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IoTrain

Master of Engineering in Internet of Things

< Market needs analysis and goal definition >

D1.2

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Contributors

Name	Organization
The stakeholder institutions responded to the market needs survey	Listed in Section 2.2, Table 1

Disclaimer

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1 Introduction

1.1 The General Procedure

This report is related to the Deliverable number 1.2 of Work package 1 entitled “Market needs analysis and goal definition” of IoTrain Project [1, 2]. The report summarizes a variety of activities that have been performed for identifying market needs in IoT sector, in Iran, Iraq and Romania. For this purpose, various data collection procedures have been performed. An overview of the performed procedures is presented at Figure 1. In the first step, we collected the data from some Iranian, Iraqi and European industries, which benefit from IoT [5]. Afterwards, we analysed inputs from each partner, which is presented in section 2.4 as summary and analysis of IoT-related Questions.

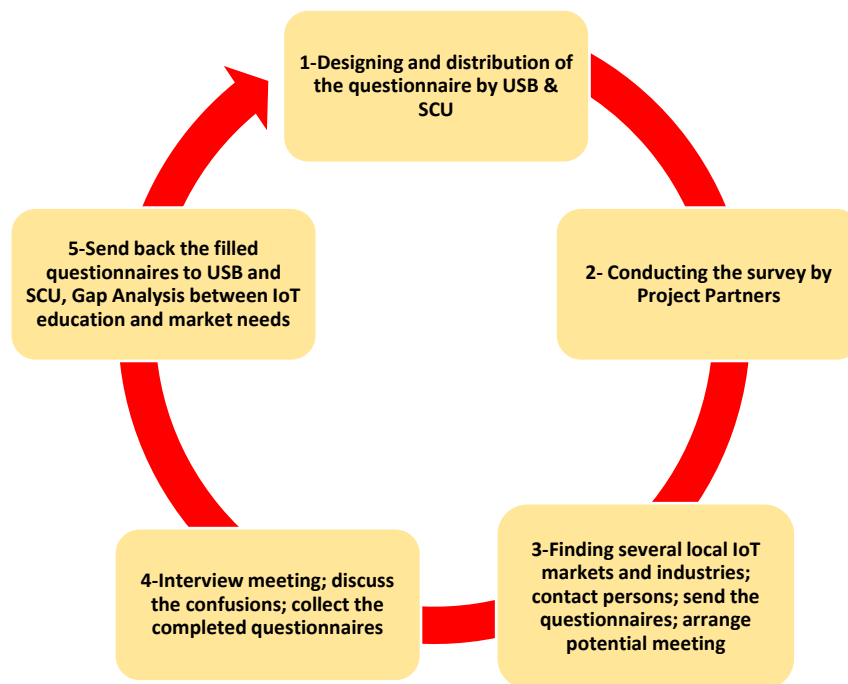


Figure 1 - The workflow of the IoT market needs analysis survey in the steps; Designing and distribution of the questionnaire; Conducting the survey by project partners; Gap Analysis between IoT education and market needs

1.2 Internet of Things (IoT) and the IoTrain Project

By definition, the Internet of Things (IoT) describes the network of physical objects, a.k.a. “things”, that are embedded with sensors, software, network and other technologies connecting and exchanging data with transmission and control devices and systems over the Internet. These devices range from household objects to complex industrial systems [3, 4]. IoT is an application domain that integrates different technological and market sectors and is actively shaping both the industrial and consumer worlds and finds its way to every business and consumer domain from retail to healthcare, from manufacturing to logistics. According to Fortune Business Insights [12], the global IoT market was close to \$380bn in 2021, with an annual growth rate (CAGR) of over 25%, marching towards 2 trillion dollars by 2030. This huge market is further divided into sections, the largest ones including the financial sector, retail, government, manufacturing, healthcare etc. Moreover, in terms of IoT platforms and solutions, Cloud platforms, networking technologies and make a huge part of the platform sector. With Internet of Things forming the foundation of future smart societies, educating and training skilled workforce is essential to keep the society technologically competent [12].

The IoTrain project is an EU-funded consortium-based project towards capacity building in higher education (CBHE) in Iran and Iraq to establish a master of IoT program in these countries with world HE and technical standards. IoTrain aims at enhancing the IoT skills of the Iranian and Iraqi engineers (those with at least a bachelor's degree), by developing and strengthening the higher education (HE) training materials and curricula to help the industries towards smart and connected societies [1, 2].

1.3 Purpose of the document

The aim of the whole IoTrain project is to provide grounds for increasing the employability of university graduates with IoT expertise in the local market. As such, the project owes the market an in-depth survey and analysis of the existing employment opportunities and the most needed skills and expertise in this field, hence the aim of D1.2 deliverable. A questionnaire was prepared (Appendix 1 and [5]) to evaluate the needs of various market sectors, including industry, to IoT related expertise, in order to propose the most relevant skills into the prospective educational curricula in higher education institutions. Each IoTrain project partner (PA) did this survey from several institutions in different market sectors. The collected responses are used to analyze the most needed skills and the corresponding expertise levels, plus the likeliness of various stakeholders hiring skilled workers with IoT-related expertise for immediate and 5-year time periods.

1.4 Relation to other deliverables in WP1

As stated in the project description [2], the aim of this work package 1 (WP1) is to carry out the scoping, needs analyses, initial planning for IoT master course development and this is a prerequisite for WP2. In D1.1, a systematic comprehensive analysis of existing academic programs, courses, and technical skills related to IoT regionally and internationally is performed. Based on the description of the WP1, the following tasks as deliverables are planned [1,2]:

D1.1: Evaluate the existing courses of each consortium partners to identify the needed courses and expertise.

D1.2; (which is this report), Identifies the current and future market requirements to make sure that IoTrain outcomes meet the market requirements. This report will be used to find the requirements and demands of industry and private sectors in IoT considering the most recent advances in the field of IoT both from technological parts and infrastructure, and staff.

D1.3: IoT Requirement and Market Needs Analysis Workshop. In this workshop aims at discussing, and summarizing the findings of the IoTrain market needs analysis survey (D1.2). At this event, after presenting a summary of the project findings, a number of stakeholder organizations will present keynote speeches, including the current applications of IoT in their organization, as well as their demand for IoT related expertise.

D1.4; Gap analysis: Identify any shortcomings of courses or expertise in all partners and make the necessary plan to compensate these shortcomings.

D1.5: Map the requirements and the courses with the Bologna system, to create a "Course Development Plan" as the roadmap and planning for course development activities.

1.5 Relation to other work packages

The results of D1.2 will be used in D1.4 (gap analysis) to analyze the gap between education status and market needs, and in deliverable D1.5 (course development plan) as well as WP2 (Development) to prepare and tailor the program details, training materials and modules in the proposed master of IoT program, in order to fulfil the requirements and address the shortcomings present in Iran/Iraq higher education systems. The results of deliverable D1.5 will be used for the course development hackathon (D2.1) and as well as for further activities in this regard.

1.6 Terminology

The abbreviations of some technical keywords used in this report are:

Computer Hardware (HW)

Computer Software (SW)

Internet of Things (IoT)

Telecommunications (COM)

Electrical and Electronic Engineering (EEE)

Computer Science (CS)

Big Data Analytics (BIG)

Machine Learning (ML) and

Artificial Intelligence (AI)

More keywords are presented as expertise abbreviations in Table 2 and some technical topics in Table 4.

1.7 Motivation

D1.2 is fundamental step in addressing the needs and fulfilling the gaps in HE training in the domain of IoT with respect to the demands and skills needed by the market sector and industry and by considering the state-of-the-art technological progress in IoTrain. This deliverable contains information about the institutions, including their location and workforce and indicating the relevance of various IoT related application markets to their operations and activities in order to propose the most relevant skills into the prospective educational curricula in HE institutions.

2 Analysing the Collected Questionnaires

2.1 The Survey Overview

The survey questionnaire which used for collecting data employing for the analysis and results in this report, can be seen in Appendix 1 [5]. For designing the questionnaire, a literature review [6-11] was performed aiming to find the key skills and technologies related to IoT, which are listed in Appendix 2. Afterward, having some meeting with academics from SCU and USB, the skills and the technologies, which are most related to IoT are prioritized. The survey questionnaire is designed based on an initial literature survey that indicates a set of electrical and computer engineering technical areas forming the fundamentals of IoT and framing IoT technologies.

The survey contains three main sections: the introduction part provides information on the goals and aspects of the IoTrain project as well as some guidelines on how to fill the questionnaire. The institutional information section collects information about the institutions, including their location and workforce. The market sector section, asks the responders to indicate the relevance of various IoT related application markets to their operations and activities.

Following the institutional information sections comes the main section of the questionnaire, containing a number of IoT related questions assessing the current IoT workforce as well as work skill requirements for relevant activities. The summary and analysis of IoT related questions is described in Section 2.4. These questions are organized in two subsections. Question 1 is related to the responder's familiarity with IoT. Question 2 evaluates the current Use of IoT technologies in the institution.

Questions 3-6 are general questions about IoT related expertise in the institution. Question 7 lists 10 general areas of expertise, asking the responder to provide the approximate number of current employees with such expertise. Question 8, which is one of the most important questions in this survey, lists 21 fundamental technical areas related to IoT at a finer scale (as described previously), asking two main questions about each:

What is the likelihood of your institution requiring such expertise, immediately, and in the next 5 years (expressed by percentage)?

Which skill levels are such new employees expected to possess?

These technical topics (areas) are described more in Section 2.4.

The following sections of the report summarize and analyse the responses collected from various institutions across partner countries. As depicted in Figure 1, the partner institutions were asked to distribute the forms among their local market players, interview the responders if needed, and collect the filled forms for analysis. A total of 52 forms were returned from institutions in Iran, Iraq and Romania, as listed in Table 1.

2.2 Institutional Information

The filled questionnaire received from 52 different stakeholders, as listed in Table 1. In addition, Figure 2 highlights their major activity areas as well as their geographical locations. In particular, Figure 2 (a) presents the most-relevant market sector for the surveyed market players. More details about the questionnaire and survey specifics can be found in the next subsections.

IT/Software, Oil & Gas, Utilities (such as water/electricity/telecom/gas production and distribution), and Smart (IoT-based) platforms are the most frequent market sectors among the surveyed institutions. These areas are in fact very relevant to this project, as IoT technologies play a major role in their development of production and service.

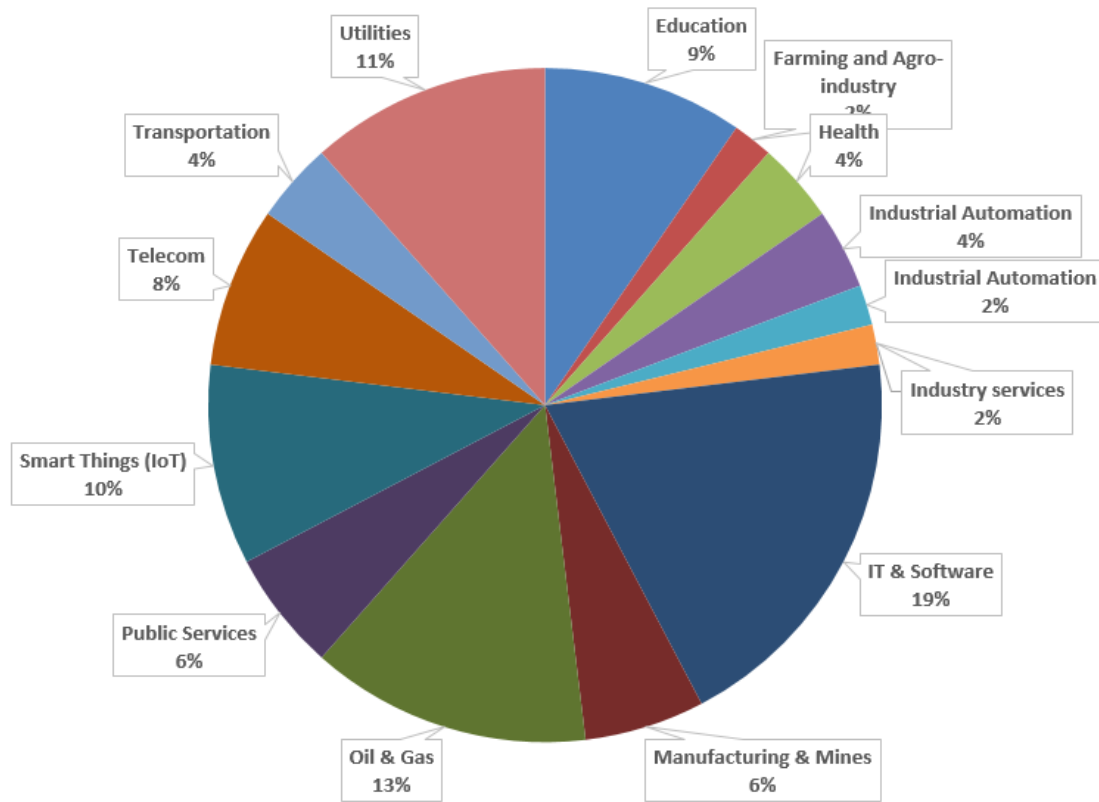
Table 1 - List of stakeholder institutions responded to the market needs survey

No.	Institution	Country / City	Main Activity Area
1	Shahid Chamran University of Ahvaz	Iran/Ahvaz	Higher Education
2	Jonoub Railways	Iran/Ahvaz	Transportation
3	The Railways of the Islamic republic of IRAN	Iran/Tehran (Country-wide operations)	Transportation
4	Ahvaz Electric	Iran/Ahvaz	Utilities
5	Khouzestan Steel Company (KSC)	Iran/Ahvaz	Manufacturing & Mines
6	National Sugarcane & By-products Development Company	Iran/Ahvaz (Country-wide operations)	Farming and Agro-industry
7	Paanaak	Iran/Ahvaz	Smart Things (IoT)
8	Energy Researchers Ariana (ERA)	Iran/Ahvaz	Oil & Gas
9	Iman Pouya Shabakeh	Iran/Ahvaz	IT & Software

10	Pars Sakhtar	Iran/Tabriz	Utilities
11	Manir co.	Iran/Tabriz	IT & Software
12	Asti Automation	Romania/Bucharest	Industrial Automation
13	Ontic Control Srl	Romania/Bucharest	Industrial Automation
14	SIV Electro Concept srl	Romania/Bucharest	Utilities
15	Faraz Novin	Iran/Ahvaz	Oil & Gas
16	Iran Diesel Engine Manufacturing (IDEM)	Iran/Tabriz	Manufacturing & Mines
17	National Iranian Drilling Company (NIDC)	Iran/Ahvaz (Country-wide operations)	Oil & Gas
18	Iran Sport For All Federation (ISFAF)	Iran/Tabriz	Public Services
19	Telecommunication Company of Iran	Iran/Tehran (Country-wide operations)	Telecom
20	Gas Transmission Co	Iran/Tabriz	Oil & Gas
21	Khouzestan Telecommunication Company	Iran/Ahvaz	Telecom
22	Tabriz University	Iran/Tabriz	Education
23	Khouzestan Water and Power Authority (KWPA)	Iran/Ahvaz	Utilities
24	Telecommunication Infrastructure Company of Khouzestan	Iran/Ahvaz	Telecom
25	Behin sayar Co	Iran/Zanjan	IT & Software
26	Kahroba chip	Iran/Zanjan	IT & Software
27	Target, data, intelligence	Iran/Zanjan	IT & Software
28	Amn Pardazan Technology Co	Iran/Zanjan	IT & Software
29	Aftab security software	Iran/Zanjan	IT & Software
30	Sarv Saba Information Technology Company	Iran/Zanjan	IT & Software
31	Tosee Hamrah Noyan	Iran/Zanjan	IT & Software
32	Department of Education	Iran/Tabriz	Education
33	Ur Nansha Company for General Trading	Iraq/Baghdad	Industry services
34	General Company for Electronic Systems	Iraq/Baghdad	Industrial Automation

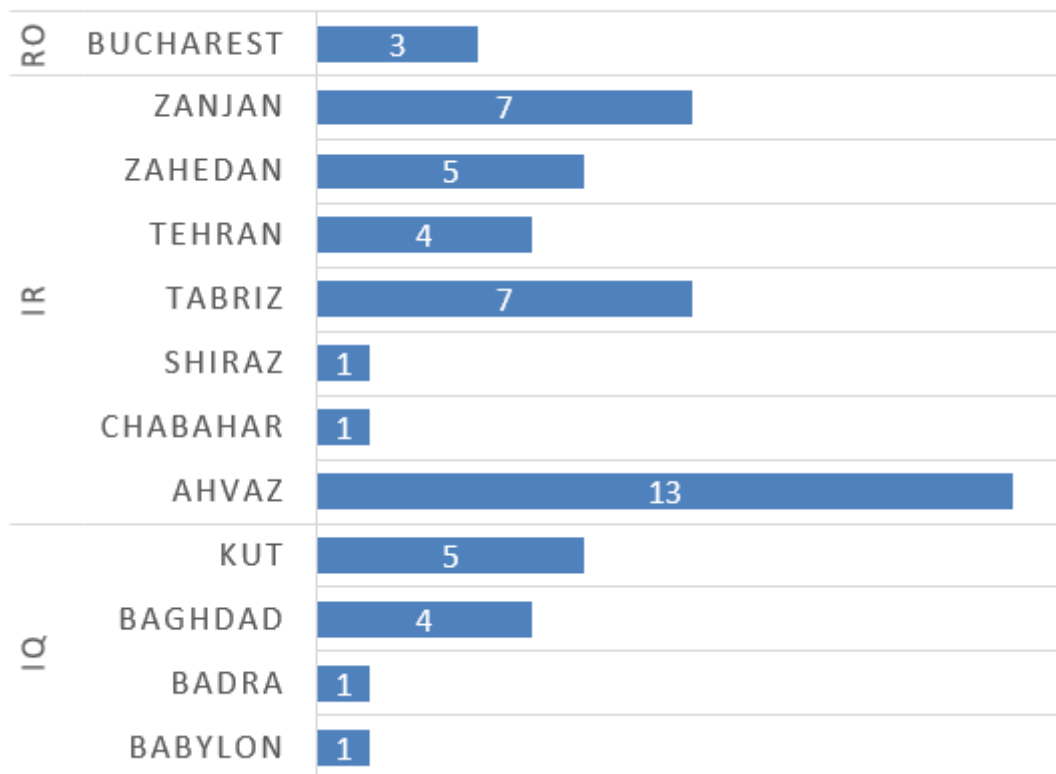
35	Tis new town development company	Iran/Chabahar	Public Services
36	Wasit Chamber of Commerce	Iraq/Kut	Public Services
37	Asiacell (Kut office)	Iraq/Kut	Telecom
38	Midland Oil company	Iraq/Baghdad	Oil & Gas
39	Gazprom neft badra	Iraq/Badra	Oil & Gas
40	The National Center for Water Resources Management	Iraq/Baghdad	Utilities
41	Wasit Health Department	Iraq/Kut	Health
42	Etihad Food Industries Co. Ltd.	Iraq/Babylon	Manufacturing & Mines
43	Office of Electricity in Wasit	Iraq/Kut	Utilities
44	Al-Waha Petroleum Co.,Ltd.	Iraq/Kut	Oil & Gas
45	Radin Knowledge & Technology Development Company	Iran/Tehran	Education
46	Idea Land Smart Solution Co Ltd	Iran/Tehran	IT & Software
47	University of Shiraz	Iran/Shiraz	Education
48	Zahedan University of Medical Science	Iran/Zahedan	Health
49	Amica	Iran/Zahedan	Smart Things (IoT)
50	Javid Green Energy	Iran/ Zahedan	Smart Things (IoT)
51	Parand Novin Company	Iran/Zahedan	Smart Things (IoT)
52	Behbood rayan	Iran/Zahedan	Smart Things (IoT)

Stakeholder's Most-relevant Market Sector



(a)

GEOGRAPHICAL DISTRIBUTION OF THE RESPONDERS





(b)

Figure 2- Stakeholders' (a) Statistics of most-relevant market sectors (based on answers to part 2 of the questionnaire) and (b) Geographical locations (based on answers to part 2 of the questionnaire)

Statistically looking, 13 of these institutions are located in the Khuzestan province of Iran (Ahvaz), which is one of the most industrialized locations in the country, followed by East-Azerbaijan province (Tabriz, 7 institutions) and Zanjan (7 institutions). In addition, eleven Iraqi stakeholders from various cities responded. We also had three companies from Bucharest, Romania.

Figure 3 shows stakeholders' years of business in addition to their years of experience with automation and IoT. Over 40% of these stakeholders have more than 25 years business experience.

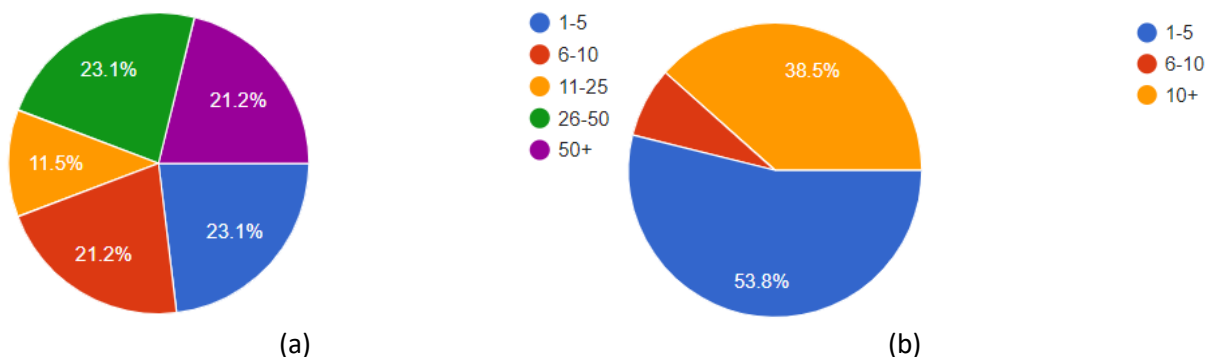


Figure 3- Stakeholders' number of years (a) in business, (b) using automation or IoT

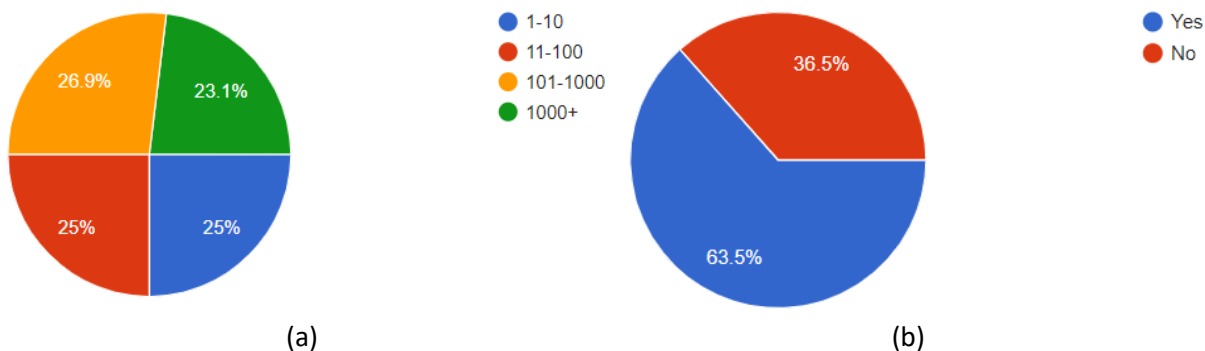


Figure 4 - Stakeholders' (a) Size of workforce, (b) Current status of using IoT

As shown in Figure 4, most of the responding institutions have a relatively large workforce, with 50% having more than 100 employees, and most of them are already using IoT technologies, hence familiar with the prospects of employing IoT technologies and skilled workforce.

2.3 Market Sectors

The market sector section, asks the responders to indicate the relevance of various IoT related application markets to their operations and activities. The answers are collected on a scale of (0-5), among the following list of pre-defined sectors, or other as specified by the responders.

- Oil & Gas
- Manufacturing and Mines
- Governmental and Public Services
- Education
- Smart Things (Cities / Homes / Fields)
- Transportation
- Utilities (Electric, Water, Gas, Telecom)
- Farming and Agro-industry
- Health & Sports

The responders are allowed to rank all sectors based on their business relevance to that particular sector. As such, a responder may mark multiple sectors as their market sector, using a relevance scale from 0-5 (color-coded as shown in Figure 5, with 0 (blue) meaning irrelevant and 5 (sky blue) meaning very relevant). While Figure 2 (a) provided a summary of most relevant market sector for the stakeholders, Figure 5 shows the spectrum of their choices as described above.

Among the stakeholders that need IoT application, it can be seen that sectors such as hotel industry, electricity generation and distribution, computer software and security, consider IoT with high priority.

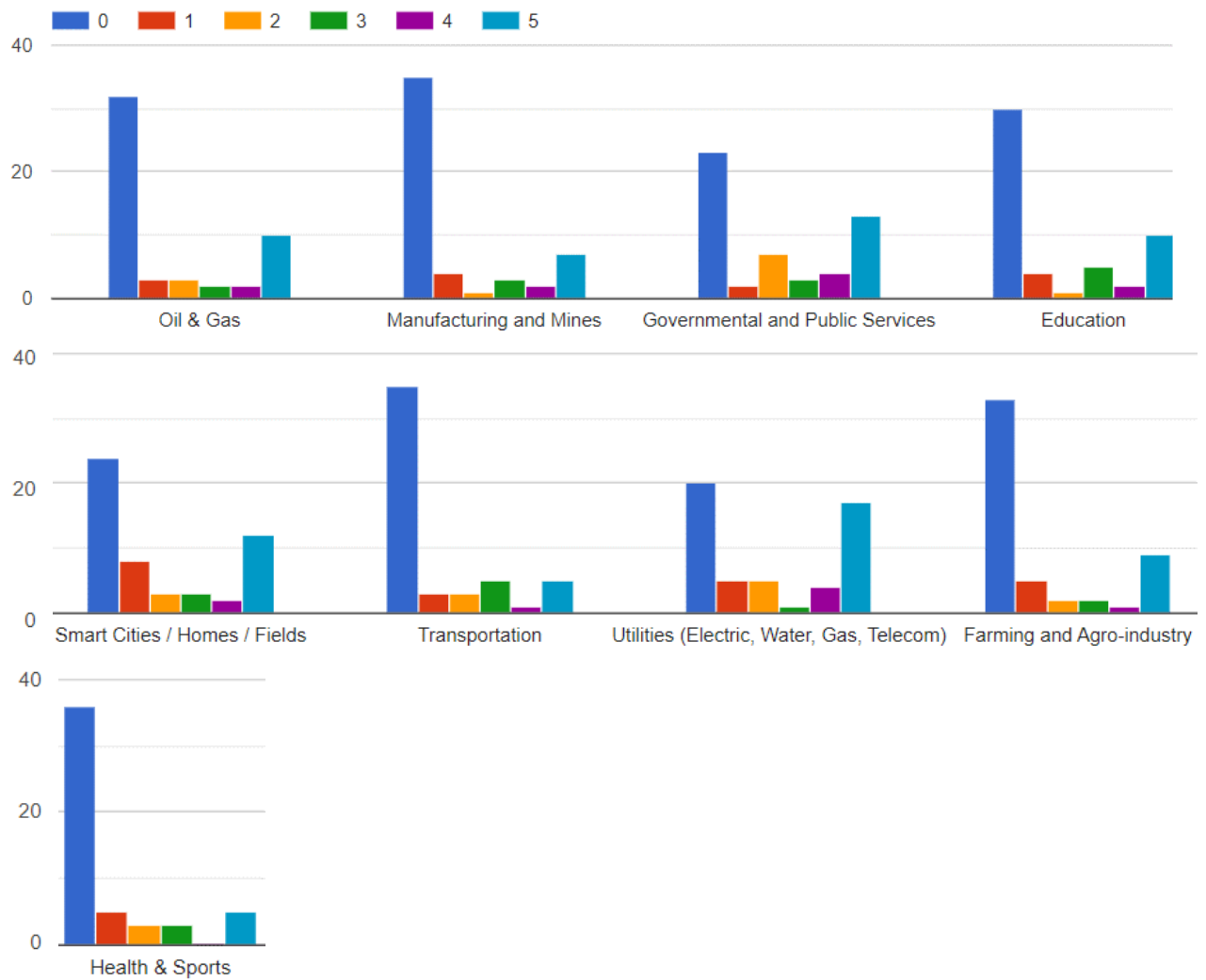


Figure 5- IoT related applications in different Industrial market sectors

2.4 Summary and Analysis of IoT-related Questions

This section presents the statistical analysis from the answers provided in the received questionnaires.

2.4.1 Question 1 – The responder’s familiarity with IoT

Here is the question text, and the summary of answers is provided in Figure 6.

Question 1-How much are you familiar with the IoT concept and applications (on the scale of 0 to 10)? (Put 0 if you have not heard of the term. Put 10, if you are fully aware of what IoT is and what are its benefits and applications).

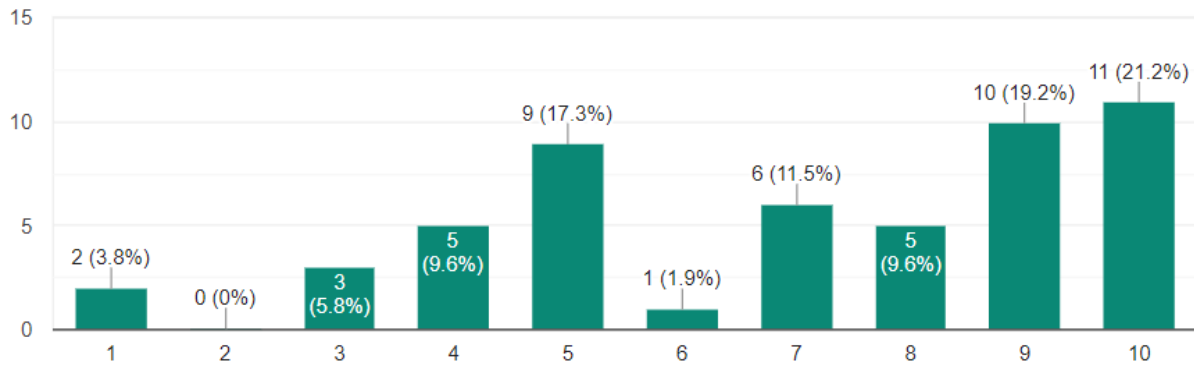


Figure 6 - Responders' level of familiarity with IoT, with response to concept and applications (on the scale of 0 to 10)

Further analysing the data in Figure 6, we can calculate a weighted average of the responders' familiarity level using the following formula:

$$WA = \frac{\sum_{i=1}^{10} c_i \times i}{N}$$

where, c_i is the number of responders with familiarity level i , and $N=32$ being the number of responders. After calculation we reach the weighted average of $WA = 7$ which indicates a pretty high average confidence among the responders, given minimal levels of IoT education and technology utilization in the surveyed areas.

2.4.2 Question 2 – Current Use of IoT

Here is the question text, and the summary of answers is provided in Figure 3 (b) as well as Figure 7 (a).

Question 2-Does your institution currently use connected objects, as in IoT, in products, services, or manufacturing processes?

The summary of responses to this question are shown in Figure 4 (b). Some responders have also provided express answers to questions 1 & 2, showing their current IoT solution usage, some establishing IoT labs and some pilot (rarely production) IoT solutions in their institutions, which indicates **two hypotheses**:

1. The utilization of IoT in Iranian and Iraqi stakeholders is still in its infancy, while many use PLC and DCS, which can be transformed onto IoT platforms.
2. There is a considerable interest in developing IoT-based operations in various market sectors. Some stakeholders such as telecom and SW companies provide infrastructure and tools for IoT, and can be the main absorbers of the graduated workforce.

2.4.3 Question 3 – Future IoT Use Considerations

Question 3-Does your institution consider using IoT technologies in products, services, or manufacturing processes in the future?

Yes No

With results shown in Figure 7 (b), some of the clearly expressed future use cases of IoT in stakeholders include:

- Transport
- Greenhouse automation
- Smart field
- Production failure and fault diagnosis
- Inventory integration
- Device and Operational monitoring and safety
- Improving the quality of services

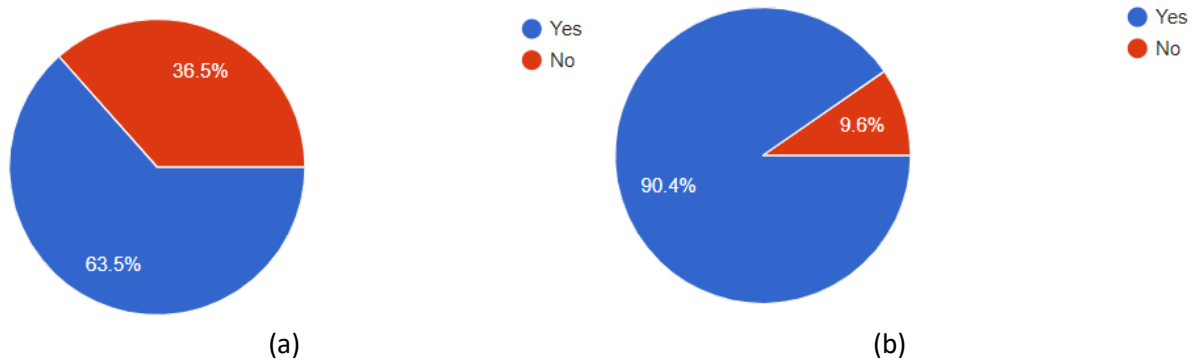


Figure 7 - Use of IoT Technologies; a) Current; b) Future

2.4.4 **Question 4** - Approved Hiring Requirement

This question deals with the availability of an approved requirement guideline for employment in the surveyed institutions. The significance of such guideline is the indication of an established employment procedure in the institution, which can potentially be utilized or amended to hire graduates with new skillsets such as those graduating from the proposed IoT MEng program. The question text is shown below, followed by the responses' chart in Figure 8. The results of this question show that the majority of responders (three quarter), either already have or are preparing / planning an approved hiring requirement guideline for their employees.

Question 4-Is there an approved employee requirement guideline for hiring new workforce in your institution?

Yes No Under preparation Planning to prepare

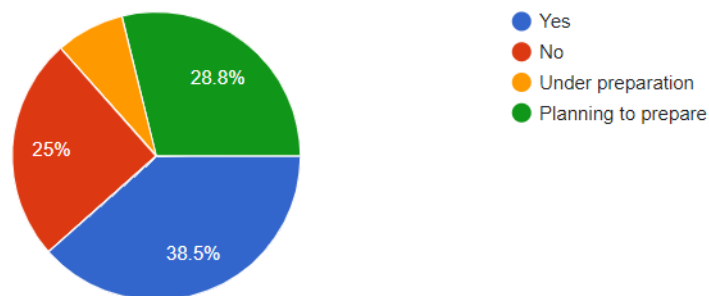


Figure 8 – Availability of a Hiring Requirement guideline

2.4.5 Question 5 – Likelihood of Requiring IoT Expertise

This question gauges the responders' assessment of current and future (5-year) demand for IoT expertise, with summary of responses depicted in Figure 9, each bar showing the number of institutions with the respective answer:

Question 5-How likely do you see your institution in need of IoT related expertise

a) right now?

Highly likely Likely Unlikely Highly unlikely I am not sure!

b) in the next 5 years?

Highly likely Likely Unlikely Highly unlikely Not sure!

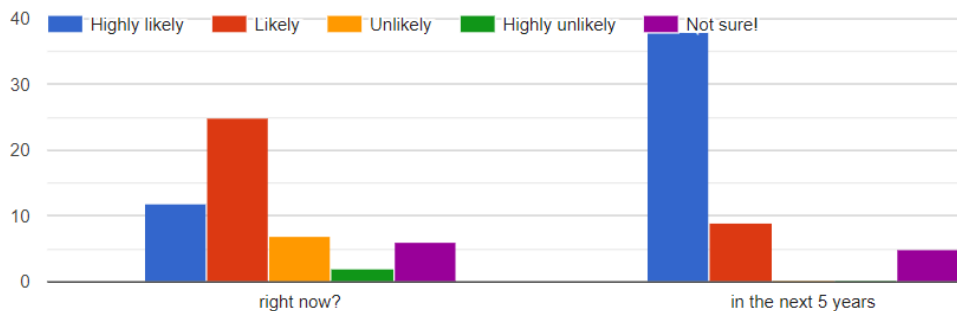


Figure 9 - IoT Expertise Demand

In summary, **over 70%** of the institutions are expecting to hire new IoT skilled workers **soon**, and **over 90%** of them are expecting to hire in the **next 5 years**. The summary as well as the expressed responses indicate a great and developing demand for IoT related skills in various market sectors present in this survey, from manufacturing sector requiring the expertise for their production and safety, to educational institutions in need of IoT experts for elevating their courses' quality, and SW and telecom companies for improving their services.

2.4.6 Question 6 – The Quantity of IoT Workforce Employment

This question roughly gauges the number of IoT experts needed in the surveyed institutions, immediately and in the next 5 years.

Question 6-How many IoT related skilled workers do you anticipate your institution hiring

a) right now?

More than 100 50-100 10-50 1-10 I am not sure!

b) in the next 5 years?

More than 100 50-100 10-50 1-10 I am not sure!

As shown in Figure 10, **nearly 35% of the responders** do not have a clear assessment of the range of IoT skilled workers needed in their institutions at the moment, while **over 75% of them** provide such estimate for the next 5-year period.

Near **half of the responders indicate the range of 1 to 10 new workers required at the moment**, while **nearly half of them demanding at least 10, to even over 100 new IoT expert employments over the next 5 years**, despite strict governmental hiring restrictions in many of these institutions.

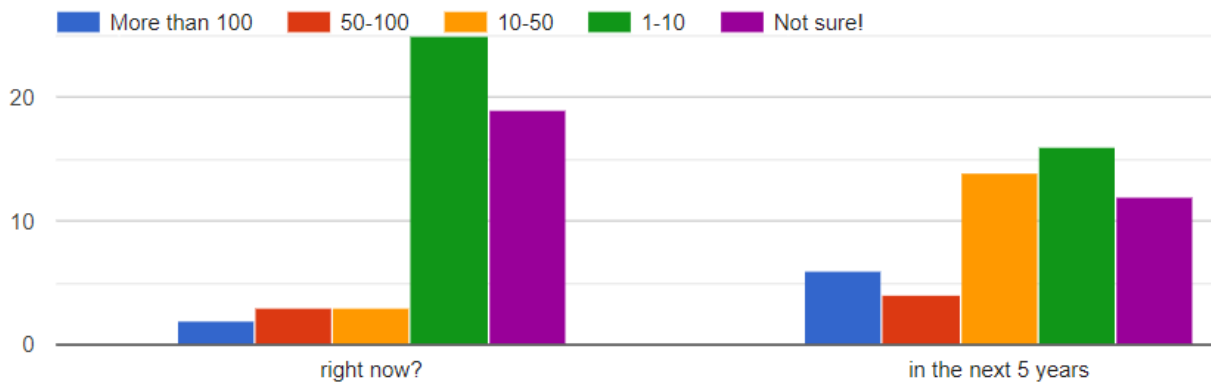


Figure 10 - Quantity of IoT experts in demand

2.4.7 Question 7 – Number of existing employees per areas of expertise

Question 7- The following lists some expertise, related to IoT. Indicate the approximate number of employees in your institution with skills related to each expertise.

This question intends to provide a view of the current skilled workforce in the set of institutions based on an spectrum of electrical and computer engineering expertise generally related to IoT. A list of ten different technical areas are provided in the following subsections. Figure 11 to Figure 20 show the number of employees with expertise in each technical area on the horizontal axes, and the number of institutions with that number of employees, on their vertical axes. For example, Figure 11 shows that 5 institutions have about 10 employees with computer hardware expertise, while only 2 have around 15 hardware experts.

To summarize these results, we calculate the weighted average for the number of workforce employees with these skills across the surveyed institutions. This weighted average is calculated by aggregating the product of each number on the horizontal axis by its vertical axis value, as shown in Figure 21.

2.4.7.1 Computer Hardware

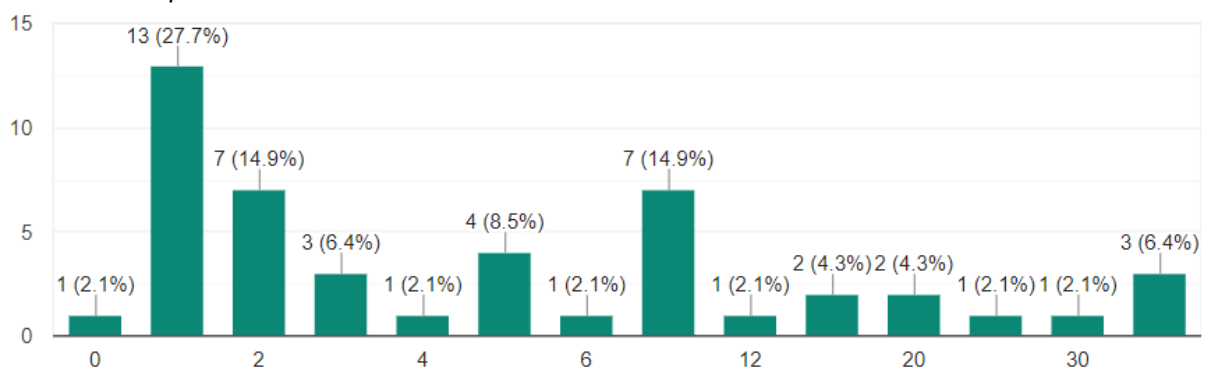


Figure 11 - Number of employees with computer hardware expertise, the number of employees with this expertise on the horizontal axis, and the number of institutions with those employees on the vertical axis.

2.4.7.2 Computer Software

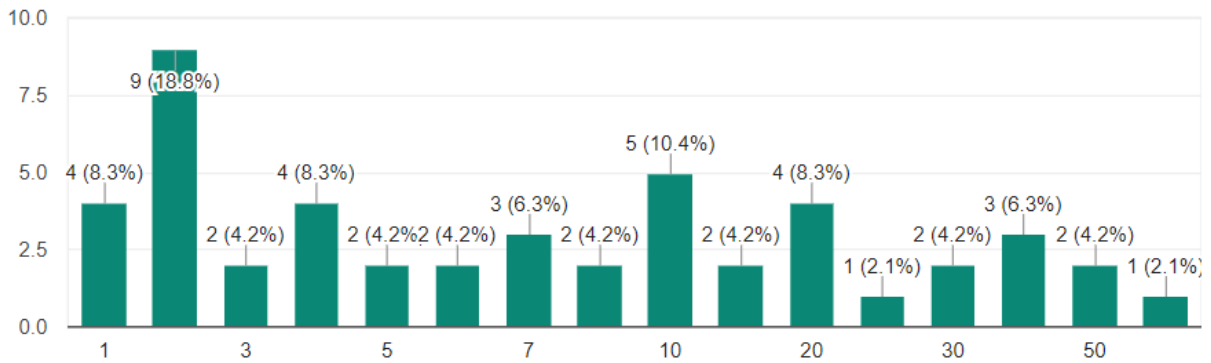


Figure 12 - Number of employees with computer software expertise, the number of employees with this expertise on the horizontal axis, and the number of institutions with those employees on the vertical axis.

2.4.7.3 Computer Networks and Distributed Systems

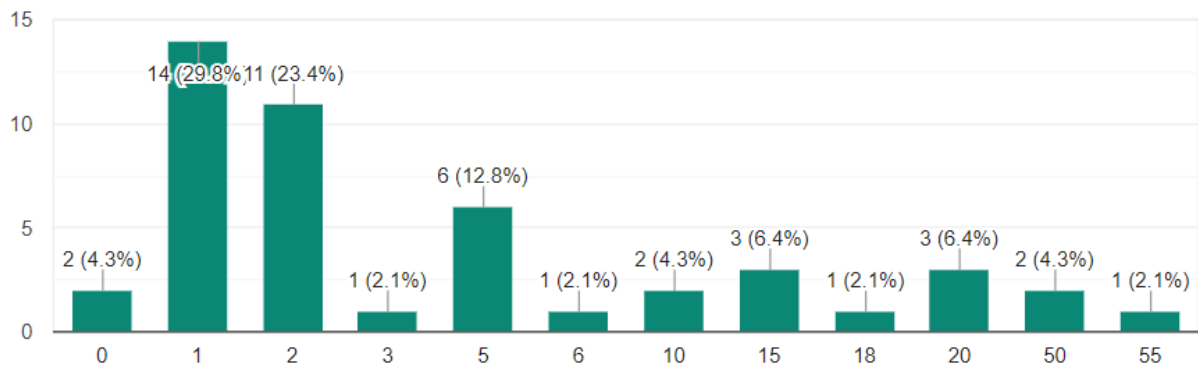


Figure 13 - Number of employees with computer networks expertise, the number of employees with this expertise on the horizontal axis, and the number of institutions with those employees on the vertical axis.

2.4.7.4 Telecommunications

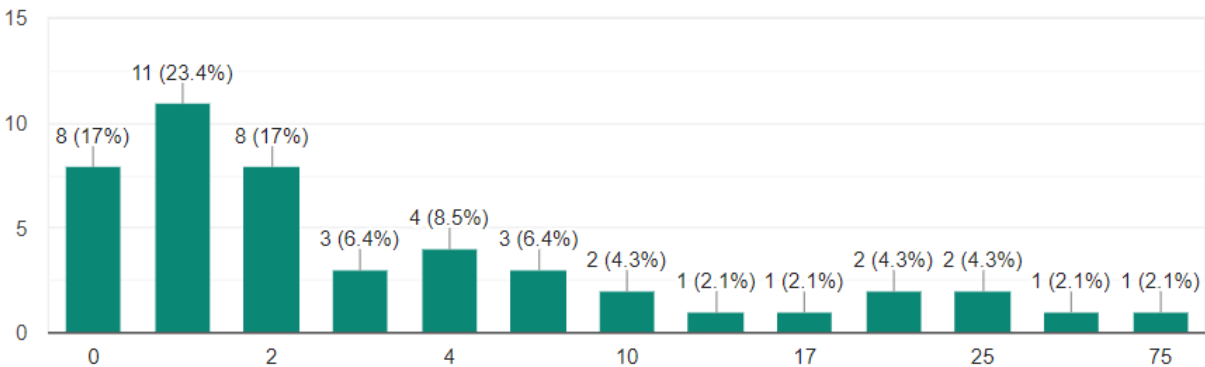


Figure 14 - Number of employees with telecommunications expertise, the number of employees with this expertise on the horizontal axis, and the number of institutions with those employees on the vertical axis.

2.4.7.5 *Electrical and Electronic Engineering*

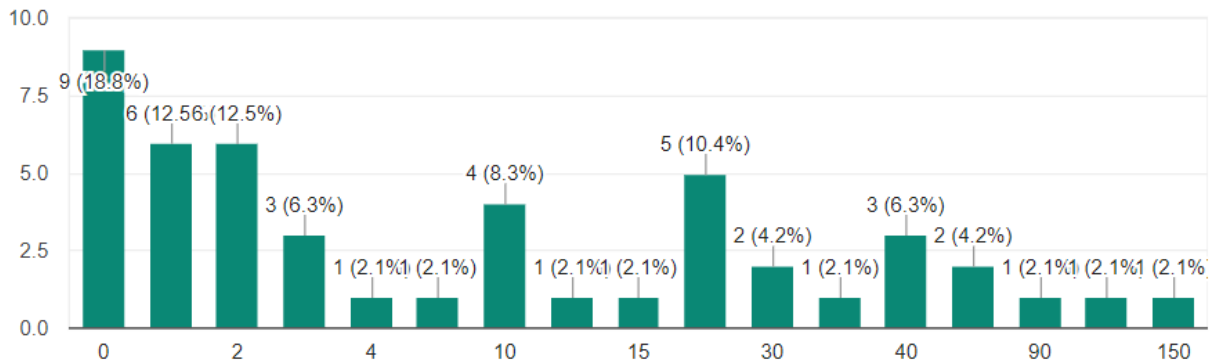


Figure 15 - Number of employees with electrical engineering expertise, the number of employees with this expertise on the horizontal axis, and the number of institutions with those employees on the vertical axis.

2.4.7.6 *Computer Science (IoT, Big data, Machine Learning, Artificial Intelligence)*

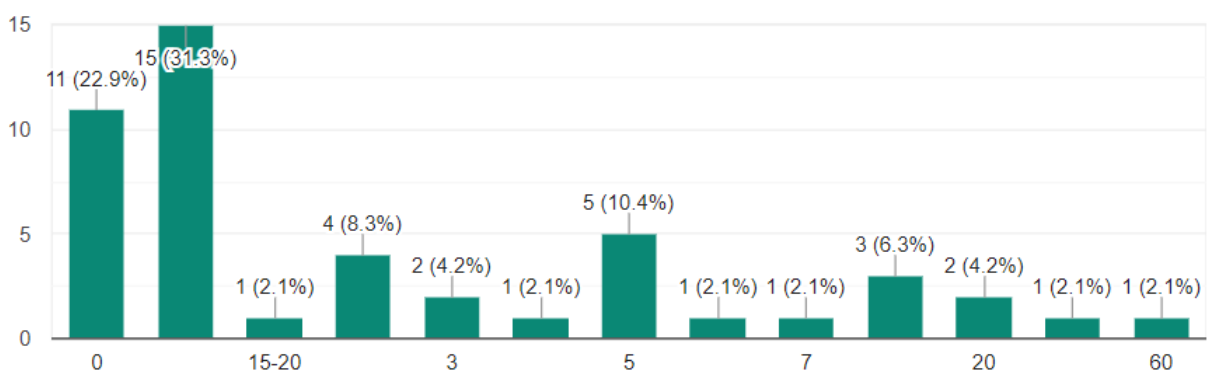


Figure 16 - Number of employees with IoT, Big data, Machine Learning or Artificial Intelligence expertise, the number of employees with this expertise on the horizontal axis, and the number of institutions with those employees on the vertical axis.

2.4.7.7 *Robotics and Control*

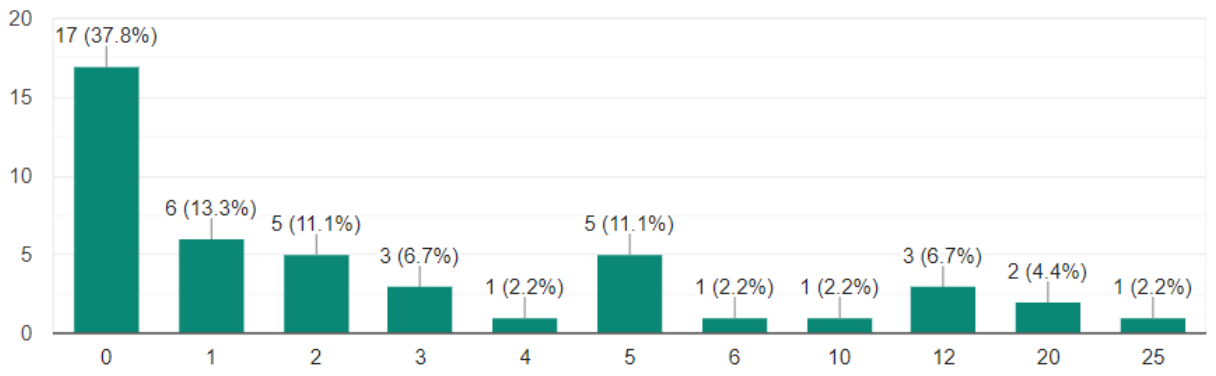


Figure 17 - Number of employees with robotics and control expertise, the number of employees with this expertise on the horizontal axis, and the number of institutions with those employees on the vertical axis.

2.4.7.8 Computer and Network Security

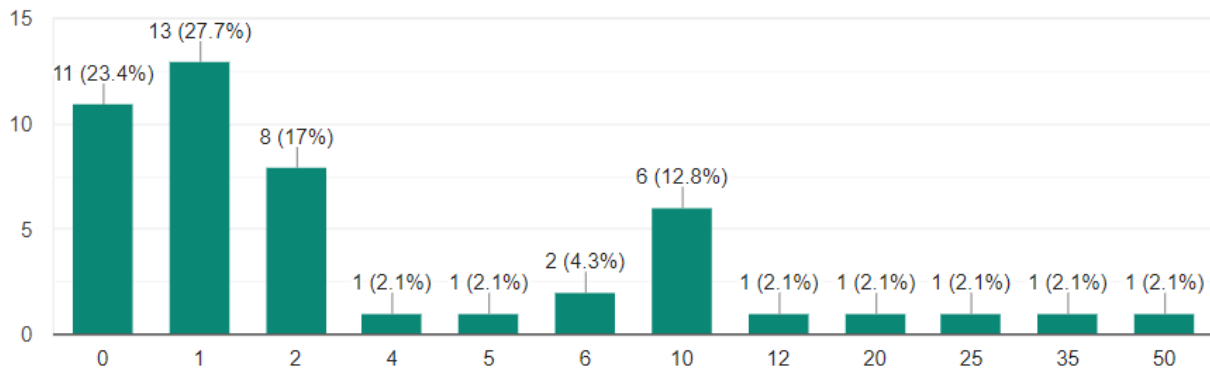


Figure 18 - Number of employees with security expertise, the number of employees with this expertise on the horizontal axis, and the number of institutions with those employees on the vertical axis.

2.4.7.9 Mobile and Satellite Technologies

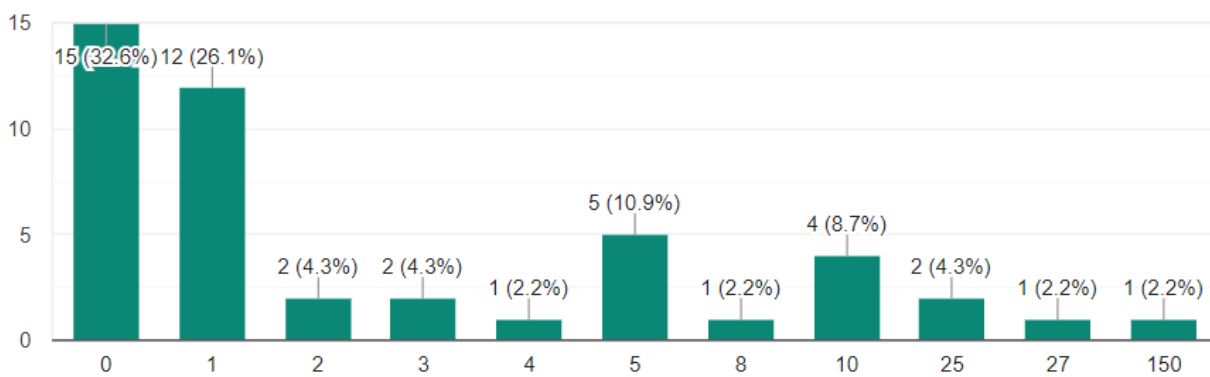


Figure 19 - Number of employees with mobile and satellite expertise, the number of employees with this expertise on the horizontal axis, and the number of institutions with those employees on the vertical axis.

2.4.7.10 Sensors and Measurement Systems

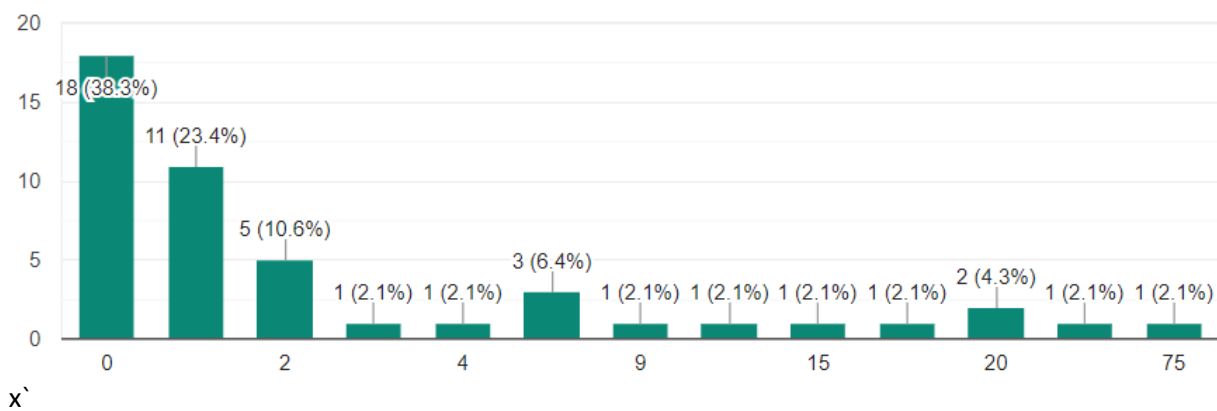


Figure 20 - Number of employees with sensors and measurement expertise, the number of employees with this expertise on the horizontal axis, and the number of institutions with those employees on the vertical axis.

Figure 21 summarizes the statistics in Figure 11 thru Figure 20 by presenting their maximum, minimum, and weighted average. The weighted average is calculated by multiplying each number on the horizontal axis (i.e., the number of employees with that particular expertise, E_i) into its vertical axis counterpart (the number of institutions with that many experts, N_i), then aggregating the products:

$$WA = \sum N_i * E_i$$

Clearly, the highest average and maximum number of employees belong to the electrical and electronics engineers' (EEE) group, remotely followed by computer SW and HW. Ironically, **the lowest number belongs to sensors and measurement experts, followed by mobile/satellite, and robotics/control experts.** This shows that **while companies have a large number of EEs, they lack some of the most relevant EEE skills to IoT.** This finding further **highlights the significance of empowering the education system with a practice-oriented program** that can train qualified workforce for local industries in need of IoT-related expertise.

Table 2 - Expertise Abbreviations for Figure 21

Expertise title	Abbreviation
Computer Hardware	HW
Computer Software	SW
Computer Networks & Distributed Systems	NET
Telecommunications	COM
Electrical and Electronic Engineering	EEE
Computer Science (IoT, Big data, Machine Learning, Artificial Intelligence)	CS
Robotics and Control	ROB
Computer and Network Security	SEC
Mobile and Satellite Technologies	MOB
Sensors and Measurement Systems	SEN

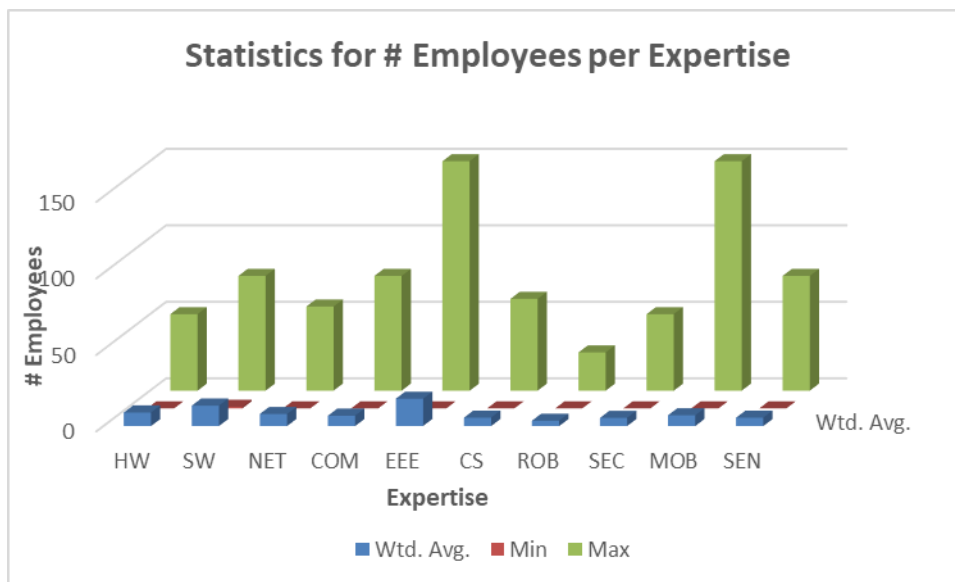


Figure 21 - Statistics for number of employees per expertise

2.4.8 Question 8 – IoT-related Technical Topics

After surveying the responding institutions about their current IoT related status, in this section we provided a number of technical topics (in a finer granularity than those in Question 7), related to Internet of Things, and asked each responder to:

- Provide a list of technical keywords that they see most related to each topic
- Estimate their institutions' immediate and 5-year potential to hire experts in each topic, and
- Indicate the expected skill levels (R&D experts, Senior Engineers, Junior Engineers, and Technicians) for prospective worker with each particular expertise.

The rationale behind such categorization of skills is for curriculum developers to know the level and type of technical material for each technical topic to be included in the curriculum. For example, if the majority of responders require their IoT workforce to possess R&D expertise in a particular technical topic, the course material related to that topic needs to include R&D related activities. On the other hand, if a particular skill is mostly required at a technician level, mostly practical and workshop/lab activities can be included in the curriculum for that particular topic.

In the following, we summarize the responses to this question in three parts:

- Part 1 – Most popular keywords related to each technical topic, in Table 3.
- Part 2 – Analysis of the hiring likeliness (both immediate and 5-year) for each topic, which can be an indicator of the importance of that topic to the market
- Part 3 – Analysis of the expected skill levels for the listed technical topics

2.4.8.1 Part 1 - Most important keywords

Table 3 shows the most popular technology keywords for the listed technical topics, from the responders' perspective. This can give us a view on what technologies or product families are more important for the market players and try to appropriately cover them in education (theory and/or lab) materials.

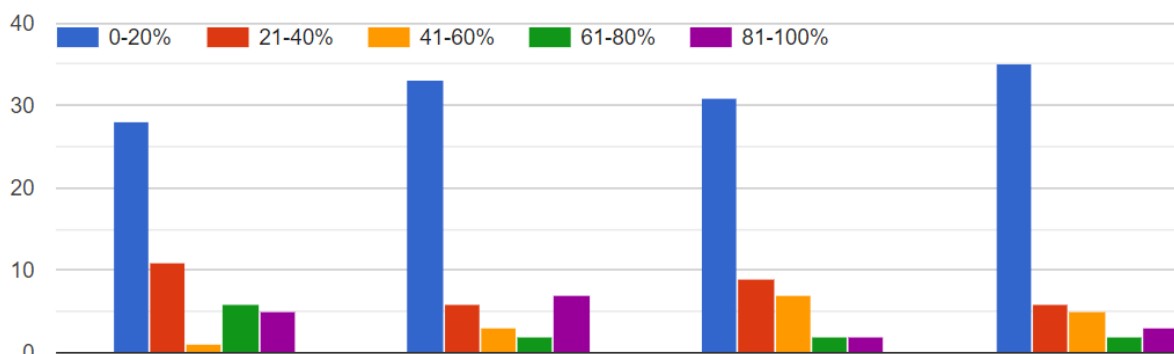
Table 3 - Most popular technologies and brands for various technical topics

Technical Topic	Most Highlighted Keywords (technology, brand, concept)
Sensors and Actuators	RFID, Wireless Sensor Networks, TE Connectivity
Robotics, Mechatronics & Control Theory	PTC, Siemens, Schneider Electric
Measurement Technologies	Texas Instruments, Schneider Electric, National Instruments
Embedded / Constrained processors, SoCs and devices	Embedded CPUs, Raspberry Pie, SoC
Interfacing circuits and standards	Industrial interfaces & I/O standards, DMA, Texas Instruments
Energy Efficiency & Energy sources	Low-energy protocols, ST Microelectronics, ABB
Wired Networks & Standards	Extreme Networks, IEEE 802 standard, Cisco
Wireless Networks & Standards	WiFi, NB-IoT, Huawei
Real-time systems	RTOS, Realtime Sensor networks, Embedded Linux

Operating Systems	Android, Executive OS, RTOS
Cloud, Virtualization and Serverless systems	VMs, Containers, Google Cloud
High performance computing	Scientific computing, Fortran, Cluster computing
Edge and Fog computing	OpenFog, HPE, IoT Gateways
Communication and Queuing standards, protocol stacks and libraries	TCP/IP, MQTT, MobileIP
Big Data Analytics & Visualization Solutions	NOSQL, Tableau, Graph processing
AI, BI and Machine Learning	Python/Numpy, Smart/Autonomous things, OpenCV
Security and Privacy	WPA/WPA2, MPU, AES
Blockchain Technologies	Cryptocurrency, Smart contract, ICO
Industrial / Production Engineering	IIoT, SCADA, FSM
Human-machine interaction	AR/VR, Rugged HMI, Mobile HMI
Software Engineering	Programming languages, Programming models, VS-Code

2.4.8.2 Part 2 - Analysis of Market Demand for Technical Skills

Figure 22 and Figure 23 summarize the likeliness of various stakeholders hiring skilled workers with expertise in the list of technical topics presented in Section 2.4.8. These results are presented for immediate and 5-year period hiring, respectively. In these figures, the technical topics are on the horizontal axes, while the vertical axes are classified (using colors) based on the likelihood of hiring (in percentage intervals). The magnitudes for each color (percentage interval) show the number of institutions expressing their hiring likelihood being in that percentage interval range. For example, in Figure 22, 28 institutions expect to 0-20% immediate hiring for “Sensors and Actuators” experts (the blue bar), while only five institutions expecting 81%-100% probability of immediately hiring engineers with the same expertise (the purple bar).



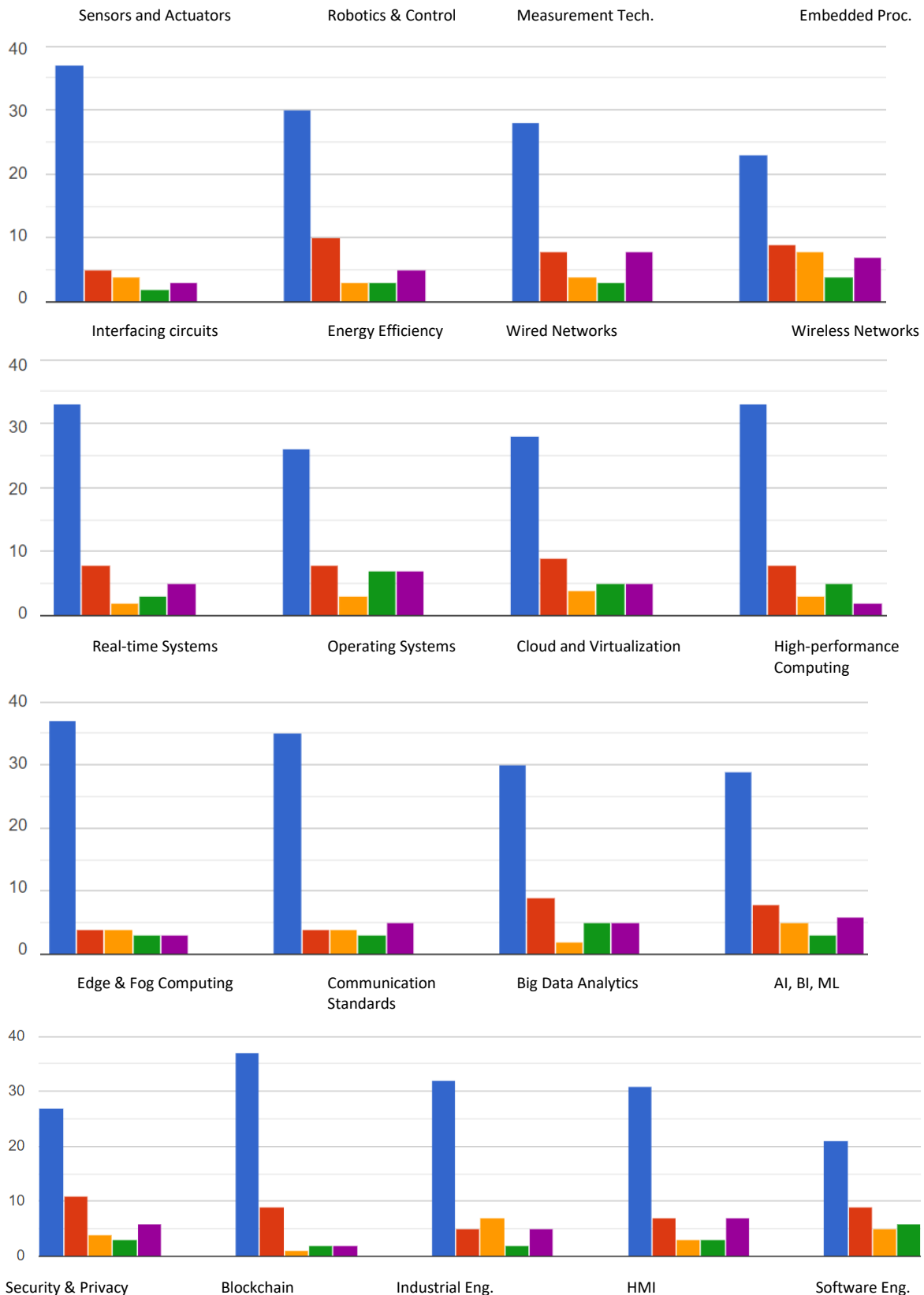
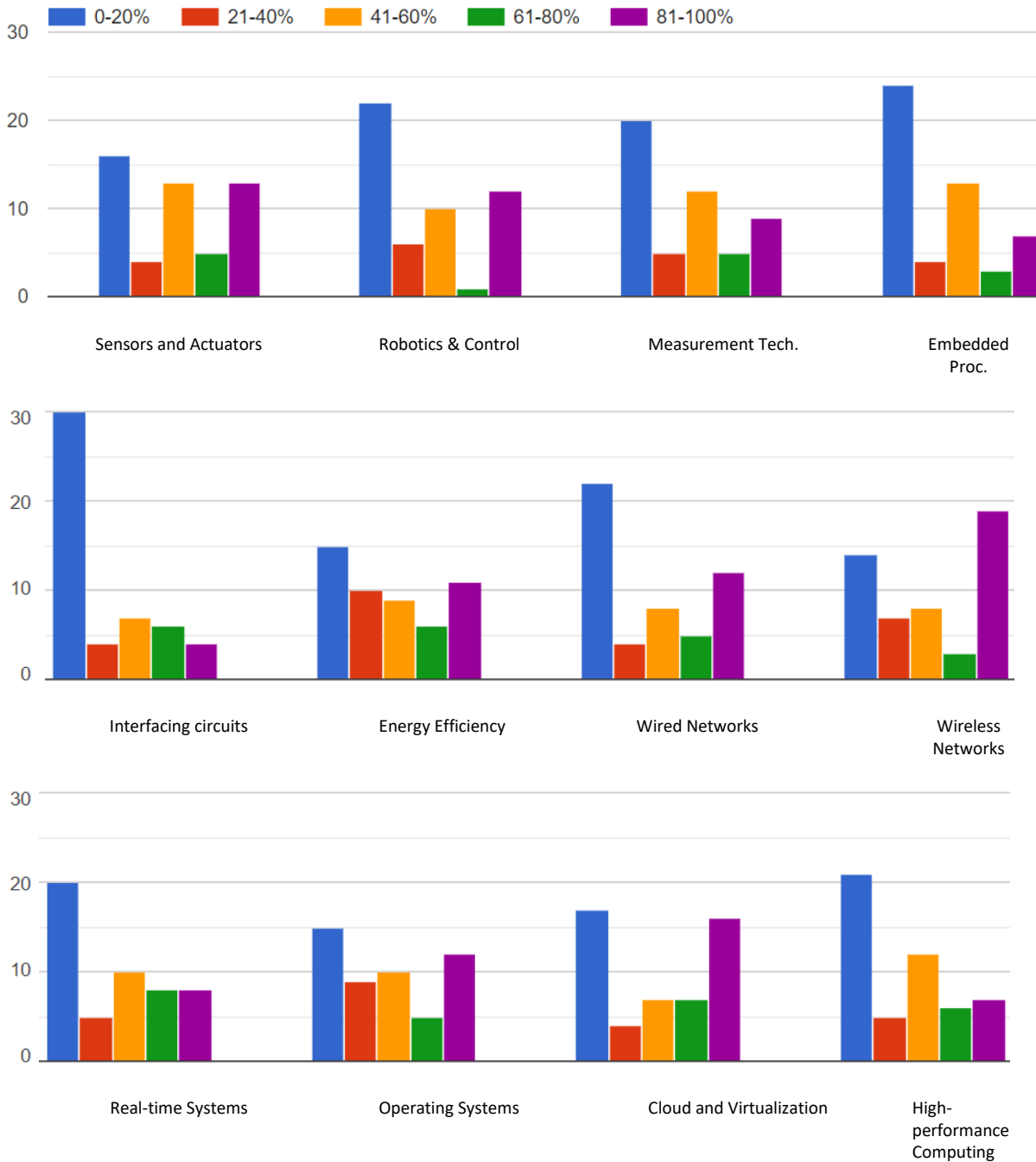


Figure 22 - Immediate hiring expectations based on expertise in specific technical topics

The observed results in Figure 22 provide the following observations:

- Immediate hiring estimates are mostly low, with at least 40% of the responders indicating less than 20% hiring demand for all queries areas.

- Calculating the weighted average of results, Immediate market demand for IoT experts in **networks (wired/wireless), software engineering, operating systems, and HMI technologies** is higher, while skills such as **interfacing circuits** and **block chain** are less on demand at this point.



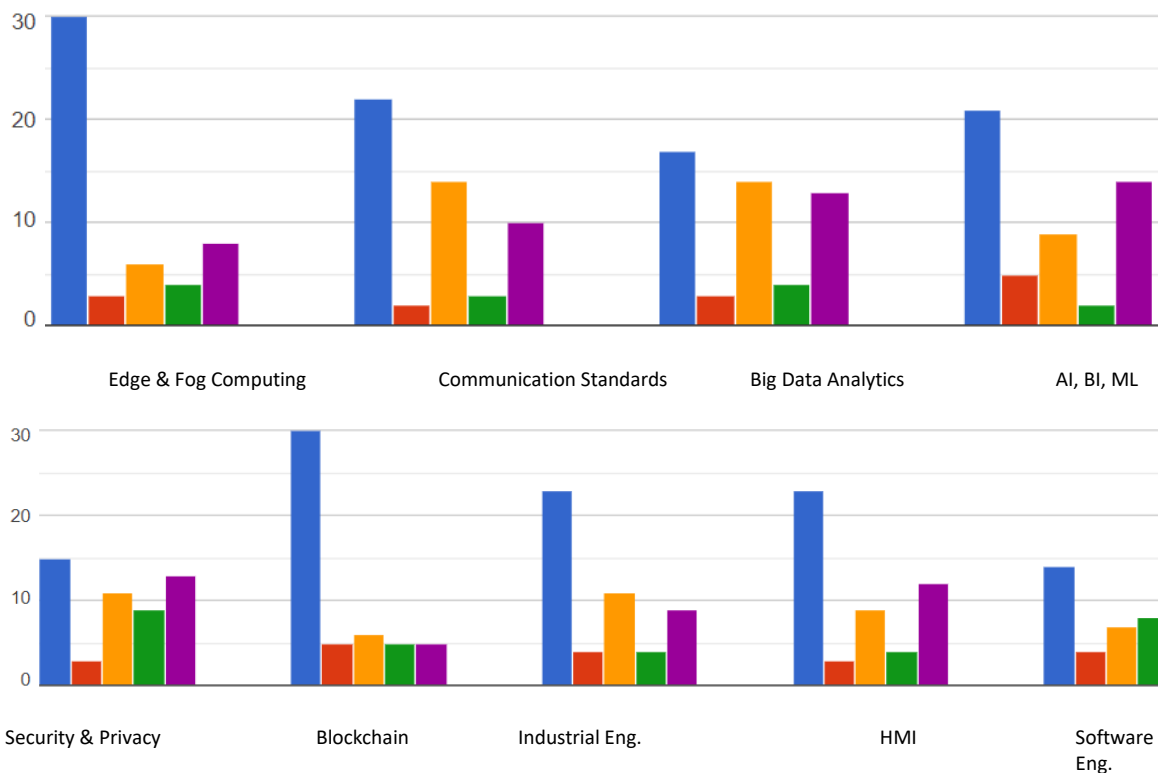
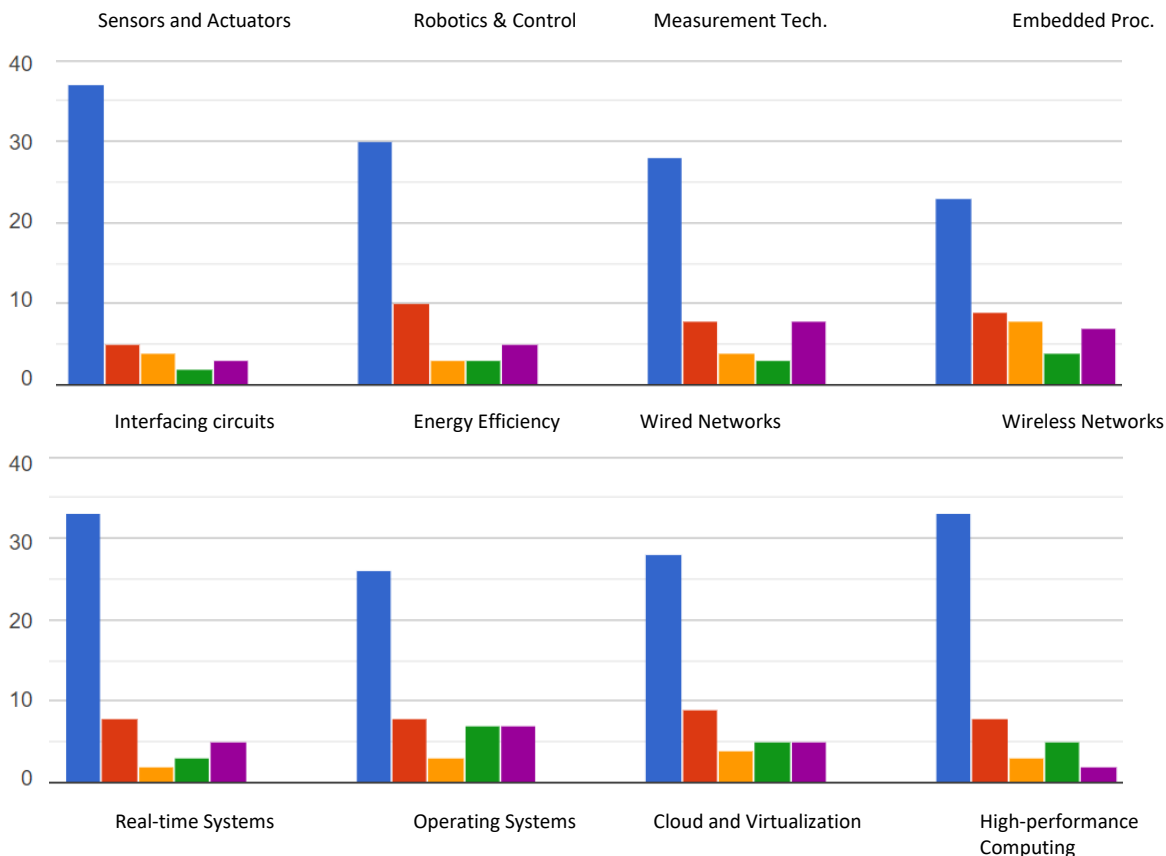
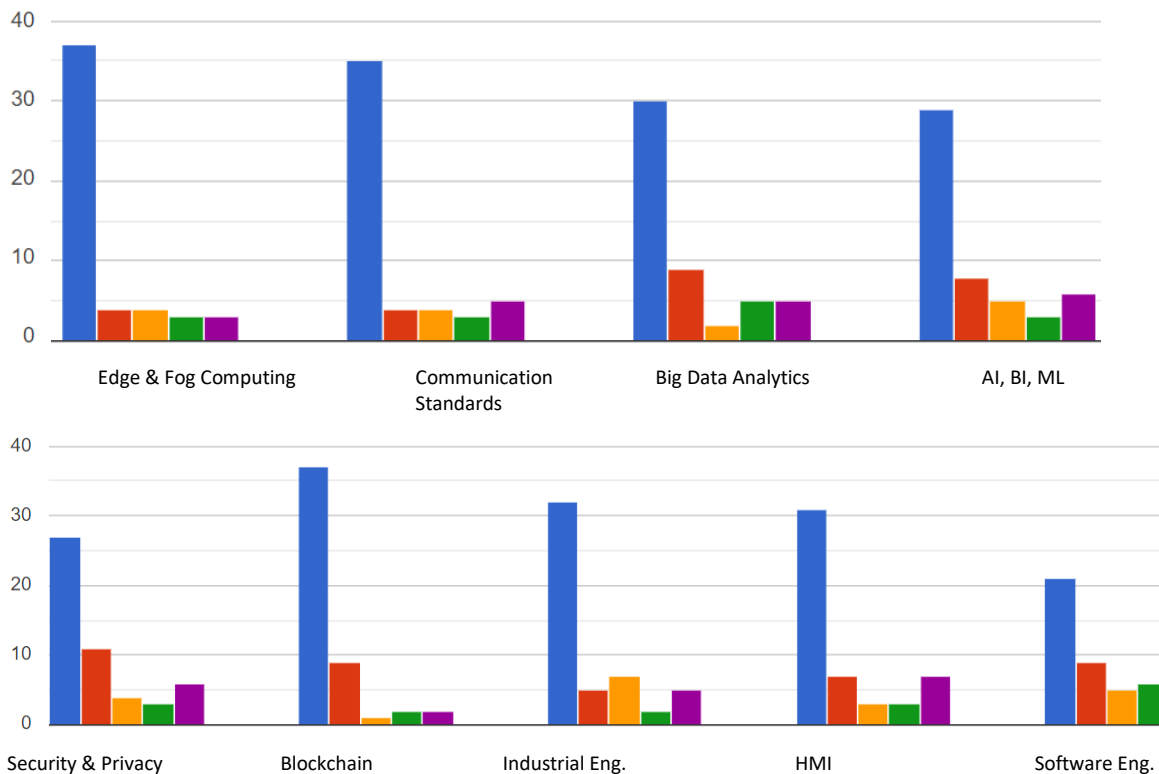


Figure 23 - Five-year hiring expectations based on expertise in specific technical topics

As can be seen in Figure 223





, the 5-year hiring expectations in the Figure 23 show wireless communications, SW engineering, cloud and virtualization, and AI/ML are the most wanted skills in the IoT market in the next 5 years, while Blockchain, interfacing circuits and edge/fog computing are at the bottom of demand.

In order to draw further conclusions out of the responses, we summarize the results by calculating a weighted average percentage using the following calculation method for each technical topic:

$$w = \frac{\sum_{i=1}^5 c_i \times u_i}{N}$$

Where c_i is the number of responders choosing the percentage interval i (p_i), and u_i is the upper limit of p_i , and $p_i \in \{[0,20], (20,40], (40,60], (60,80], (80,100]\}$ for $i \in \{1,2,3,4,5\}$. Therefore, we can say that $u_i \in \{20,40,60,80,100\}$ and $\sum_{i=1}^5 c_i = N$ for all cases. Figure 24 depicts these summary results, and Table 4 lists the technical topic abbreviations used in Figure 24.

Table 4 - Abbreviations for the technical topics

Technical Topic (Area)	Abbreviation
Sensors and Actuators	SEN
Robotics, Mechatronics & Control Theory	ROB
Measurement Technologies	MES
Embedded / Constrained processors, SoCs and devices	EMB
Interfacing circuits and standards	INT
Energy Efficiency & Energy sources	ENG

Wired Networks & Standards	WRD
Wireless Networks & Standards	WRL
Real-time systems	RTS
Operating Systems	OS
Cloud, Virtualization and Serverless systems	VIR
High performance computing	HPC
Edge and Fog computing	EDG
Communication and Queuing standards, protocol stacks and libraries	COM
Big Data Analytics & Visualization Solutions	BIG
AI, BI and Machine Learning	ML
Security and Privacy	SEC
Blockchain Technologies	BLK
Industrial / Production Engineering	IND
Human-machine interaction	HMI
Software Engineering	SW

As we can observe in Figure 24, in which the immediate and 5-yr weighted average expectation of requiring each technical topic expertise in the market is presented, **skills such as software engineering (SW), cloud & virtualization (VIR), security and privacy (SEC), and wireless technologies (WRL) have the highest average market demand in the next 5 years**, while skills such as **interfacing circuits (INT), Blockchain (BLK) and edge processing (EDG) seem to be on the lowest demand**. The immediate market needs are also more or less similar to the 5-year percentages, with SW, WRL, and OS leading, and again BLK, INT, and EDG trailing.

While observing high demand for wireless technologies and cloud/virtualization skills is somewhat expected, embedded processors and interfacing circuits expertise showing some of the lowest market requirements is rather strange and unexpected, since the knowledge of embedded systems is directly related to developing devices with IoT capabilities. This can be attributed to the fact that large organizations, that make up the majority of this survey are mostly interested in software-oriented technologies and importing hardware solutions, a trend that seems prevailing in developing countries, due to high R&D and workforce costs related to hardware-oriented technologies.

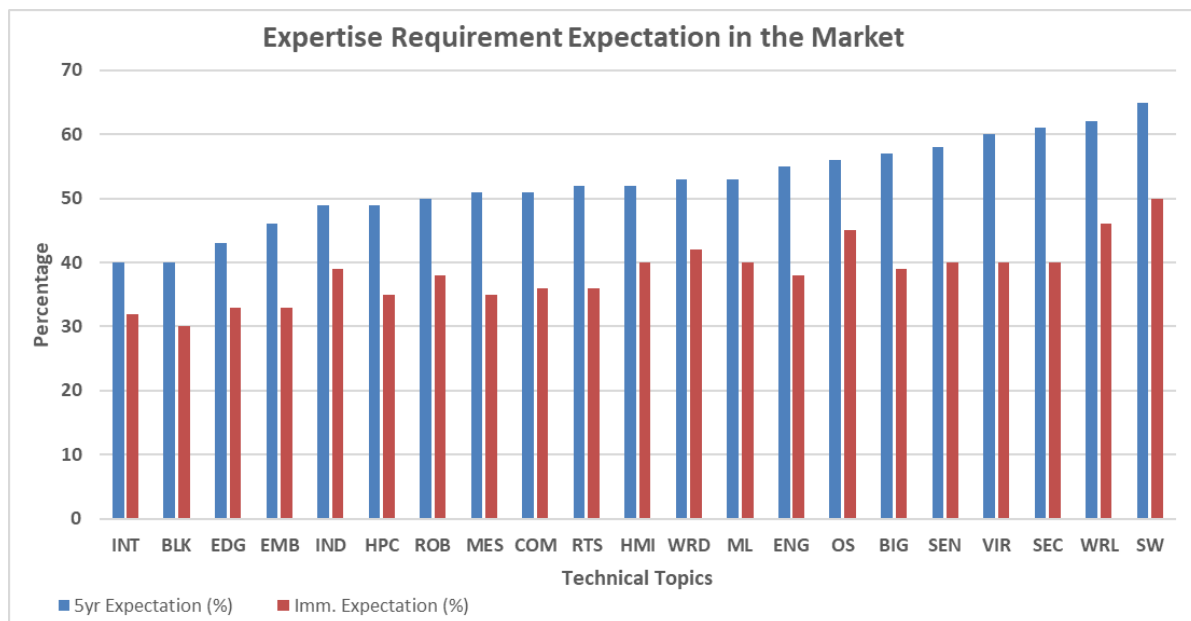


Figure 24 - Immediate and 5-yr weighted average expectation of requiring each technical topic expertise in the market

2.4.8.3 Technical Skill Demand per Market Sector

This section further reviews the market demand for various technical skills in a sector-based analysis. The observations are summarized in Table 5, where for each technical skill, we list three industry sectors with highest (immediate and 5-year) demand for that skill. The maximum demand percentages among all sectors for the above time lines are also listed.

Table 5 - Sector-based market demand

Technical topic (Area)	Industry sectors with highest immediate demand	Max immediate demand (%)	Industry sectors with highest 5-year demand	Max 5-year demand (%)	Two Most demanded expertise level
Sensors and Actuators	Ind. Automation, IoT, Utilities	60	IoT, Oil & Gas, IT & SW	72	Junior Eng.
Robotics, Mechatronics & Control Theory	Ind. Automation, IT & SW, Utilities	72	Ind. Automation, Oil & Gas, IoT	72	Senior Eng., Technician
Measurement Technologies	Farming, IT & SW, Utilities	60	IoT, Health, Farming	63	Junior Eng. & Technician
Embedded / Constrained processors, SoCs and devices	IoT, IT & SW, Ind. Automation	52	IoT, IT & SW, Ind. Automation	72	Junior & Senior Eng.

Interfacing circuits and standards	Utilities, IoT, Manufacturing	46	IoT, IT & SW, Utilities	56	Junior & Senior Eng.
Energy Efficiency & Energy sources	Utilities, Farming, Public services	60	Utilities, Public services, Farming	77	Senior & Junior Eng.
Wired Networks & Standards	Telecom, Farming, Manufacturing,	80	Telecom, Farming, Public services	93	Junior Eng. & Technician
Wireless Networks & Standards	Farming, Telecom, Utilities	80	Telecom, Public services, Farming	100	Senior & Junior Eng.
Real-time systems	Utilities, IT & SW, Farming	50	Education, Health, IT & SW	62	Senior & Junior Eng.
Operating Systems	Farming, IoT, Manufacturing	80	Farming, Telecom, Manufacturing	80	Junior & Senior Eng.
Cloud, Virtualization and Serverless systems	Farming, Telecom, IT & SW	80	Telecom, Public services, Farming	94	Senior & Junior Eng.
High performance computing	Farming, Telecom, Utilities	80	Farming, Telecom, Utilities	80	R&D Expert & Senior Eng.
Edge and Fog computing	Ind. Automation, IT & SW, Utilities	53	IT & SW, Ind. Automation, Utilities	55	Junior Eng. & R&D Expert
Communication and Queuing standards, protocol stacks and libraries	Farming, Utilities, Ind. Automation	60	Telecom, IoT, Public services	70	Junior & Senior Eng.
Big Data Analytics & Visualization Solutions	Farming, IT & SW, Utilities	60	Ind. Automation, IT & SW, Telecom	80	Senior Eng. & R&D Expert
AI, BI and Machine Learning	Education, IT & SW, Utilities	52	Ind. Automation, IT & SW, IoT	72	Senior & Junior Eng.

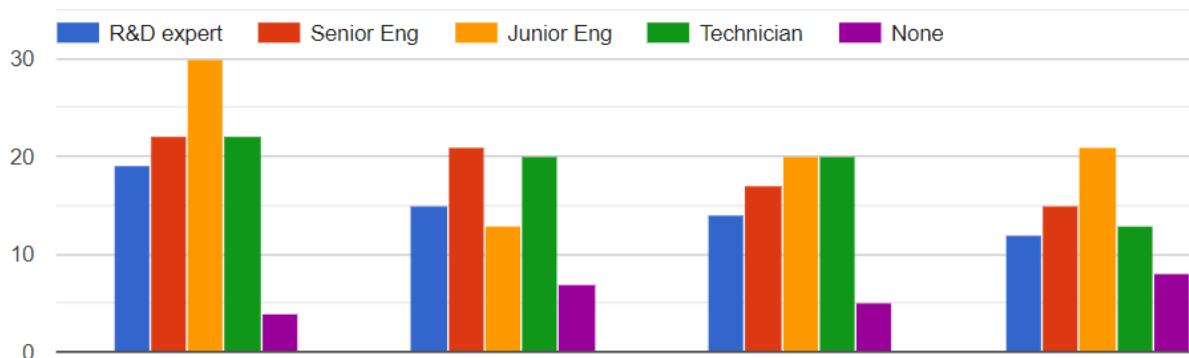
Security and Privacy	Farming, Utilities, Telecom	60	IT & SW, Ind. Automation, Telecom	75	Senior & Junior Eng.
Blockchain Technologies	Education, Farming, IoT	47	Education, Ind. Automation, Telecom	63	Senior Eng. & R&D Expert
Industrial Production Engineering /	Ind. Automation, Farming, Utilities	60	Ind. Automation, Oil & Gas, Farming	87	Senior Eng. & R&D Expert
Human-machine interaction	Ind. Automation, Utilities, Manufacturing	67	Ind. Automation, Utilities, Manufacturing	80	Junior & Senior Eng.
Software Engineering	Farming, Education, IoT	80	Telecom, Farming, Education	90	Senior & Junior Eng.

The Table 5 observations suggest that in most cases, the highest-demanding industry sectors stay mostly the same for both time periods. Moreover, **the expected highest-demanding industry sectors for each technical skill are more or less expected, considering the industry’s technical activities.** For example, Telecom industry is the most demanding one for wireless technologies, while industrial automation is the most demanding sector for industrial engineering or HMI. Of course, there are some exceptions to this expectation, such as the **Health industry not appearing in the list of most demanding ones for security and privacy skills.** We attribute such exceptions to the low number of responders in this sector.

Moreover, this table (in the rightmost column) shows the two most demanded expertise levels (in order), for each technical area based on the responses. **These results along with Table 6 can be used in course development to identify the level of material as well as course activities for topics in each technical area.**

2.4.8.4 Part 3 - Analysis of the expected skill levels

This section presents the summary of expected levels of expertise for prospective IoT skilled workers with each technical topic expertise.



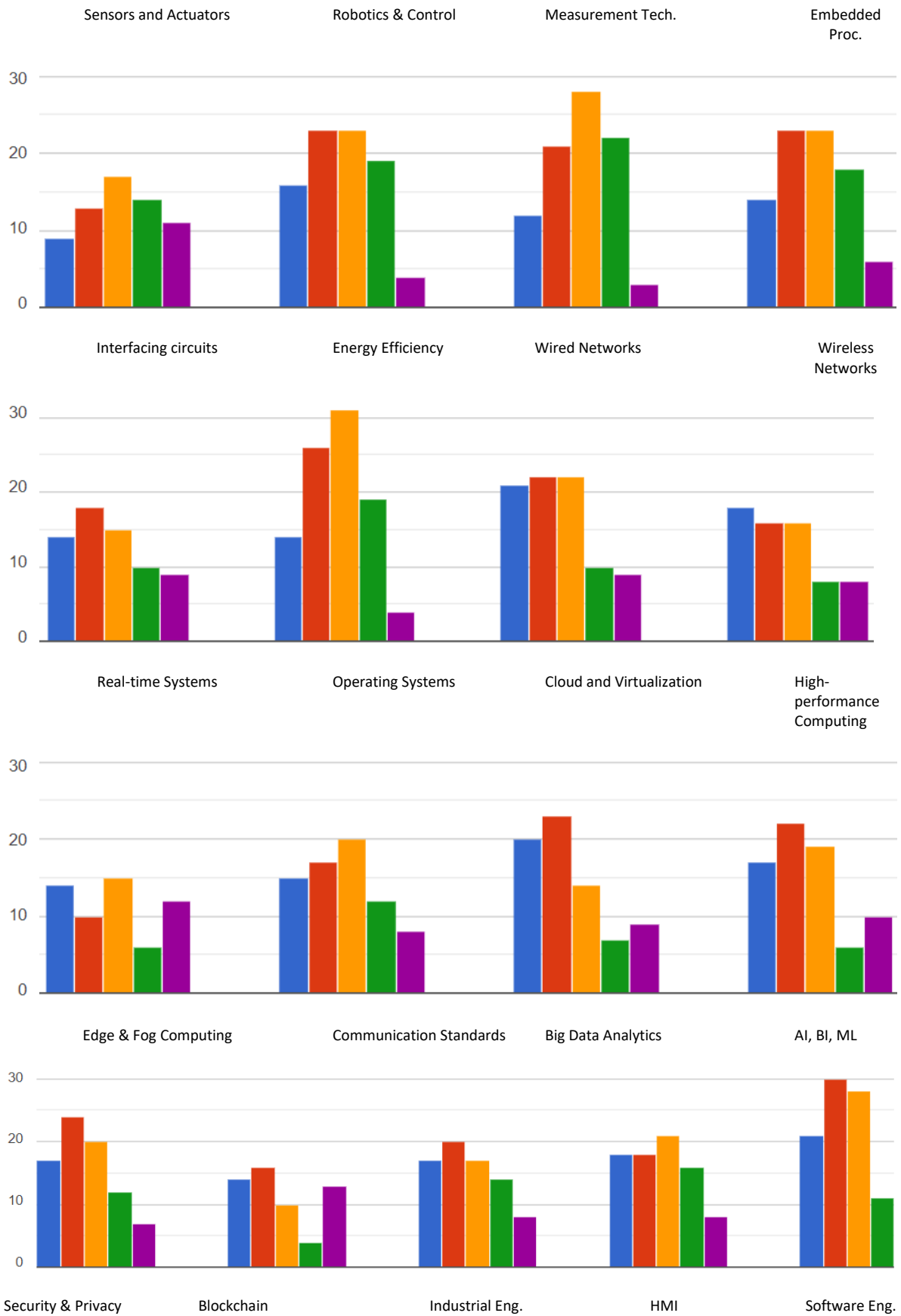


Figure 25 - Skill level of prospective employees based on expertise in specific technical topics

On average, **most wanted skill levels across various technical areas are junior and senior engineers**, which account for over half of the selections, and nearly a fifth asking for R&D experts. This leads us to conclude that the market does not require much R&D expertise from their IoT workforce, but rather technical skills that can drive their main technical operations. Therefore, the university graduates are better off gaining **practical skills rather than research experience**. Therefore, probably a **non-thesis-based program** (or a program with minimum credits associated to research activities), fortified with industry-sponsored labs and internships will serve the purpose of training hands-on engineers that can solve market's immediate requirements. This will also be closer to the industry's aim of hiring workforce that are familiar with their challenges and needs.

On the other hand, looking at the details of the results, and calculating the percentage of market players indicating skill levels for each technical area, we observe that the technical areas with the highest demand for **R&D experts are big data, HPC, edge computing and block chain**, while **for areas such as robotics, measurement technologies, sensors and networking skills**. See Table 6 for most wanted skill areas (compared to other skill areas), for each expertise level.

Table 6 - Technical skills mostly needed at each expertise level

Expertise level	Mostly needed in the following technical areas (see Table 4 for abbreviations)	Recommendations for course activities in these technical areas
R&D Experts	BIG, HPC, EDG, BLK	Theses, course research projects, seminars
Senior Engineers	SW, BIG, ML, BLK	Technical and tech. mgmnt. Projects, excursions
Junior Engineers	OS, WRD, SEN, EMB	Technical projects, lab exer., excursions
Technicians	ROB, MES, WRD, SEN	Internships, lab exer.

2.5 Course Activity Recommendations

The results presented in Section 2.4.8 can further help designing the IoT master's curriculum by **highlighting the most wanted skills** at each expertise level. Table 6 makes some recommendations for course activities at each expertise level. These recommendations should be implemented with the goal of developing the corresponding expertise level. For example, we recommend that for technical areas that are mostly wanted at a **technician level**, we should include **internships or lab exercises in the courses**, while for **technical areas at senior engineer or R&D levels**, the student skills can be built up in a **theory-lab course co-design methodology, beside seminars and course research projects**. Moreover, R&D-level topics can be used in defining theses and technology development projects.

3 Conclusions:

The aim of this survey is market needs analysis and goal definition of IoT local market and industry. A questionnaire was prepared to evaluate the needs of various market sectors, including industry, to IoT related expertise, in order to propose the most relevant skills into the prospective educational curricula in higher education institutions. Various data collection procedures have been performed. In the first step, we collected the data from some Iranian, Iraqi and European market players (organizations, and industries) which benefits from IoT. Subsequently, we collected the filled forms and analysed the responses.

The filled questionnaires were received from 52 different stakeholders. Some responders have expressed their current IoT solution usage, some establishing IoT labs and some pilot (rarely production) IoT solutions in their institutions. The summary as well as the expressed responses indicate a great and developing demand for IoT related skills in various market sectors included in this survey, from manufacturing sector requiring the expertise for their production and safety, to educational institutions in need of IoT experts for elevating their training quality, and SW and telecom companies for improving their services.

While we have highlighted significant results throughout the text, this section tries to summarize and draw conclusions. This report highlights technical skills that are most needed by the market, and their most-demanded expertise level. In addition, we analyze the likeliness of various stakeholders hiring skilled workers with expertise in the list of technical topics presented in Section 2.4.8, for immediate and 5-year period hiring. The immediate and 5-yr weighted average expectation of requiring each technical topic expertise in the market also is studied. Indicating in the related figures, skills such as software engineering (SW), virtualization (VIR), security and privacy (SEC), and wireless technologies (WRL) have the highest average likelihood of being required by the market in the next 5 years, while skills such as interfacing circuits (INT), Blockchain (BLK) and embedded systems (EMB) seem to be on the lowest demand. The immediate market needs are also more or less similar to the 5-year percentages, with SW, WRL, VIR, and SEC leading, and again BLK, INT, and EMB trailing.

Despite of observing high demand for wireless technologies and cloud/virtualization skills, is somewhat expected, embedded systems expertise showing one of the lowest market requirements is rather unexpected, since the knowledge of embedded systems is directly related to developing devices with IoT capabilities. Such skews in the results could be attributed to the relatively low number of responders in some sectors, as well as the fact that the responders self-declared familiarity with IoT is not very high.

Moreover, we have explored the expected skill levels for prospective workers with each technical topic expertise. As observed, senior and junior engineers are most widely needed in the majority of technical topics, while R&D experts are usually the least needed. Therefore, probably a non-thesis-based program fortified with industry-sponsored labs and internships will serve the academia's purpose of training hands-on engineers that can solve market's immediate requirements, while approaching industry's aim of hiring workforce that are familiar with their challenges and needs.

This information is valuable for curriculum designers in prioritizing certain technical topics and in declaring the extent of educational material to be covered in the curriculum for each technical topic in order to provide the students with the demanded level of knowledge and expertise.

The outcome of this report in addition to the recommendations in D1.1 need to be used in D1.4 and D1.5 in order to suggest courses that could properly cover market needs in terms of both the technical topics and their requested expertise level. Technical areas more wanted at the R&D level need to be covered with a research-oriented approach. On the other hand, those mostly wanted at engineering levels, need more hands-on experience. For example, to cover industry needs our courses may cover areas such as HPC & big data in more theoretical and scientific way with a research-oriented approach, while areas such as sensors, robotics and networks need a more practical and hands-on approach in their respective courses.

4 References:

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- 2- [IoTrain Project Management Handbook \(https://www.iotrain.eu \)](https://www.iotrain.eu)
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Appendix 1: The IoT Market Sector Questionnaire

Can be accessed online at (<https://scu.ac.ir/en/iotrain-project>)

Part 1 –Institutional Information					
Name of the Institution	Place (City, Country)	Years in business	Years using, Digital Technology, robotics and IoT	Size of workforce (#employees)	Elec/Comp. employee percent or Number
Part 2 - Market Sector					
(Rank the sectors based on matching with your institution products and services)					
<input type="checkbox"/> Oil & Gas	<input type="checkbox"/> Manufacturing and Mines	<input type="checkbox"/> Governmental and Public Services	<input type="checkbox"/> Education	<input type="checkbox"/> Smart Cities / Homes / Fields	
<input type="checkbox"/> Transportation	<input type="checkbox"/> Utilities (Electric, Water, Gas, Telecom)	<input type="checkbox"/> Farming and Agro-industry	<input type="checkbox"/> Health & Sports	<input type="checkbox"/> Other. Please specify:	

Part 3 – IoT related questions
<p>1. How much are you familiar with the IoT concept and applications (on the scale of 0 to 10)? (Put 0 if you have not heard of the term. Put 10, if you are fully aware of what IoT is and what are its benefits and applications).</p>
<p>Explanation for answer 1:</p>
<p>2. Does your institution currently use connected objects, as in IoT, in products, services, or manufacturing processes? <input type="checkbox"/> Yes <input type="checkbox"/> No</p>
<p>Explanation for answer 2:</p>
<p>3. Does your institution consider using IoT technologies in products, services, or manufacturing processes in the future? <input type="checkbox"/> Yes <input type="checkbox"/> No</p>

Explanation for answer 3:

4. Is there an approved employee requirement guideline for hiring new workforce in your institution?
 Yes No Under preparation Planning to prepare

Explanation for answer 4:

5. How likely do you see your institution in need of IoT related expertise

- a) right now?
 Highly likely Likely Unlikely Highly unlikely I am not sure!
 b) in the next 5 years?
 Highly likely Likely Unlikely Highly unlikely Not sure!

Explanation for answer 5:

6. How many IoT related skilled workers do you anticipate your institution hiring
- a) right now?
 More than 100 50-100 10-50 1-10 I am not sure!
 b) in the next 5 years?
 More than 100 50-100 10-50 1-10 I am not sure!

Explanation for answer 6:

7. The following table lists some expertise, related to IoT. Indicate the approximate number of employees in your institution with skills related to each expertise.

Expertise	No. of Employees
Computer Hardware	
Computer Software	
Computer Networks & Distributed Systems	
Telecommunications	
Electrical and Electronic Engineering	

Computer Science (IoT, Big data, Machine Learning, Artificial Intelligence)					
Robotics and Control					
Computer and Network Security					
Mobile and Satellite Technologies					
Sensors, GPs Systems					
Explanation for answer 7:					

Table 8: For each of the following technical skills topics a number of representative technologies and standards are provided as a guideline in Table 9 at Appendix 2. Considering these standards or any other similar industrial technologies; firstly write the related technology which your industry may use at each row related to the technical skills; secondly specify the likeliness that your institution being in need for employees experiences such skills immediately or in the next five years.

No.	Technical skills Topics	Representative technologies and standards (See Table 9 as a guideline)	Immediate Likeliness (0%-100%)	Next 5 years Likeliness (0%-100%)	Skill type – Tick all applicable			
					R&D expert	Senior Eng.	Junior Eng.	Technician
1	Sensors and Actuators							
2	Robotics, Mechatronics & Control Theory							
3	Measurement Technologies							
4	Embedded / Constrained processors, SoCs and devices							
5	Interfacing circuits and standards							
6	Energy Efficiency & Energy sources							

7	Wired Networks & Standards								
8	Wireless Networks & Standards								
9	Real-time systems								
10	Operating Systems								
11	Cloud, Virtualization and Serverless systems								
12	High performance computing								
13	Edge and Fog computing								
14	Communication and Queuing standards, protocol stacks and libraries								
15	Big Data Analytics & Visualization Solutions								
16	AI, BI and Machine Learning								
17	Security and Privacy								
18	Blockchain Technologies								
19	Industrial / Production Engineering								
20	Human-machine interaction								
21	Software Engineering								
	<i>Add new rows for technical topics not included in this questionnaire</i>								

Appendix 2: key IoT technologies and standards

Table 9 indicates some technologies and standards which can be employed in IoT technology as a guideline for filling Table 8. Considering the technical skills and these standards or any other similar industrial technologies, to fill Table 8; firstly, write the related technology which your industry may use at each row related to the technical skills; secondly specify the likeliness that your institution being in need for employees experience such skills immediately or in the next five years.

Table 9: the key IoT technical skills topics and the associated technologies and standards [6-11]; a guideline for filling the Table 8		
No.	Technical Topics	Representative technologies and standards
1	Sensors and Actuators	Texas Instruments, TE Connectivity, Broadcom Sensor electronics, RFID, Cyber physical systems, WSNs, RFID
2	Robotics, Mechatronics & Control Theory	PTC, Siemens, ABB, Schneider Electric, PLC
3	Measurement Technologies	Texas Instruments, Schneider Electric,
4	Embedded / Constrained processors, SoCs and devices	Xilinx, Intel, Altera, Intel, HPE, AMD, Raspberry, Arduino Embedded processors, SoCs, SBCs
5	Interfacing circuits and standards	Texas Instruments, Schneider Electric, I/O standards, Industrial interfaces (Modbus, CAN, ...), DMA/RDMA, Schneider Electric, I/O's standards Interface
6	Energy Efficiency & Energy sources	STMicroelectronics, ABB, Power/energy measurement & management, Low-energy protocols
7	Wired Networks & Standards	Cisco, Aruba, Extreme Networks, IEEE 802.1, IEEE 802.3 (Ethernet), OC-X, SONET/SDH, Ethernet, IB
8	Wireless Networks & Standards	Huawei, Ericsson, Nokia, IEEE 802.11 (WiFi), IEEE 802.15 (BT and Zigbee), IEEE 802.16 (WiMAX), 4G (LTE), 5G, Zigbee, 6LOWPAN, Lora, WiFi, NB-IoT
9	Real-time systems	Panasonic, Oledcomm, Philips, RTOS, Realtime sensor networks
10	Operating Systems	Microsoft, Rigetti, Apple, Linux, Unix, Android, Contiki, Executive OSs, RTOS, Windows, Linux, Android
11	Cloud, Virtualization and Serverless systems	AWS, Google Cloud, PubNub, IBM, ThingSpeak, Thingworx, Oracle IoT platform, FaaS, IaaS, PaaS, SaaS, Virtualization (VMs & Containers)
12	High performance computing	Scientific data analytics and simulation
13	Edge and Fog computing	Dell, HPE, Gateways, OpenFog,
14	Communication and Queuing standards, protocol stacks and libraries	TCP/IP, HTTP/HTTPS, MQTT, CoAP, AMQP, REST, Zigbee, Bluetooth, 6LoWPAN, ICMPv6, Ipv6, RPL, MobileIP, M2M & LWM2M, AMQP, CoAP, Kafka, XMPP, DDS

15	Big Data Analytics & Visualization Solutions	IBM, Microsoft, Rigiitti, Processing models (Stream / Event, Graph, Batch), Storage models (SQL, NoSQL), Visualization tools (Kibana, Tableau, Google charts)
16	AI, BI and Machine Learning	Python, Numpy, Tensorflow, opencv, PyTorch, AIoT, Smart Things / Places, Autonomous Things,
17	Security and Privacy	Apple, Alphabet, AES, WEP, WPA/WPA2, TKIP, PGP Physically unclonable functions (PUF), M2M authentication and IAM, Memory protection unit (MPU), AAA
18	Blockchain Technologies	DLT, ICO, Smart contract, Cryptocurrency
19	Industrial / Production Engineering	IIoT, PLC, SCADA, Manufacturing Execution Systems (MES), ICS (Industrial control systems), Distributed control systems (DCS), Field service management systems (FSM)
20	Human-machine interaction	Mobile HMI, AR/VR, Rugged HMI
21	Software Engineering	Java, SCALA, and Python, Formal modeling,