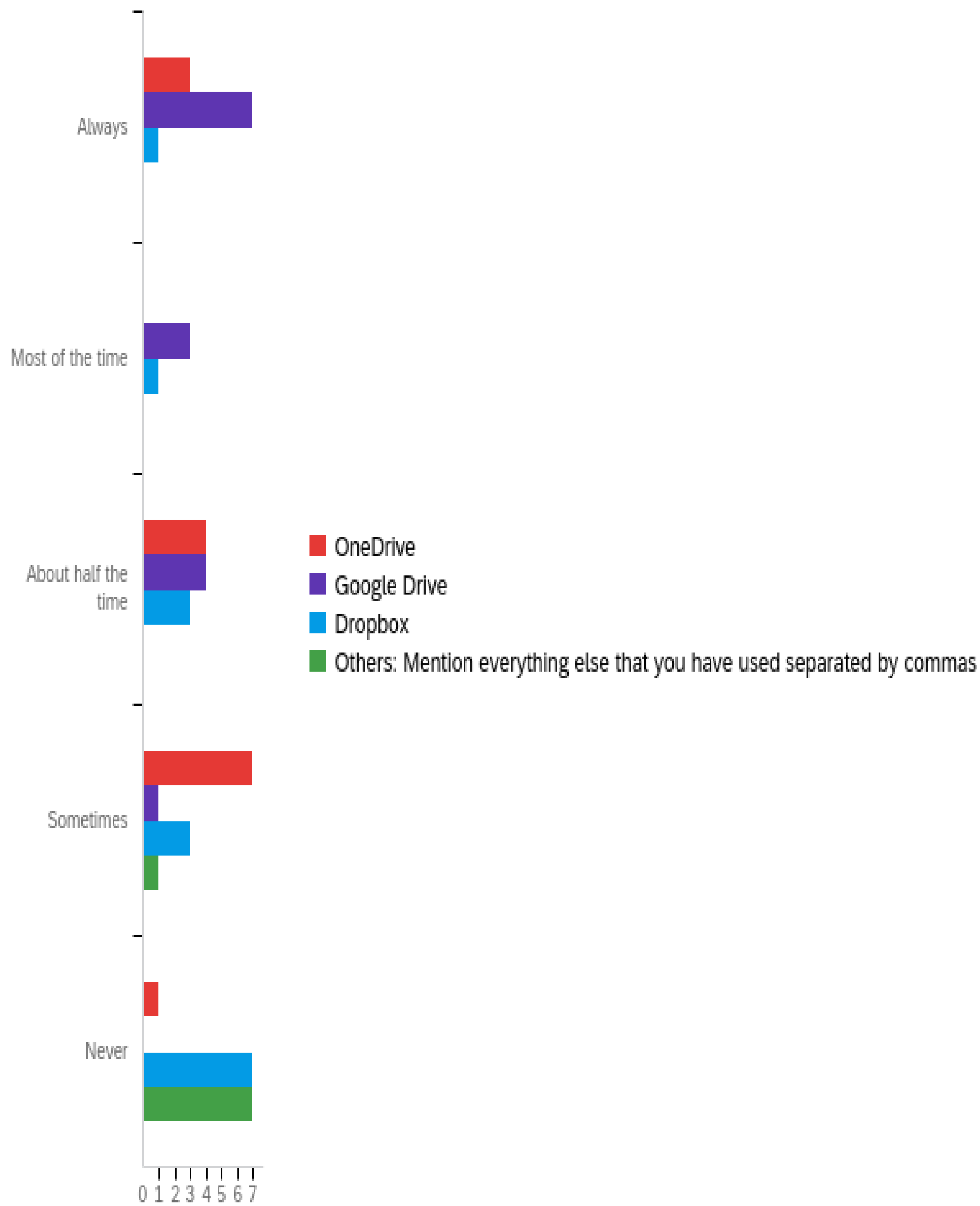
Table 57:I have used the following cloud storage platform to aid collaborative project development or team based project development (Student) - Statistical Analysis

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	OneDrive	1.00	5.00	3.20	1.22	1.49	15
2	Google Drive	1.00	4.00	1.93	1.00	1.00	15
3	Dropbox	1.00	5.00	3.93	1.24	1.53	15
4	Others:	4.00	5.00	4.88	0.33	0.11	8

Sources: Primary Data

Student Response

Chart 31: I have used the following cloud storage platform to aid collaborative project development or team based project development- Student



Sources: Primary Data

From the above table and chart it can be inferred that among the student respondents with respect to the use of cloud storage platform to aid collaborative project development or team based project development, most of the student respondents used google drive as a cloud storage platform to aid collaborative project development or team based project development, where a small number of respondetnts used one drive and dropbox as their cloud storage platform to aid collaborative project development or team based project development.

Student Response

Table 58: I have used the following project management apps to aid collaborative project development or team based project development (Student) - Percentage Analysis

#	Question	Always	#	Most of the time	#	About half the time	#	Sometimes	#	Never	#	Total
1	WTCLASS	40.00%	6	20.00%	3	0.00%	0	26.67%	4	13.33%	2	15
2	GitHub	20.00%	3	6.67%	1	6.67%	1	26.67%	4	40.00%	6	15
3	Jira Cloud	0.00%	0	0.00%	0	0.00%	0	6.67%	1	93.33%	14	15
4	Stack Overflow	0.00%	0	6.67%	1	13.33%	2	6.67%	1	73.33%	11	15
5	Backlog	0.00%	0	0.00%	0	0.00%	0	6.67%	1	93.33%	14	15
6	Stand-Bot	0.00%	0	0.00%	0	0.00%	0	0.00%	0	100.00%	15	15
7	Trello	0.00%	0	0.00%	0	0.00%	0	6.67%	1	93.33%	14	15
8	Microsoft Project	6.67%	1	13.33%	2	0.00%	0	0.00%	0	80.00%	12	15
9	Primavera P6	0.00%	0	0.00%	0	0.00%	0	6.67%	1	93.33%	14	15
10	Others:	0.00%	0	0.00%	0	0.00%	0	0.00%	0	100.00%	8	8

Sources: Primary Data

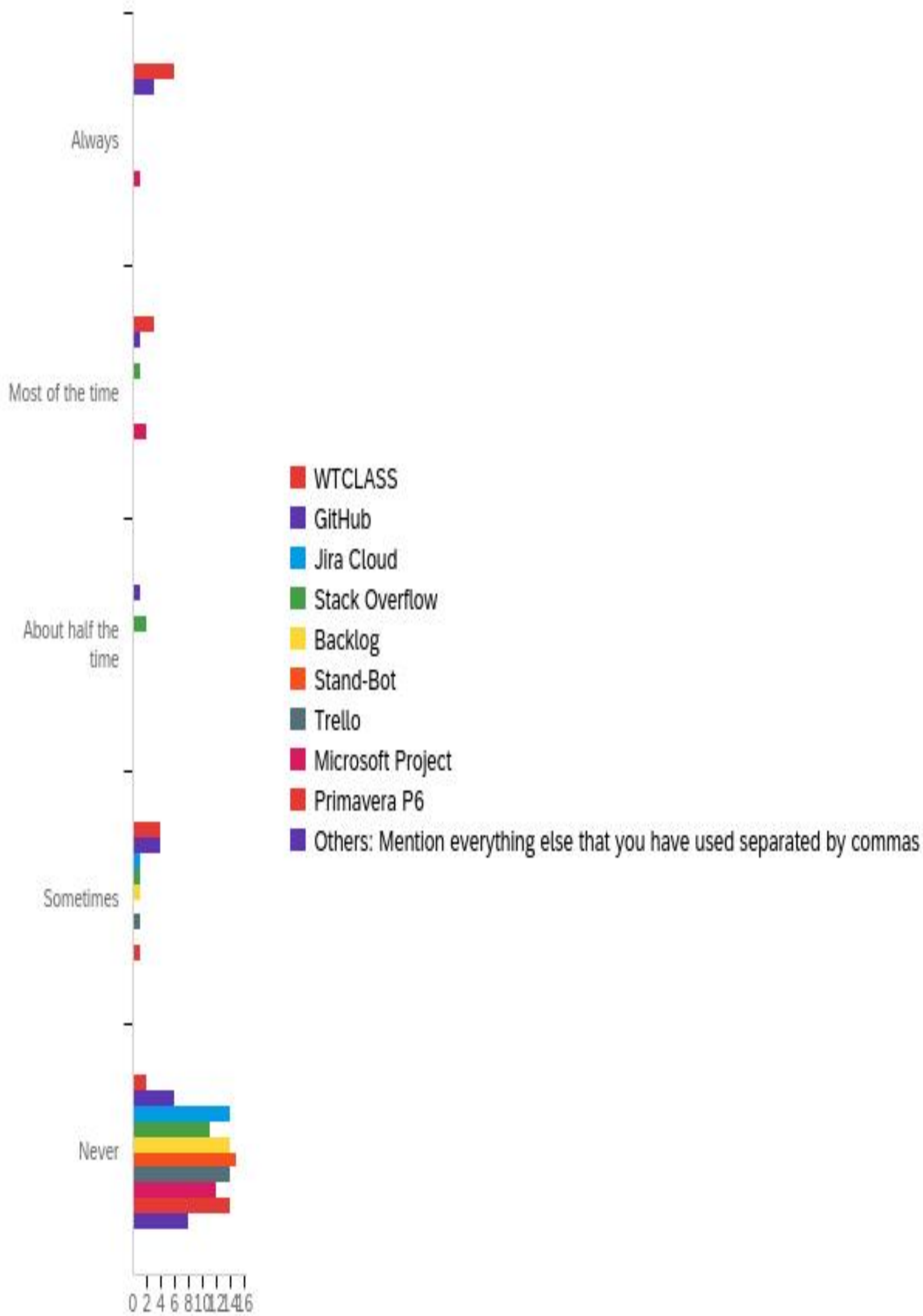
Table 59: I have used the following project management apps to aid collaborative project development or team based project development (Student)- Statistical Analysis

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	WTCLASS	1.00	5.00	2.53	1.54	2.38	15
2	GitHub	1.00	5.00	3.60	1.54	2.37	15
3	Jira Cloud	4.00	5.00	4.93	0.25	0.06	15
4	Stack Overflow	2.00	5.00	4.47	0.96	0.92	15
5	Backlog	4.00	5.00	4.93	0.25	0.06	15
6	Stand-Bot	5.00	5.00	5.00	0.00	0.00	15
7	Trello	4.00	5.00	4.93	0.25	0.06	15
8	Microsoft Project	1.00	5.00	4.33	1.35	1.82	15
9	Primavera P6	4.00	5.00	4.93	0.25	0.06	15
10	Others:	5.00	5.00	5.00	0.00	0.00	8

Sources: Primary Data

Student Response

Chart 32: I have used the following project management apps to aid collaborative project development or team based project development- Student



Sources: Primary Data

From the above table and chart it can be inferred the student respondents, use of project management apps to aid collaborative project development or team based project development. Student respondents are used the following project mangement apps frequently to aid collaborative project development or team based project development such as WT class, github, stack overflow, and microsoft project. On the other hand jira cloud,backlog,stand-bot,trello and primavera are used either very low nor not used on their projectmangement apps to aid collaborative project development or team based project development.

Student Response

Table 60: I have used the following project design/development apps to aid collaborative project development or team based project development (Student) - Percentage Analysis

#	Question	Always	#	Most of the time	#	About half the time	#	Sometimes	#	Never	#	Total
1	GitHub	14.29%	2	0.00%	0	7.14%	1	35.71%	5	42.86%	6	14
2	REVIT	0.00%	0	0.00%	0	0.00%	0	0.00%	0	100.00%	14	14
3	Autodesk Product Design Suite	0.00%	0	0.00%	0	0.00%	0	0.00%	0	100.00%	14	14
4	MATLAB	0.00%	0	7.14%	1	28.57%	4	42.86%	6	21.43%	3	14
5	CATIA	0.00%	0	0.00%	0	0.00%	0	0.00%	0	100.00%	14	14
6	ZW3D	0.00%	0	0.00%	0	0.00%	0	0.00%	0	100.00%	14	14
7	MechDesigner	0.00%	0	0.00%	0	0.00%	0	0.00%	0	100.00%	14	14
8	PTC Creo	0.00%	0	0.00%	0	0.00%	0	0.00%	0	100.00%	14	14
9	Primavera P6	0.00%	0	0.00%	0	0.00%	0	0.00%	0	100.00%	14	14
10	CAD Inventor	0.00%	0	7.14%	1	0.00%	0	7.14%	1	85.71%	12	14
11	Fusion 360	0.00%	0	0.00%	0	7.69%	1	0.00%	0	92.31%	12	13
12	ANSYS	0.00%	0	0.00%	0	0.00%	0	0.00%	0	100.00%	14	14
13	SolidWorks	0.00%	0	0.00%	0	7.14%	1	14.29%	2	78.57%	11	14
14	Adreno IDE	0.00%	0	0.00%	0	7.14%	1	0.00%	0	92.86%	13	14
15	PSpice	0.00%	0	0.00%	0	0.00%	0	0.00%	0	100.00%	13	13
16	PSCAD	0.00%	0	0.00%	0	0.00%	0	0.00%	0	100.00%	14	14
17	LabView	0.00%	0	0.00%	0	0.00%	0	0.00%	0	100.00%	14	14
18	ArcGis	0.00%	0	7.14%	1	7.14%	1	0.00%	0	85.71%	12	14
19	Others:	0.00%	0	14.29%	1	0.00%	0	0.00%	0	85.71%	6	7

Sources: Primary Data

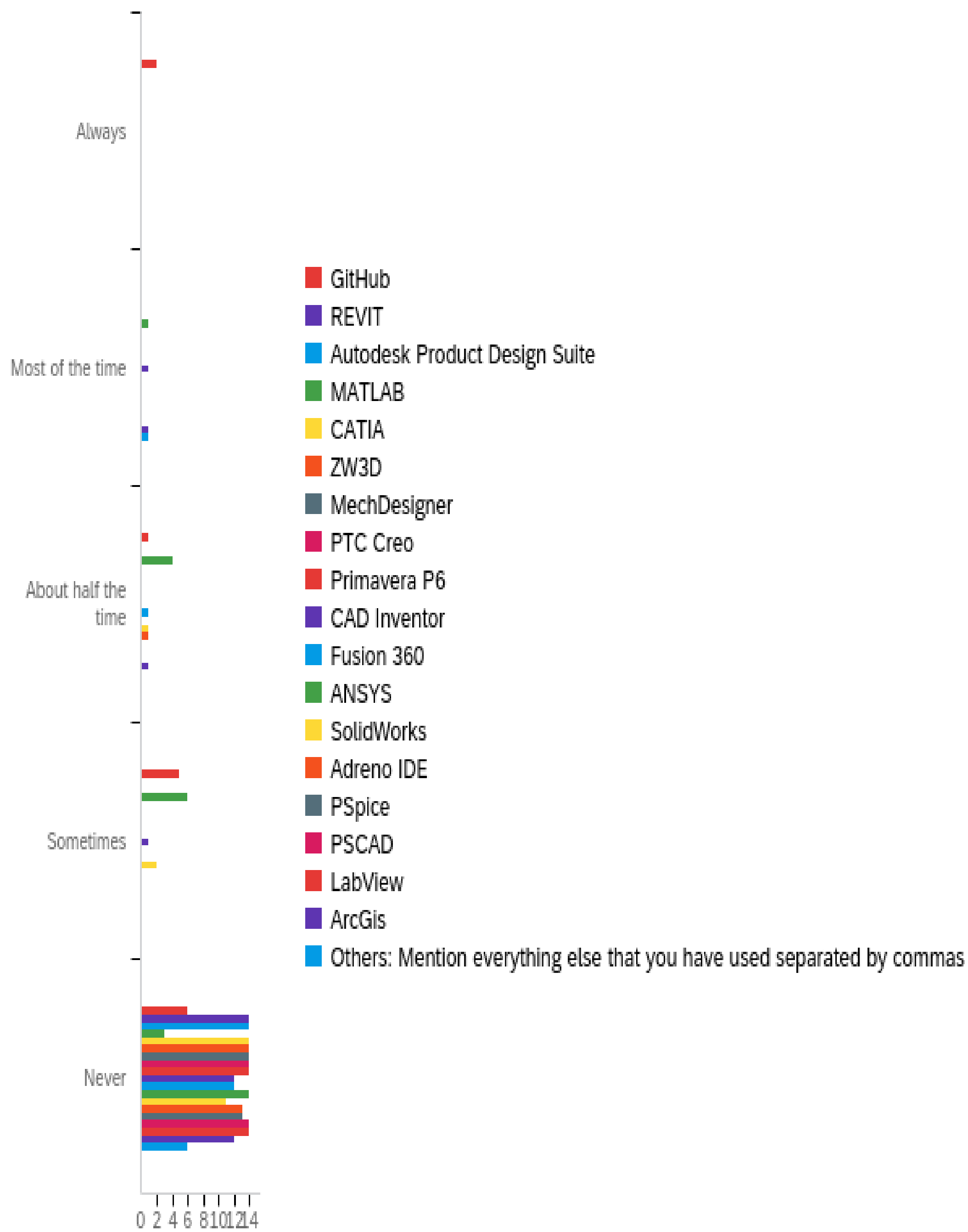
Table 61: I have used the following project design/development apps to aid collaborative project development or team based project development (Student) - Statistical Analysis

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	GitHub	1.00	5.00	3.93	1.33	1.78	14
2	REVIT	5.00	5.00	5.00	0.00	0.00	14
3	Autodesk Product Design Suite	5.00	5.00	5.00	0.00	0.00	14
4	MATLAB	2.00	5.00	3.79	0.86	0.74	14
5	CATIA	5.00	5.00	5.00	0.00	0.00	14
6	ZW3D	5.00	5.00	5.00	0.00	0.00	14
7	MechDesigner	5.00	5.00	5.00	0.00	0.00	14
8	PTC Creo	5.00	5.00	5.00	0.00	0.00	14
9	Primavera P6	5.00	5.00	5.00	0.00	0.00	14
10	CAD Inventor	2.00	5.00	4.71	0.80	0.63	14
11	Fusion 360	3.00	5.00	4.85	0.53	0.28	13
12	ANSYS	5.00	5.00	5.00	0.00	0.00	14
13	SolidWorks	3.00	5.00	4.71	0.59	0.35	14
14	Adreno IDE	3.00	5.00	4.86	0.52	0.27	14
15	PSpice	5.00	5.00	5.00	0.00	0.00	13
16	PSCAD	5.00	5.00	5.00	0.00	0.00	14
17	LabView	5.00	5.00	5.00	0.00	0.00	14
18	ArcGis	2.00	5.00	4.64	0.89	0.80	14
19	Others:	2.00	5.00	4.57	1.05	1.10	7

Sources: Primary Data

Student Response

Chart 33: I have used the following project design/development apps to aid collaborative project development or team based project development -Student



Sources: Primary Data

From the above table and chart it can be inferred among the student respondents with respect to the use of project design and development apps to aid collaborative project development or team based project development, student respondents have used the following project design and development apps frequently to aid collaborative project development or team based project development: GitHub, MATLAB,CAD inventor, Fusion 360, Soildworks,Adreno IDE and ArcGIS. On the other hand REVIT, Autodesk produt design suite, CATIA, ZW3D, MechDesigner,PTC Creo,Primavera p6, ANSYS, PSpice, PSCAD and labview were either used very low or not used for their project mangement to aid collaborative project development or team based project development.

4.2 Results from Open - Ended Questions

How the above did specified software tools help you incorporate collaborative project development into the coursework?

Instructor Response

- Better project management

In your perspective, what are some of the strengths to the approaches currently followed in the courses you have taught that has helped students develop their Industry 4.0 skills mentioned above?

Instructor Response

- Simulation, real world applications
- Hands on learning, interdisciplinary or multidisciplinary projects
- Problem solving

In your perspective, what are some of the strengths to the approaches currently followed in the courses you have taken that has helped you develop the Industry 4.0 skills mentioned above?

Student Response

- Having skilled professors, and having a connection between the upper and lower class men.
- Project management
- I have no industry 4.0 skills as I just learned about it from this
- I do not know enough about this topic.

- Hands on, team based projects
- The courses have done a good job of creating an environment that welcomes students who have no prior experience in computer science. The SI's and Instructors do a good job explaining fundamental components of programming.
- The learning and testing of fundamental concepts is strongly there for most CS courses, especially the freshman and sophomore ones. This provides a foundation to build on and fosters problem solving, critical thinking and creativity, in a sense.
- I have developed those skills in from my courses a little bit in every course.

In your perspective, what are some of the weaknesses to the approaches currently followed in the courses you have taught that could be rectified to help students develop the Industry 4.0 skills mentioned above?

Instructor Response

- Rate of adoption
- More lab periods
- lack of decision making skills

In your perspective, what are some of the weaknesses to the approaches currently followed in the courses you have taken that could be rectified to help you develop the Industry 4.0 skills mentioned above?

Student Response

- Difficulty in building those connections
- Creativity

- I do not know enough about this topic. This is my first time hearing about Industry 4.0
- Lack of software and programming skills learned in classes.
- None of my classes have final projects. Labs are great for learning fundamentals and practicing concepts; however, projects allow the student to show what they have learned and be creative and inventive. These projects would help prepare students for their senior design class, as well as give students the opportunity to have projects to put on their resume and talk to recruiters about. Also the lack of electives is disappointing.
- On the other hand, there is not a lot of exploration of current problems and how they are being solved, or the discussion of strategies or approaches for problem solving. A lot of the upper level courses entail self-teaching of concepts and does not leave a lot of room for projects that could help us obtain jobs. We could definitely do more projects that could help in our experiences building for internship/job hunts. There is not a lot of discussion of emerging technologies. Most of the knowledge I have about additive manufacturing, simulation, industrial IoT, artificial intelligence, machine learning, autonomous robotics and other technologies comes from self-exploration by reading, attending virtual seminars, or simply watching lectures or seminars via YouTube.
- Some courses do not talk about the skills very much or even how to develop those skills better.

In your perspective, what are some of the strengths to the approaches currently followed in the courses you have taken that has helped you with collaborative software development?

Student Response

- Skilled professors and open classmates
- working with others in my class in order to help each other figure out how everything works
- I have learned to work together as a team to finish a project effectively. I have not had much experience as a sophomore.
- Hands on projects requiring software development.
- The use of Git (GitHub) is a really beneficial tool especially for software developers.
- It has been very helpful. I have benefitted from this greatly especially when it came time to experience it in a real-world setting in an internship. Virtual meetings with cameras on, screen sharing, file sharing and live discussion of project topics.
- That the professor gives us the opportunity to collaborate with each other as students.

In your perspective, what are some of the weaknesses to the approaches currently followed in the courses you have taken that could be rectified to help you work more with collaborative software development?

Student Response

- Some professors and classmates aren't as open
- Having to figure out new things that I am not familiar with
- When in a group, some people do not do work and it costs others to do that persons part. It made me realize that I need more practice on certain software sites.
- Lack of learning software development and programming in the EE degree program.
- Probably could do a better job encouraging teamwork.
- N/A
- No weaknesses.

4.3 Chi-Square Analysis

Using the cross tabulation tool supplied by Qualtrics we can do multivariate analysis on two or more variables at the same time. This tool allows one to personalize your crosstabs with a variety of choices, including the ability to calculate Chi-squared statistics. As a Chi-squared test, the Overall Stats Test of Percentages is used. The chi-squared statistic is used to determine the association between two category variables. This test yields a p-value, which is used to determine whether or not the link is significant. The pop-up box as seen in the figure below let us observe the p-value in the crosstabs to see if the test was significant.

4.3.1. Chi- Square Test -1

In order to find the relationship between the genders of the respondent's use of any software tools that tie specific to the Industry 4.0 pillars in their course work, a chi-square test was used and the result of the test is shown below in the table.

Table 62:Gender of the student and use of any software tools that tie specific to the Industry 4.0 pillars in their course work

Stub: Have you used any software tools that tie specific to the following Industry 4.0 pillars (topics) in your courses? If answered yes, please specify the software tools/technology used.

		Q5: Select your gender:				
		Total	Male	Female	Non-binary / third gende	Prefer not to say
	Total Count (All)	24.0	11.0	12.0	1.0	0.0
Have you used any software tools that tie specific to the following Industry 4.0 pillars (topics) in your courses? If answered yes, please specify the software tools/technology used.	Yes (Big Data)	4.2%	9.1%	0.0%	0.0%	0.0%
	No (Big Data)	62.5%	63.6%	58.3%	100.0%	0.0%
	Yes (Autonomous Robots)	4.2%	9.1%	0.0%	0.0%	0.0%
	No (Autonomous Robots)	62.5%	63.6%	58.3%	100.0%	0.0%
	Yes (Simulation)	12.5%	9.1%	8.3%	100.0%	0.0%
	No (Simulation)	54.2%	63.6%	50.0%	0.0%	0.0%
	Yes (Universal System Integration)	0.0%	0.0%	0.0%	0.0%	0.0%
	No (Universal System Integration)	66.7%	72.7%	58.3%	100.0%	0.0%
	Yes (Industrial IoT)	0.0%	0.0%	0.0%	0.0%	0.0%
	No (Industrial IoT)	66.7%	72.7%	58.3%	100.0%	0.0%
	Yes (Cybersecurity)	16.7%	27.3%	0.0%	100.0%	0.0%
	No (Cybersecurity)	50.0%	45.5%	58.3%	0.0%	0.0%
	Yes (Cloud Computing)	4.2%	0.0%	0.0%	100.0%	0.0%
	No (Cloud Computing)	62.5%	72.7%	58.3%	0.0%	0.0%
	Yes (Additive Manufacturing)	0.0%	0.0%	0.0%	0.0%	0.0%
	No (Additive Manufacturing)	66.7%	72.7%	58.3%	100.0%	0.0%
	Yes (Augmented Reality)	0.0%	0.0%	0.0%	0.0%	0.0%
	No (Augmented Reality)	66.7%	72.7%	58.3%	100.0%	0.0%
	Overall Stat Test of Percentages (Big Data)	0.5866462195100317				
	Overall Stat Test of Percentages (Autonomous Robots)	0.5866462195100317				
	Overall Stat Test of Percentages (Simulation)	0.09876437511422759				
	Overall Stat Test of Percentages (Universal System Integration)	1				
	Overall Stat Test of Percentages (Industrial IoT)	1				
	Overall Stat Test of Percentages (Cybersecurity)	0.04978706836786395				
	Overall Stat Test of Percentages (Cloud Computing)	0.0003354626279025119				
	Overall Stat Test of Percentages (Additive Manufacturing)	1				
	Overall Stat Test of Percentages (Augmented Reality)	1				

Overall Stat Test of Percentages (Big Data)	0.6
Overall Stat Test of P...s (Autonomous Robots)	0.6
Overall Stat Test of Percentages (Simulation)	< 0.1
Overall Stat Test of P...System Integration)	1.0
Overall Stat Test of P...tages (Industrial IoT)	1.0
Overall Stat Test of P...ntages (Cybersecurity)	**< 0.1**
Overall Stat Test of P...ages (Cloud Computi...	**< 0.1**

There is a statistically significant relationship between these variables.

Result: From the analysis above, it is concluded that there is significant relationship between gender of the respondents and use of any software tools that tie specific to the Industry 4.0 pillars (Simulation, Cyber security and Cloud computing) within their course work.

Yes (Augmented Reality)	0.0%	0.0%	0.0%	0.0%
No (Augmented Reality)	66.7%	[illegible]	[illegible]	100.0%
Overall Stat Test of Percentages (Big Data)	0.6			
Overall Stat Test of P...s (Autonomous Robots)	0.6			
Overall Stat Test of Percentages (Simulation)	< 0.1			
Overall Stat Test of P...System Integration)	1.0			
Overall Stat Test of P...tages (Industrial IoT)	1.0			
Overall Stat Test of P...ntages (Cybersecurity)	**< 0.1**			
Overall Stat Test of P...ages (Cloud Computi...	**< 0.1**			

There is no statistically significant relationship between these variables.

Result: From the analysis above, it is concluded that there is no significant relationship between gender of the respondents and use of any software tools that tie specific to the Industry 4.0 pillars (are Big Data, Autonomous Robots, System Integration and Industrial IOT) within their course work.

4.3. 2 Chi- Square Test -2

In order to find the relationship between the genders of the respondent's and their involvement in any projects that tie specific to the Industry 4.0 pillars in their course work, a chi-square test was used and the result of the test is shown below in the table.

Table 63: Gender of the student and they have worked on any projects that tie specific to the Industry 4.0 pillars in their course work.

Stub: Have you worked on any projects that tie specific to the following Industry 4.0 pillars (topics) in your courses? If answered yes, please specify the project title and course name.

		Q5: Select your gender:				
		Total	Male	Female	Non-binary / third gende	Prefer not to say
Have you worked on any projects that tie specific to the following Industry 4.0 pillars (topics) in your courses? If answered yes, please specify the project title and course name.	Total Count (All)	24.0	11.0	12.0	1.0	0.0
	Yes (Big Data)	4.2%	9.1%	0.0%	0.0%	0.0%
	No (Big Data)	62.5%	63.6%	58.3%	100.0%	0.0%
	Yes (Autonomous Robots)	4.2%	9.1%	0.0%	0.0%	0.0%
	No (Autonomous Robots)	58.3%	54.5%	58.3%	100.0%	0.0%
	Yes (Simulation)	8.3%	9.1%	0.0%	100.0%	0.0%
	No (Simulation)	58.3%	63.6%	58.3%	0.0%	0.0%
	Yes (Universal System Integration)	0.0%	0.0%	0.0%	0.0%	0.0%
	No (Universal System Integration)	66.7%	72.7%	58.3%	100.0%	0.0%
	Yes (Industrial IoT)	0.0%	0.0%	0.0%	0.0%	0.0%
	No (Industrial IoT)	66.7%	72.7%	58.3%	100.0%	0.0%
	Yes (Cybersecurity)	8.3%	18.2%	0.0%	0.0%	0.0%
	No (Cybersecurity)	58.3%	54.5%	58.3%	100.0%	0.0%
	Yes (Cloud Computing)	0.0%	0.0%	0.0%	0.0%	0.0%
	No (Cloud Computing)	62.5%	63.6%	58.3%	100.0%	0.0%
	Yes (Additive Manufacturing)	0.0%	0.0%	0.0%	0.0%	0.0%
	No (Additive Manufacturing)	66.7%	72.7%	58.3%	100.0%	0.0%
	Yes (Augmented Reality)	0.0%	0.0%	0.0%	0.0%	0.0%
	No (Augmented Reality)	66.7%	72.7%	58.3%	100.0%	0.0%
	Overall Stat Test of Percentages (Big Data)	0.5866462195100317				
	Overall Stat Test of Percentages (Autonomous Robots)	0.5421324699199652				
	Overall Stat Test of Percentages (Simulation)	0.018315638888734182				
	Overall Stat Test of Percentages (Universal System Integration)	1				
	Overall Stat Test of Percentages (Industrial IoT)	1				
	Overall Stat Test of Percentages (Cybersecurity)	0.3189065573239704				
	Overall Stat Test of Percentages (Cloud Computing)	1				
	Overall Stat Test of Percentages (Additive Manufacturing)	1				
	Overall Stat Test of Percentages (Augmented Reality)	1				

Yes (Augmented Reality)	0.0%	0.0%	0.0%	0.0%
No (Augmented Reality)	66.7%	72.7%	58.3%	100.0%

Overall Stat Test of Percentages (Big Data)	0.6
Overall Stat Test of P...s (Autonomous Robots)	0.5
Overall Stat Test of Percentages (Simulation)	**< 0.1**
Overall Stat Test of P...System Integration)	1.0
Overall Stat Test of P...tages (Industrial IoT)	1.0
Overall Stat Test of P...ntages (Cybersecurity)	0.3

There is a statistically significant relationship between these variables.

Result: From the analysis above, it is concluded that there is significant relationship between gender of the respondents and their involvement in projects that tie specific to the Industry 4.0 pillars Simulation within their course work.

4.3.3 Chi- Square Test -3

In order to find the relationship between the genders of the respondent's and their exposure to the Industry 4.0 pillars in their course work, a chi-square test was used and the result of the test is shown below in the table.

Table 64: Gender of the student and their exposure to the Industry 4.0 pillars in their course work.

Stub: To what extent have you been exposed to the following Industry 4.0 pillars (topics) in your courses?Please list the courses in the textbox provided below.

		Q5: Select your gender:				
		Total	Male	Female	Non-binary / third gende	Prefer not to say
To what extent have you been exposed to the following Industry 4.0 pillars (topics) in your courses?Please list the courses in the textbox provided below.	Total Count (All)	24.0	11.0	12.0	1.0	0.0
	Extremely well (Big Data)	0.0%	0.0%	0.0%	0.0%	0.0%
	I have not heard about this topic (Big Data)	33.3%	18.2%	50.0%	0.0%	0.0%
	Extremely well (Autonomous Robots)	0.0%	0.0%	0.0%	0.0%	0.0%
	I have not heard about this topic (Autonomous Robots)	37.5%	18.2%	50.0%	100.0%	0.0%
	Extremely well (Simulation)	0.0%	0.0%	0.0%	0.0%	0.0%
	I have not heard about this topic (Simulation)	41.7%	27.3%	50.0%	100.0%	0.0%
	Extremely well (Universal System Integration)	0.0%	0.0%	0.0%	0.0%	0.0%
	I have not heard about this topic (Universal System Integration)	45.8%	27.3%	58.3%	100.0%	0.0%
	Extremely well (Industrial IoT)	0.0%	0.0%	0.0%	0.0%	0.0%
	I have not heard about this topic (Industrial IoT)	37.5%	9.1%	58.3%	100.0%	0.0%
	Extremely well (Cybersecurity)	0.0%	0.0%	0.0%	0.0%	0.0%
	I have not heard about this topic (Cybersecurity)	33.3%	9.1%	50.0%	100.0%	0.0%
	Extremely well (Cloud Computing)	0.0%	0.0%	0.0%	0.0%	0.0%
	I have not heard about this topic (Cloud Computing)	37.5%	18.2%	58.3%	0.0%	0.0%
	Extremely well (Additive Manufacturing)	0.0%	0.0%	0.0%	0.0%	0.0%
	I have not heard about this topic (Additive Manufacturing)	45.8%	27.3%	58.3%	100.0%	0.0%
	Extremely well (Augmented Reality)	0.0%	0.0%	0.0%	0.0%	0.0%
	I have not heard about this topic (Augmented Reality)	37.5%	18.2%	50.0%	100.0%	0.0%
	Overall Stat Test of Percentages (Big Data)	0.03808881366497758				
	Overall Stat Test of Percentages (Autonomous Robots)	0.29938858293052506				
	Overall Stat Test of Percentages (Simulation)	0.5365053142779466				
	Overall Stat Test of Percentages (Universal System Integration)	0.1221588201397169				
	Overall Stat Test of Percentages (Industrial IoT)	0.014334880303020357				
	Overall Stat Test of Percentages (Cybersecurity)	0.12616410507996703				
	Overall Stat Test of Percentages (Cloud Computing)	0.06579190250257172				
	Overall Stat Test of Percentages (Additive Manufacturing)	0.1221588201397169				
	Overall Stat Test of Percentages (Augmented Reality)	0.33199719899349817				

Extremely well (Augmented Reality)	0.0%	0.0%	0.0%	0.0%
I have not heard about...ic (Augmented Reality)	37.5%			100.0%

There is a statistically significant relationship between these variables.

Overall Stat Test of Percentages (Big Data)	**< 0.1**
Overall Stat Test of P...s (Autonomous Robots)	0.3
Overall Stat Test of Percentages (Simulation)	0.5
Overall Stat Test of P...System Integration)	0.1
Overall Stat Test of P...tages (Industrial IoT)	**< 0.1**
Overall Stat Test of P...ntages (Cybersecurity)	0.1

Result: From the analysis above, it is concluded that there is significant relationship between gender of the respondents and their exposure to the Industry 4.0 pillars Big Data and Industrial IoT within their course work.

4.3.4. Chi- Square Test -4

In order to find the relationship between the major of the study and use of communication apps to aid their collaborative project development or team based project development in their course work, a chi-square test was used and the result of the test is shown below in the table.

Table 65: Major of the study and use of communication apps to aid their collaborative project development or team based project development in their course work.

Stub: Select all that apply:I have used the following communication apps to aid collaborative project development or team based project development.

Select all that apply:I have used the following communication apps to aid collaborative project development or team based project development.

	Q2: Choose your major: - Selected Choice								
	Total	Mechanical Engineering	Civil Engineering	Electrical Engineering	Environmental Engineeri	Engineering Technology	Computer Science	Math	Others specify
Total Count (All)	24.0	4.0	0.0	2.0	3.0	0.0	12.0	3.0	0.0
Always (WTCLASS)	20.8%	0.0%	0.0%	0.0%	33.3%	0.0%	33.3%	0.0%	0.0%
Most of the time (WTCLASS)	16.7%	25.0%	0.0%	0.0%	0.0%	0.0%	25.0%	0.0%	0.0%
About half the time (WTCLASS)	8.3%	0.0%	0.0%	50.0%	0.0%	0.0%	0.0%	33.3%	0.0%
Sometimes (WTCLASS)	8.3%	0.0%	0.0%	0.0%	0.0%	0.0%	8.3%	33.3%	0.0%
Never (WTCLASS)	8.3%	25.0%	0.0%	0.0%	33.3%	0.0%	0.0%	0.0%	0.0%
Always (Microsoft Teams)	4.2%	0.0%	0.0%	0.0%	0.0%	0.0%	8.3%	0.0%	0.0%
Most of the time (Microsoft Teams)	12.5%	0.0%	0.0%	50.0%	33.3%	0.0%	8.3%	0.0%	0.0%
About half the time (Microsoft Teams)	4.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	33.3%	0.0%
Sometimes (Microsoft Teams)	12.5%	50.0%	0.0%	0.0%	33.3%	0.0%	0.0%	0.0%	0.0%
Never (Microsoft Teams)	29.2%	0.0%	0.0%	0.0%	0.0%	0.0%	50.0%	33.3%	0.0%
Always (Slack)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Most of the time (Slack)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
About half the time (Slack)	4.2%	0.0%	0.0%	0.0%	0.0%	0.0%	8.3%	0.0%	0.0%
Sometimes (Slack)	12.5%	25.0%	0.0%	0.0%	0.0%	0.0%	16.7%	0.0%	0.0%
Never (Slack)	45.8%	25.0%	0.0%	50.0%	66.7%	0.0%	41.7%	66.7%	0.0%
Always (Discord)	12.5%	0.0%	0.0%	0.0%	0.0%	0.0%	25.0%	0.0%	0.0%
Most of the time (Discord)	20.8%	0.0%	0.0%	0.0%	0.0%	0.0%	41.7%	0.0%	0.0%
About half the time (Discord)	4.2%	25.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Sometimes (Discord)	12.5%	25.0%	0.0%	50.0%	0.0%	0.0%	0.0%	33.3%	0.0%
Never (Discord)	12.5%	0.0%	0.0%	0.0%	66.7%	0.0%	0.0%	33.3%	0.0%
Always (Join.me)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Most of the time (Join.me)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
About half the time (Join.me)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Sometimes (Join.me)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Never (Join.me)	62.5%	50.0%	0.0%	50.0%	66.7%	0.0%	66.7%	66.7%	0.0%
Always (Skype)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Most of the time (Skype)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
About half the time (Skype)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Sometimes (Skype)	8.3%	25.0%	0.0%	50.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Never (Skype)	54.2%	25.0%	0.0%	0.0%	66.7%	0.0%	66.7%	66.7%	0.0%
Always (Google Hangouts)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Most of the time (Google Hangouts)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
About half the time (Google Hangouts)	4.2%	25.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Sometimes (Google Hangouts)	4.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	33.3%	0.0%
Never (Google Hangouts)	50.0%	25.0%	0.0%	0.0%	66.7%	0.0%	66.7%	33.3%	0.0%
Always (Zoom)	16.7%	0.0%	0.0%	0.0%	33.3%	0.0%	25.0%	0.0%	0.0%
Most of the time (Zoom)	25.0%	25.0%	0.0%	0.0%	33.3%	0.0%	16.7%	66.7%	0.0%
About half the time (Zoom)	4.2%	0.0%	0.0%	50.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Sometimes (Zoom)	16.7%	25.0%	0.0%	0.0%	0.0%	0.0%	25.0%	0.0%	0.0%
Never (Zoom)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Always (Others: Mention everything else that you have used separated	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Most of the time (Others: Mention everything else that you have used :	4.2%	0.0%	0.0%	0.0%	0.0%	0.0%	8.3%	0.0%	0.0%
About half the time (Others: Mention everything else that you have us	4.2%	25.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Sometimes (Others: Mention everything else that you have used separ	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Never (Others: Mention everything else that you have used separated I	25.0%	0.0%	0.0%	50.0%	0.0%	0.0%	25.0%	66.7%	0.0%
Overall Stat Test of Percentages (WTCLASS)	0.1421853799567489								
Overall Stat Test of Percentages (Microsoft Teams)	0.058183335680754476								
Overall Stat Test of Percentages (Slack)	0.8883526962576829								
Overall Stat Test of Percentages (Discord)	0.018002193147830716								
Overall Stat Test of Percentages (Join.me)	1								
Overall Stat Test of Percentages (Skype)	0.030494594939324812								
Overall Stat Test of Percentages (Google Hangouts)	0.04576031005558561								
Overall Stat Test of Percentages (Zoom)	0.0513031910511271								
Overall Stat Test of Percentages (Others: Mention everything else that	0.17357807091003602								

Overall Stat Test of Percentages (WTCLASS)	0.1
Overall Stat Test of P...ages (Microsoft Teams)	< 0.1
Overall Stat Test of Percentages (Slack)	0.9
Overall Stat Test of Percentages (Discord)	**< 0.1**
Overall Stat Test of Percentages (Join.me)	1.0
Overall Stat Test of Percentages (Skype)	**< 0.1**
Overall Stat Test of P...ages (Google Hangou...	**< 0.1**
Overall Stat Test of Percentages (Zoom)	< 0.1

There is a statistically significant relationship between these variables.

Result: From the analysis above, it is concluded that there is significant relationship between the major of the study and use of specific communication apps such Microsoft Teams, Discord, Skype, Google Hangout and Zoom as to aid their collaborative project development or team based project development within their course work.

4.3.5 Chi- Square Test -5

In order to find the relationship between the major of the study and how well the courses they have taken in their respective degree programs have prepared them with top rated soft skills that align closely with industry 4.0, a chi-square test was used and the result of the test is shown below in the table.

Table 66: Major of the study and how well the courses they have taken in their respective degree programs have prepared them with top rated soft skills that align closely with industry 4.0

Stub: How well do you think the courses you have taken in your respective degree programs have prepared you with the following top rated soft skills that align closely with Industry 4.0?

How well do you think the courses you have taken in your respective degree programs have prepared you with the following top rated soft skills that align closely with Industry 4.0?

	Total	Q2: Choose your major: - Selected Choice							
		Mechanical Engineering	Civil Engineering	Electrical Engineering	Environmental Engineeri	Engineering Technology	Computer Science	Math	Others specify
Total Count (All)	24.0	4.0	0.0	2.0	3.0	0.0	12.0	3.0	0.0
Extremely competent (Complex problem solving)	25.0%	0.0%	0.0%	50.0%	33.3%	0.0%	33.3%	0.0%	0.0%
Somewhat competent (Complex problem solving)	20.8%	0.0%	0.0%	0.0%	33.3%	0.0%	33.3%	0.0%	0.0%
Neither competent nor incompetent (Complex problem solving)	12.5%	25.0%	0.0%	0.0%	0.0%	0.0%	0.0%	66.7%	0.0%
Somewhat incompetent (Complex problem solving)	4.2%	25.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Extremely incompetent (Complex problem solving)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Extremely competent (Critical thinking)	25.0%	0.0%	0.0%	50.0%	33.3%	0.0%	33.3%	0.0%	0.0%
Somewhat competent (Critical thinking)	25.0%	0.0%	0.0%	0.0%	33.3%	0.0%	33.3%	33.3%	0.0%
Neither competent nor incompetent (Critical thinking)	12.5%	50.0%	0.0%	0.0%	0.0%	0.0%	0.0%	33.3%	0.0%
Somewhat incompetent (Critical thinking)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Extremely incompetent (Critical thinking)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Extremely competent (Creativity)	12.5%	0.0%	0.0%	0.0%	0.0%	0.0%	25.0%	0.0%	0.0%
Somewhat competent (Creativity)	41.7%	25.0%	0.0%	50.0%	66.7%	0.0%	41.7%	33.3%	0.0%
Neither competent nor incompetent (Creativity)	8.3%	25.0%	0.0%	0.0%	0.0%	0.0%	0.0%	33.3%	0.0%
Somewhat incompetent (Creativity)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Extremely incompetent (Creativity)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Extremely competent (People management)	8.3%	0.0%	0.0%	0.0%	0.0%	0.0%	16.7%	0.0%	0.0%
Somewhat competent (People management)	29.2%	25.0%	0.0%	0.0%	66.7%	0.0%	33.3%	0.0%	0.0%
Neither competent nor incompetent (People management)	20.8%	25.0%	0.0%	50.0%	0.0%	0.0%	8.3%	66.7%	0.0%
Somewhat incompetent (People management)	4.2%	0.0%	0.0%	0.0%	0.0%	0.0%	8.3%	0.0%	0.0%
Extremely incompetent (People management)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Extremely competent (Coordinating with others)	12.5%	0.0%	0.0%	0.0%	33.3%	0.0%	16.7%	0.0%	0.0%
Somewhat competent (Coordinating with others)	37.5%	25.0%	0.0%	0.0%	33.3%	0.0%	50.0%	33.3%	0.0%
Neither competent nor incompetent (Coordinating with others)	12.5%	25.0%	0.0%	50.0%	0.0%	0.0%	0.0%	33.3%	0.0%
Somewhat incompetent (Coordinating with others)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Extremely incompetent (Coordinating with others)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Extremely competent (Emotional intelligence)	8.3%	0.0%	0.0%	0.0%	0.0%	0.0%	16.7%	0.0%	0.0%
Somewhat competent (Emotional intelligence)	29.2%	25.0%	0.0%	0.0%	66.7%	0.0%	33.3%	0.0%	0.0%
Neither competent nor incompetent (Emotional intelligence)	20.8%	25.0%	0.0%	50.0%	0.0%	0.0%	16.7%	33.3%	0.0%
Somewhat incompetent (Emotional intelligence)	4.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	33.3%	0.0%
Extremely incompetent (Emotional intelligence)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Extremely competent (Judgment and decision-making)	12.5%	25.0%	0.0%	0.0%	0.0%	0.0%	8.3%	33.3%	0.0%
Somewhat competent (Judgment and decision-making)	33.3%	0.0%	0.0%	50.0%	66.7%	0.0%	41.7%	0.0%	0.0%
Neither competent nor incompetent (Judgment and decision-making)	8.3%	25.0%	0.0%	0.0%	0.0%	0.0%	0.0%	33.3%	0.0%
Somewhat incompetent (Judgment and decision-making)	4.2%	0.0%	0.0%	0.0%	0.0%	0.0%	8.3%	0.0%	0.0%
Extremely incompetent (Judgment and decision-making)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Extremely competent (Service orientation)	8.3%	0.0%	0.0%	0.0%	0.0%	0.0%	8.3%	33.3%	0.0%
Somewhat competent (Service orientation)	20.8%	0.0%	0.0%	0.0%	66.7%	0.0%	25.0%	0.0%	0.0%
Neither competent nor incompetent (Service orientation)	29.2%	50.0%	0.0%	50.0%	0.0%	0.0%	25.0%	33.3%	0.0%
Somewhat incompetent (Service orientation)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Extremely incompetent (Service orientation)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Overall Stat Test of Percentages (Complex problem solving)	0.04683727570891462								
Overall Stat Test of Percentages (Critical thinking)	0.08851882801757248								
Overall Stat Test of Percentages (Creativity)	0.35835944709311357								
Overall Stat Test of Percentages (People management)	0.5167171454788198								
Overall Stat Test of Percentages (Coordinating with others)	0.26502591529736164								
Overall Stat Test of Percentages (Emotional intelligence)	0.3411442813453852								
Overall Stat Test of Percentages (Judgment and decision-making)	0.4591560990128116								
Overall Stat Test of Percentages (Service orientation)	0.3199186376919966								

Extremely incompetent (Service orientation)	0.0%	0.0%
	There is a statistically significant relationship between these variables.	
Overall Stat Test of P...mplex problem solving)	**< 0.1**	
Overall Stat Test of P...es (Critical thinking)	< 0.1	
Overall Stat Test of Percentages (Creativity)	0.4	
Overall Stat Test of P...es (People managem...	0.5	
Overall Stat Test of P...rdinating with others)	0.3	

Result: From the analysis above, it is concluded that there is significant relationship between major of the study and how well the courses they have taken in their respective degree programs have prepared them with top rated soft skills such as problem solving and critical thinking that align closely with industry 4.0 skills.

CHAPTER V

DISCUSSION OF RESULTS

To stay competitive in today's fast-paced world, academic institutions must adapt to the new technology revolution known as Industry 4.0, as previously indicated. Industry 4.0, ushered in by the introduction of IoT and IoS into the manufacturing environment [31], holds tremendous promise not only for the manufacturing sector, but for all industries globally. Industry 4.0, which is based on interoperability, virtual representations of reality, decentralized control, real-time data capture, and decision making in a standardized yet flexible service-oriented environment [32], is expected to increase efficiency and reduce costs [33]. Other expected benefits of Industry 4.0 implementation include improved customer service, optimized procedures, new employment sectors, and more revenue. In this chapter the key findings of the research has been discussed.

5.1 Key Findings

Some of the key findings from the results obtained through this research effort are listed below:

5.1.1 Instructor and Student Background

Following are the results obtained from the instructors and the students regarding their background information:

- 33% of the instructors were from the mechanical engineering program

- 52.17 % of the students were from the Computer science program
- 83 % of the instructors were Assistant professors
- 47 % of the student respondents represented male and female population equally

5.1.2 Digital Performance

The following information is inferred from the instructors and the students with regards to their digital performance:

- 33% of the instructors use laptop as well as desktop as their digital devices for educational purpose
- 29% of the students own smartphone as their digital devices and 37% of them use laptop as their digital devices for educational purpose
- 50% of the instructors were extremely comfortable using technology for teaching purpose
- 82 % of the students frequently they used digital device for educational purpose to check the course postings in WTCLASS
- 60 % of the instructors have heard about Industry 4.0 and 87 % of student have not heard about Industry 4.0.

5.1.3 Industry 4.0

Instructors and students exposure to Industry 4.0 skills has been studied and following are the details inferred from the survey results:

- Instructors agree that the 9 pillars of the Industry 4.0. namely, big data, autonomous robots, simulation, universal system integration, industrial IoT, cybersecurity, cloud computing ,additive manufacturing, and augmented reality were used on a moderate level within their subject area / courses.

- Students agree that the 9 pillars of the Industry 4.0. namely, big data, autonomous robots, simulation, universal system integration, industrial IoT, cybersecurity, cloud computing ,additive manufacturing and augmented reality were used on a low moderate level within their subject area / courses.
- Instructor and student respondents with regards to the usage of software tools that tie specific to the Industry 4.0 pillars within their course, both instructors and students agree that the software tools were used at a moderate level when it came to simulations. On the other hand, no software tools were used with regards to the following industry 4.0 pillars: big data, autonomous robots, universal system integration, industrial IoT, cybersecurity, cloud computing, additive manufacturing, and augmented reality.
- With respect to collaborative project development that ties specific to the Industry 4.0 pillars: big data, autonomous robots, simulations, industrial IoT, cloud computing and additive manufacturing, instructor respondents felt that they have used them on somewhat moderate level within their courses. On the other hand, they have not used the following Industry 4.0 pillars namely universal system integration, cybersecurity and augmented reality.
- Student respondents have used the Industry 4.0 pillars namely big data, autonomous robots, simulations and cyber security on somewhat moderate level within the courses. On the other hand, they have not used the Industry

4.0 pillars namely universal system integration, industrial IoT, cloud computing, additive manufacturing and augmented reality.

5.1.4 Software Tools

The use of software tools to aid the development of Industry 4.0 skill sets were assessed using a set of survey questions and following are the results observed:

- Instructor respondents agree that they have used the following software tools- system modeling, simulation, visualization, project planning, system design, system testing, creation of prototypes, project scheduling, manufacturing, optimization, system optimization and documentation at a moderate level within their course work. Whereas they have not used the following software within their course work: quality control, system development and project scheduling.
- Student respondents agree that they have used the following software tools- system modeling, simulation, visualization, project planning, quality control, system design, system testing, creation of prototypes, manufacturing, optimization, system development, system optimization and documentation at a low-moderate level within their course work.
- Instructor respondents say that 40% of them used the software tool on interdisciplinary or multidisciplinary projects at least in one their courses. 40% of them used the software tool to encourage students to be involved in team based projects most them they have completed 50% the course at the time of survey, and 40% of them used the software tool to encourage students to involved with hands on learning experience.

- Student respondents say that 46.67% of them used the software tool for interdisciplinary or multidisciplinary projects at least in one their courses. 33.3% of them say that the software tool helped them to be involved in team based projects most them they have completed 50% the course at the time of survey, and 40% of them say that the software tool helped them to be involved with hands on learning experience.

5.1.5 Soft Skills

The level to which students and instructors have used the soft skills within their coursework was assessed and results are as follows:

- Both Instructor and students respondents agree that they have used the following top rated skills on somewhat competent level within the courses they have taught or taken. Skills are complex problem solving, critical thinking, creativity, people management, coordinating with others, emotional intelligence, judgment and decision making and service orientation.

5.1.6 Collaborative Project Development

The involvement of students in collaborative project development within their coursework was assessed and the results obtained are as follows:

- 60% of the instructors say they have encouraged their students to use software tools in collaborative project development.
- 93% of the students say that they have worked on collaborative project development or team based project development in at least one of their courses.

- Student respondents have used the following communication apps frequently to aid collaborative project development or team based project development such as WT class, Microsoft teams, discord and zoom. On the other hand slack, join.me, skype and google hangouts were used sparsely to aid collaborative project development or team based project development.
- Most of the student respondents used google drive as a cloud storage platform to aid collaborative project development or team based project development, whereas small number of respondents used one drive and drop box as their cloud storage platform to aid collaborative project development or team based project development.
- Student respondents used the following project management apps frequently to aid collaborative project development or team based project development such as WT class, GitHub, stack overflow, and Microsoft project. On the other hand, Jira cloud, backlog, stand-bot, trello and primavera were sparsely used to aid collaborative project development or team based project development.
- Student respondents used the following project design and development apps frequently to aid collaborative project development or team based project development namely GitHub, MATLAB,CAD inventor, Fusion 360, Soildworks, Adreno IDE and ArcGIS. On the other hand, REVIT, Autodesk product design suite, CATIA, ZW3D, MechDesigner, PTC Creo, Primavera p6, ANSYS, PSpice, PSCAD and LabVIEW were sparsely used to aid collaborative project development or team based project development.

5.1.7 Addressing Curriculum Gap

The instructor's view of curriculum gap in terms of addressing the Industry 4.0 skills within the existing curriculum was studied and the results obtained are as follows:

- 60% of the instructors say they have to change the existing curriculum in order to address the industry 4.0 skills in their courses.
- 60% of the instructors were some where in-between when it came to making changes to the existing curriculum in order to address the industry 4.0 skills in their courses.
- 50% of the instructors say that they may be need to use new software applications/ technologies that they considering on using their courses in future that would fill the gap towards industry 4.0 skill.

CHAPTER VI

CONCLUSION

Industry 4.0 which encompasses nine different areas such as: cyber-physical systems, the Internet of Things, Big data, 3D printing, robotics, simulation, augmented reality, cloud computing, and cyber security has become extremely important for the future of manufacturing companies. The main purpose of this thesis was to perform a complete literature review of Industry 4.0 concepts and collaborative software development and to identify the gap when it comes to adoption of these skills sets within undergraduate engineering education.

The research model using the survey tool developed was described and discussed. Previous study findings were analyzed to determine the state of art when it comes to introducing Industry 4.0 skills within the undergraduate curriculum and the changes executed at various institutions with regards to these skills sets. The survey developed aided in the collection of a shared knowledge from the instructors and the student's perspective, allowing for a high level of reference. The survey tool developed in this thesis allowed for the definition and delineation of Industry 4.0 concepts. Industry 4.0 was broken down into its different pillars and was studied separately in the questionnaire in order to assess the exposure of the specific knowledge areas within the undergraduate curriculum.

The survey respondents were briefed on Industry 4.0 concepts, as well as the important aspects and difficulties when it comes to adapting the concepts within the course curriculum prior to the data collection phase. The respondents had the opportunity to ask any questions or clarify any information presented in the survey by contacting me via email. The factor that the individuals who took part in the survey were from different academic programs and at various levels of the hierarchy offered a solid foundation for analysis and helped ensure that the impact of potential participant errors and bias was minimal.

The results obtained helped to create a common understanding of the challenges and the existing gap when it comes to adapting Industry 4.0 skills sets within the undergraduate engineering curriculum. The research findings highlight the importance of Industry 4.0 concepts and the need to enhance the use of engineering technology within the coursework in-order to educate young graduates about the new Industrial 4.0 era. Also, the results obtained through this research effort clearly highlight the challenges of Industry 4.0 adoption within the undergraduate curriculum as being based on reliable instructor and student responses. The data analysis, in particular, assisted in identifying the most pressing issue of addressing the gap within the undergraduate engineering curriculum when it comes to moving towards the Industry 4.0 revolution and getting the student body ready for the current job market.

On the whole, this research effort was successful in terms of helping the undergraduate engineering students and instructors gain valuable and provocative knowledge on Industry 4.0 concepts and the results obtained will be beneficial for the academic institution to shape the future engineering curriculum.

Future curriculum changes and course enhancements after careful review and assessment of the exiting courses is recommended. In addition, reviewing and assessing the course outcomes with industrial partners with respect to Industry 4.0 skill sets, collecting their feedback and ideas, and incorporate them into course content can be beneficial.

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APPENDIX

QUESTIONNAIRE DESCRIPTION

This chapter contains the questionnaire design for this thesis that explains the survey tool developed. Furthermore, the questionnaire is spilt into two surveys one administered with the course instructors and the other administered with the students. Some of the key areas focused during survey development are the instructor's and student's view on digital presence, exposure to Industry 4.0 concepts, awareness of Industry 4.0 skills, courses/projects that discuss Industry 4.0 concepts, software tools used within the coursework that support Industry 4.0, exposure to collaborative software development, software tools used within coursework to aid collaborative software development.

4.1. Instructor Questionnaire

Instructor Information and Background

Name:
Leave this field blank if you choose to remain anonymous.

Choose your discipline:

- ○ Mechanical Engineering
- ○ Civil Engineering
- ○ Electrical Engineering
- ○ Environmental Engineering
- ○ Engineering Technology
- ○ Computer Science
- ○ Math
- ○ Others specify

Are you a ---------------?

- ○ Assistant Professor
- ○ Associate Professor
- ○ Professor
- ○ Ful-ltime Instructor
- ○ Part-time Instructor
- ○ Other

Block 1

Instructor Digital Presence

Select all the digital devices you use for teaching purpose.

- ☐ Desktop
- ☐ Laptop
- ☐ Tablet
- ☐ Smartphone
- ☐ E-book reader
- ☐ Gaming console
- ☐ Others specify ________

How would you rate yourself in terms of using technology for teaching purpose?

- ○ Extremely comfortable
- ○ Somewhat comfortable
- ○ Neither comfortable nor uncomfortable
- ○ Somewhat uncomfortable
- ○ Extremely uncomfortable

Block 2

Industry 4.0 skills

Industry 4.0 also known as fourth industry revolution was based on Cyber-Physical systems(CPS). There are nine pillars of the technological advancement in this Industry 4.0, and they comprise the following technologies: Big Data; Autonomous Robots; Simulation; Universal System Integration; Industrial IoT; Cybersecurity; Cloud Computing; Additive Manufacturing and Augmented Reality.

Reference: M. Rüßmann, M. Lorenz, P.Gerbert, M. Waldner, J. Justus, P. Engel, M. Harnisch M. Industry 4.0: The future of productivity and growth in manufacturing industries. [Online] Available at: https://www.bcgperspectives.com/content/articles/engineered_products_project_business_industry_40_future_productivity_growth_manufacturing_industries/ [Acessed 01-Mar-2017].

Have you heard about Industry 4.0?

- ○ Yes
- ○ Maybe
- ○ No

To what extent the following Industry 4.0 pillars (topics/subject areas) get covered/included in the courses you teach? Please list the courses in the textbox provided below.

	Extremely well				Never covered this subject area in my courses
Big Data	○	○	○	○	○
Autonomous Robots	○	○	○	○	○
Simulation	○	○	○	○	○
Universal System Integration	○	○	○	○	○
Industrial IoT	○	○	○	○	○
Cybersecurity	○	○	○	○	○
Cloud Computing	○	○	○	○	○
Additive Manufacturing	○	○	○	○	○
Augmented Reality	○	○	○	○	○

Have you used any software tools that tie specific to the following Industry 4.0 pillars (topics) in your courses? If answered yes, please specify all the software tools/technology used.

	Yes	No
Big Data	○	○
Autonomous Robots	○	○
Simulation	○	○
Universal System Integration	○	○
Industrial IoT	○	○
Cybersecurity	○	○
Cloud Computing	○	○
Additive Manufacturing	○	○
Augmented Reality	○	○

Have you involved students on any collaborative project development that tie specific to the following Industry 4.0 pillars (topics) in your courses? If answered yes, please specify the project title and course name.

	Yes	No
Big Data ☐	○	○
Autonomous Robots ☐	○	○
Simulation ☐	○	○
Universal System Integration ☐	○	○
Industrial IoT ☐	○	○
Cybersecurity ☐	○	○
Cloud Computing ☐	○	○
Additive Manufacturing ☐	○	○
Augmented Reality ☐	○	○

Mention the name of the software tool used in your courses for the following activities in the textbox provided. Also, select the level to which you have used the software tool in your courses.

Note: The word system specified below can be either a hardware system or software system.

Software tools that aid in

	Have not used any software tool	Used them for a specific assignment/project in my course(s)	Used them throughout the coursework
System modeling ☐	☐	☐	☐
Simulation ☐	☐	☐	☐
Visualization ☐	☐	☐	☐
Project planning ☐	☐	☐	☐
Quality control ☐	☐	☐	☐
System design ☐	☐	☐	☐
System testing ☐	☐	☐	☐
Creation of prototypes ☐	☐	☐	☐
Project scheduling ☐	☐	☐	☐
Manufacturing ☐	☐	☐	☐
System development ☐	☐	☐	☐
Optimization ☐	☐	☐	☐
System optimization ☐	☐	☐	☐
Documentation ☐	☐	☐	☐
Others ☐	☐	☐	☐

How did the above specified software tools help you incorporate the Industry 4.0 skills into the coursework?

☐

Select all that apply:

	Atleast in one of my courses	Less than 10% of the courses I have taught so far	Between 10%and 50% of the courses I have taught so far	More than 50% of the courses I have taught so far
I have involved students in interdisciplinary or multidisciplinary projects	○	○	○	○
I have involved students in team based projects	○	○	○	○
I have involved students in hands-on learning experience	○	○	○	○

How well do you think the courses you have taught in your respective degree programs have prepared the students with the following top rated soft skills that align closely with Industry 4.0?

	Extremely competent	Somewhat competent	Neither competent nor incompetent	Somewhat incompetent	Extremely incompetent
Complex problem solving	○	○	○	○	○
Critical thinking	○	○	○	○	○
Creativity	○	○	○	○	○
People management	○	○	○	○	○
Coordinating with others	○	○	○	○	○
Emotional intelligence	○	○	○	○	○
Judgment and decision-making	○	○	○	○	○
Service orientation	○	○	○	○	○

Have you encouraged students to use any software tools in particular to help them with collaborative project development? If yes, please specify.

○ Yes

○ No

Do you think we need to make changes to the existing curriculum in order to address the Industry 4.0 skills in our courses?

○ Yes

○ Maybe

○ No

If you answered yes to the above question how significant will the changes have to be?

○ Major

○ Somewhere in-between

○ Minor

How did the above specified software tools help you incorporate collaborative project development into the coursework?

Are there any new software applications/technologies that you are considering on using in your courses in future that would fill the gap towards Industry 4.0? If yes/maybe, please specify the new applications/technologies that you are considering.

○ Yes

○ Maybe

○ No

In your perspective, what are some of the strengths to the approaches currently followed in the courses you have taught that has helped students develop their Industry 4.0 skills mentioned above?

In your perspective, what are some of the weaknesses to the approaches currently followed in the courses you have taught that could be rectified to help students develop the Industry 4.0 skills mentioned above?

4.2. Student Questionnaire

The Use of Software Tools In Engineering Courses: Towards Industry 4.0 Skill Set and Collaborative Project Development

Student Information and Background

Name:
Leave this field blank if you choose to remain anonymous.

Choose your major:
- Mechanical Engineering
- Civil Engineering
- Electrical Engineering
- Environmental Engineering
- Engineering Technology
- Computer Science
- Math
- Others specify

Are you a --------------?
- Undergraduate - Freshman
- Undergraduate - Sophomore
- Undergraduate - Junior
- Undergraduate - Senior
- Masters

Select your gender:
- Male
- Female
- Non-binary / third gender
- Prefer not to say

Block 1

Student's Digital Presence

Select all the digital devices you own from the following list:

- ☐ Desktop
- ☐ Laptop
- ☐ Tablet
- ☐ Smartphone
- ☐ E-book reader
- ☐ Gaming console
- ☐ Others specify ______

Select all the digital devices you use for educational purpose.

- ☐ Desktop
- ☐ Laptop
- ☐ Tablet
- ☐ Smartphone
- ☐ E-book reader
- ☐ Gaming console
- ☐ Others specify ______

How frequently do you use the above mentioned digital devices to do the following activities?

	Daily	4-6 times a week	2-3 times a week	Once a week	Never
To contact an instructor, student, and/or any individual within the WT system	○	○	○	○	○
To complete course assignments and projects	○	○	○	○	○
To collaborate with others students in the class	○	○	○	○	○
To check the course postings in WTCLASS	○	○	○	○	○
Others specify ______	○	○	○	○	○

Block 2

Industry 4.0 skills

Industry 4.0 also known as fourth industry revolution was based on Cyber-Physical systems(CPS). There are nine pillars of the technological advancement in this Industry 4.0, and they comprise the following technologies: Big Data; Autonomous Robots; Simulation; Universal System Integration; Industrial IoT; Cybersecurity; Cloud Computing; Additive Manufacturing and Augmented Reality.

Reference: M. Rüßmann, M. Lorenz, P.Gerbert, M. Waldner, J. Justus, P. Engel, M. Harnisch M. Industry 4.0: The future of productivity and growth in manufacturing industries. [Online] Available at: https://www.bcgperspectives.com/content/articles/engineered_products_project_business_industry_40_future_productivity_growth_manufacturing_industries/ [Acessed 01-Mar-2017].

Have you heard about Industry 4.0?

- ○ Yes
- ○ Maybe
- ○ No

To what extent have you been exposed to the following Industry 4.0 pillars (topics) in your courses?
Please list the courses in the textbox provided below.

	Extremely well				I have not heard about this topic
Big Data	○	○	○	○	○
Autonomous Robots	○	○	○	○	○
Simulation	○	○	○	○	○
Universal System Integration	○	○	○	○	○
Industrial IoT	○	○	○	○	○
Cybersecurity	○	○	○	○	○
Cloud Computing	○	○	○	○	○
Additive Manufacturing	○	○	○	○	○
Augmented Reality	○	○	○	○	○

Have you used any software tools that tie specific to the following Industry 4.0 pillars (topics) in your courses? If answered yes, please specify the software tools/technology used.

	Yes	No
Big Data	○	○
Autonomous Robots	○	○
Simulation	○	○
Universal System Integration	○	○
Industrial IoT	○	○
Cybersecurity	○	○
Cloud Computing	○	○
Additive Manufacturing	○	○
Augmented Reality	○	○

Have you worked on any projects that tie specific to the following Industry 4.0 pillars (topics) in your courses? If answered yes, please specify the project title and course name.

	Yes	No
Big Data	○	○
Autonomous Robots	○	○
Simulation	○	○
Universal System Integration	○	○
Industrial IoT	○	○
Cybersecurity	○	○
Cloud Computing	○	○
Additive Manufacturing	○	○
Augmented Reality	○	○

Mention the name of the software tool used in the textbox provided below each category. Also, select the level to which you have used the software tool in your courses.

Note: The word system specified below can be either a hardware system or software system.

Software tools that aid in

	Have heard about them in atleast one of my courses, but not used them	Used them for a specific assignment/project in my course(s)	Used them throughout the coursework	Have never heard about them or used them in any of my courses
System modeling	☐	☐	☐	☐
Simulation	☐	☐	☐	☐
Visualization	☐	☐	☐	☐
Project planning	☐	☐	☐	☐
Quality control	☐	☐	☐	☐
System design	☐	☐	☐	☐
System testing	☐	☐	☐	☐
Creation of prototypes	☐	☐	☐	☐
Project scheduling	☐	☐	☐	☐
Manufacturing	☐	☐	☐	☐
System development	☐	☐	☐	☐
Optimization	☐	☐	☐	☐
System optimization	☐	☐	☐	☐
Documentation	☐	☐	☐	☐

Select all that apply:

	Atleast in one of my courses	Less than 10% of the courses I have taken so far	Between 10%and 50% of the courses I have taken so far	More than 50% of the courses I have taken so far
I have worked on interdisciplinary or multidisciplinary projects	○	○	○	○
I have worked on team based projects	○	○	○	○
I have had hands-on learning experience	○	○	○	○

How well do you think the courses you have taken in your respective degree programs have prepared you with the following top rated soft skills that align closely with Industry 4.0?

	Extremely competent	Somewhat competent	Neither competent nor incompetent	Somewhat incompetent	Extremely incompetent
Complex problem solving	○	○	○	○	○
Critical thinking	○	○	○	○	○
Creativity	○	○	○	○	○
People management	○	○	○	○	○
Coordinating with others	○	○	○	○	○
Emotional intelligence	○	○	○	○	○
Judgment and decision-making	○	○	○	○	○
Service orientation	○	○	○	○	○

In your perspective, what are some of the strengths to the approaches currently followed in the courses you have taken that has helped you develop the Industry 4.0 skills mentioned above?

In your perspective, what are some of the weaknesses to the approaches currently followed in the courses you have taken that could be rectified to help you develop the Industry 4.0 skills mentioned above?

Block 3

Collaborative project development skills

Have you worked on collaborative project development or team based project development in alteast one of your courses?

○ Yes

○ No

Select all that apply:
I have used the following communication apps to aid collaborative project development or team based project development.

	Always	Most of the time	About half the time	Sometimes	Never
WTCLASS	○	○	○	○	○
Microsoft Teams	○	○	○	○	○
Slack	○	○	○	○	○
Discord	○	○	○	○	○
Join.me	○	○	○	○	○
Skype	○	○	○	○	○
Google Hangouts	○	○	○	○	○
Zoom	○	○	○	○	○
Others: Mention everything else that you have used separated by commas	○	○	○	○	○

Select all that apply:
I have used the following cloud storage platform to aid collaborative project development or team based project development.

	Always	Most of the time	About half the time	Sometimes	Never
OneDrive	○	○	○	○	○
Google Drive	○	○	○	○	○
Dropbox	○	○	○	○	○
Others: Mention everything else that you have used separated by commas	○	○	○	○	○

Select all that apply:
I have used the following project management apps to aid collaborative project development or team based project development.

	Always	Most of the time	About half the time	Sometimes	Never
WTCLASS	○	○	○	○	○
GitHub	○	○	○	○	○
Jira Cloud	○	○	○	○	○
Stack Overflow	○	○	○	○	○
Backlog	○	○	○	○	○
Stand-Bot	○	○	○	○	○
Trello	○	○	○	○	○
Microsoft Project	○	○	○	○	○
Primavera P6	○	○	○	○	○
Others: Mention everything else that you have used separated by commas	○	○	○	○	○

Select all that apply:
I have used the following project design/development apps to aid collaborative project development or team based project development.

	Always	Most of the time	About half the time	Sometimes	Never
GitHub	○	○	○	○	○
REVIT	○	○	○	○	○
Autodesk Product Design Suite	○	○	○	○	○
MATLAB	○	○	○	○	○
CATIA	○	○	○	○	○
ZW3D	○	○	○	○	○
MechDesigner	○	○	○	○	○
PTC Creo	○	○	○	○	○
Primavera P6	○	○	○	○	○
CAD Inventor	○	○	○	○	○
Fusion 360	○	○	○	○	○
ANSYS	○	○	○	○	○
SolidWorks	○	○	○	○	○
Adreno IDE	○	○	○	○	○
PSpice	○	○	○	○	○
PSCAD	○	○	○	○	○
LabView	○	○	○	○	○
ArcGis	○	○	○	○	○
Others: Mention everything else that you have used separated by commas	○	○	○	○	○

In your perspective, what are some of the strengths to the approaches currently followed in the courses you have taken that has helped you with collaborative software development?

In your perspective, what are some of the weaknesses to the approaches currently followed in the courses you have taken that could be rectified to help you work more with collaborative software development?