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KÄRNTEN University of Applied Sciences

ETAT Online Survey Results and Needs Analysis Report

(WP3.1 Needs Analysis)

Project Title:

Education & Training for Automation 4.0 in Thailand /ETAT

Project. No.610154-EPP-1-2019-1-DE-EPPKA2-CBHE-JP

Document control

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Introduction and aim

The ETAT project aims to create exemplary Education & Training Centers in the field of engineering education at participating EEC universities that are able to support as education hubs in the EEC region for industry-related education and training for engineers and young specialists. The following objectives are to be achieved with it:

- Modernization of Higher Education in Thailand based on the experience of European countries.
- Increase the employment rate of university graduates and implement the concept of Life-Long learning with the help of special training modules in the field of industrial automation.
- Development of partnerships with enterprises.
- Improve the quality and relevance of Higher Education in Thailand in the field of industrial automation.
- Establishment of 6 certified ETAT Training Centers at partner universities, which will be equipped with 24 special training places (respectively 4 ETAT Smart Labs per Thai university).
- Establishment of a platform for distance learning and cooperation between the partners for providing E-Learning & Cloud-based learning courses and for exchange of didactical documents and information.

ETAT Training Centers will be provided with teaching materials and certificated courses for different target groups (students, employees, post-graduates, trainees) as well as with the Thai trainers trained by EU university partners during the ETAT project.

The main aim of this survey is to estimate the level of interest in teaching and using different technologies for industrial automation in the context of Industry 4.0 by students, teachers and professionals in the field of process automation.

Section 1 – Participants Analysis

The first section of this report aims at providing general information about the characteristics of participants. In first instance, it is worth to mention the background of each participant, whereas 94 people took part to the survey. 53% of the survey have been provided by students (**TG1**, 50 participants), 29% by professionals from industry (**TG3**, 27 participants) and the remaining by teachers and professors (**TG2**, 17 participants).

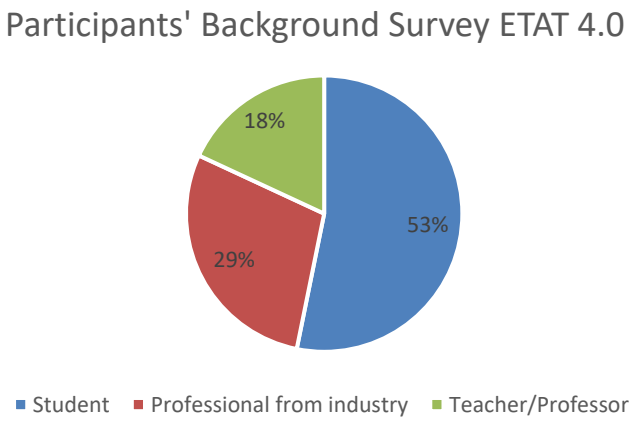

Figure 1: Participants background

Among the student subgroup, it has been asked which the type of study are they currently involved in. The great majority of the students taking part to the survey said to be currently part of a Bachelor course (76%), while 18% of students is attending a Master course and the remaining (6%) is undertaking a Research Doctorate.

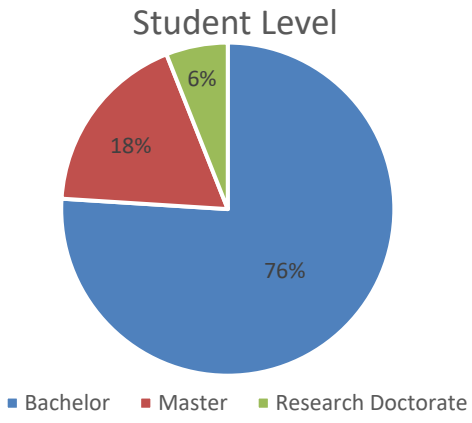

Figure 2: Students background

Among the professionals from industry subgroup, it is interesting to be aware about the size of the companies participating to the survey. In this sense, it has been observed that the majority (52%) of the responding companies are large firms with more than 250 employees. Small and medium enterprises show the same amount of share, equal to 15%. Micro enterprises are present with a share of 18%.

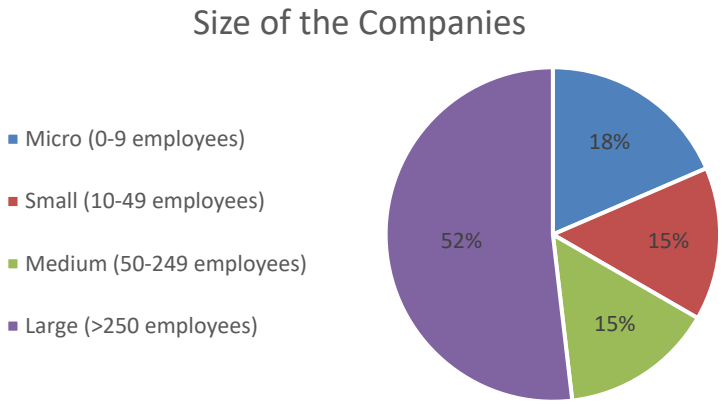

Figure 3: Size of the companies

As a further characteristic of the companies that took part to the survey, the sector into which each company operates has been inspected. As a result, the sectors into which the companies are present the most are the ones related to automotive (8/27), industrial and electronics (6/27) and machine building and process industry (5/27 each). Other sectors in which the companies are present are transport systems, telecommunications, home and building (each with a share of 3/27) and energy supply (1/27).

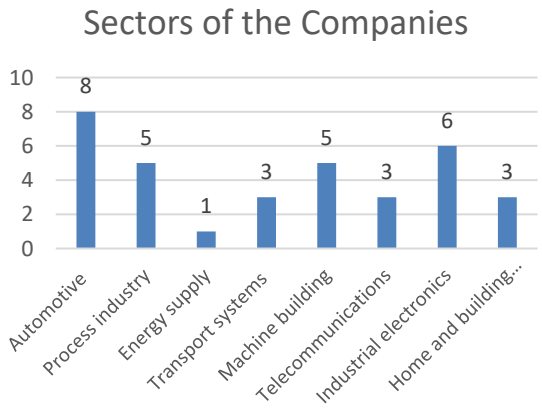

Figure 4: sector of the companies

Section 2 - Knowledge in Automation 4.0

The second section of the questionnaire provides information about the current knowledge of participants about automation in the context of Industry 4.0, which have been presented with the following question:

> **Q**: *How knowledgeable are you in the following Automation 4.0 technology areas? (from 1 to 5, with 1 being the expression of minimum level and 5 the maximum). Highest/lowest values are marked in red.*

Observing the feedback obtained from this section of the survey, the subgroup referred to students display an acceptable knowledge in the fields of Cyber-Physical Systems and Industrial Internet of Things (IIoT) (2,90/5), vision systems (2,96/5), cloud computing (3,06/5) and Big Data (3,16/5). On the other hand, their knowledge lacks when considering digital twin application (2,76/5), additive manufacturing (2,68/5) and horizontal and vertical system integration (2,64/5). From a general perspective, it can be observed that student knowledge in the observed knowledge field never shows considerably high values (the highest value recorded is 3,16/5 concerning knowledge in Big Data). Ph.D. students appear to have the most valuable knowledge in every technological field, reasonably explained by a higher experience. Though, it is observed that Master students seem to express lower knowledge values compared to both Bachelor and Ph.D. students (Figure 5).

Teachers display a better knowledge of Cyber-Physical Systems and Industrial Internet of Things (IIoT) (2,82/5), Robotics/Basic of Robotic Control/Robotic Programming (2,88/5) and advanced PLC programming (2,94/5). While they appear to deficit in knowledge fields such as horizontal and vertical system integration (2,06/5), digital twin application (2,00/5) and cybersecurity (1,94/5).

Professionals from industry are reportedly more knowledgeable in Robotics/Basic of Robotic Control/Robotic Programming (2,89/5), advanced PLC programming (2,89/5) and feedback control technology (2,93/5). The less familiar themes for professionals from industry are big data analysis for industrial applications (2,48/5), additive manufacturing (2,44/5) and Augmented Reality (AR) (2,37/5). Comparing the operating field of each responding company, it is not possible to identify a trend, since, as could be awaited, the focus of knowledge of each firm strongly depends on its operative field (Figure 6).

Comparing the three subgroups, it can be assessed that students are the ones that show the highest knowledge in the proposed technology fields with an average value of 2,85/5. Professionals from industry follows, with an average value of 2,69/5. The group that shows the least average knowledge is the one referred to teachers and professors, which result to have an average knowledge value of 2,44/5. From a general stand point, it has to be underlined that, in general, the values obtained from each subgroup for each knowledge field are located around the center of the scale. There is no complete ignorance nor excellence for any of the proposed knowledge fields.

Students	Average(1-5)
· Cyber-Physical Systems and Industrial Internet of Things (IIoT)	2,90
· Advanced PLC programming	2,82
· Feedback Control Technology	2,78
· Robotics/ Basic of Robotic Control/ Robotic Programming	2,82
· Advanced Human-Machine Systems	2,82
· Big Data Analysis for Industrial Applications	**3,16**
· Digital twin application	2,76
· Cybersecurity	2,84
· Vision system	2,96
· Cloud computing	3,06
· Augmented Reality (AR)	2,78
· Horizontal and vertical system integration	**2,64**
· Additive manufacturing	2,68

*Table 1: knowledge in automation 4.0 Students**

Professional from industry	Average(1-5)
· Cyber-Physical Systems and Industrial Internet of Things (IIoT)	2,85
· Advanced PLC programming	2,89
· Feedback Control Technology	2,93
· Robotics/ Basic of Robotic Control/ Robotic Programming	2,89
· Advanced Human-Machine Systems	2,56
· Big Data Analysis for Industrial Applications	2,48
· Digital twin application	2,48
· Cybersecurity	2,70
· Vision system	2,89
· Cloud computing	**2,96**
· Augmented Reality (AR)	**2,37**
· Horizontal and vertical system integration	2,56
· Additive manufacturing	2,44

*Table 2: knowledge in automation 4.0 Professional from industry**

*Items highlighted in **green** are the ones with the highest rating, whilst the ones highlighted in **red** are the less rated ones.

Teachers/Professors	Average(1-5)
· Cyber-Physical Systems and Industrial Internet of Things (IIoT)	2,82
· Advanced PLC programming	**2,94**
· Feedback Control Technology	2,71
· Robotics/ Basic of Robotic Control/ Robotic Programming	2,88
· Advanced Human-Machine Systems	2,47
· Big Data Analysis for Industrial Applications	2,41
· Digital twin application	2,00
· Cybersecurity	**1,94**
· Vision system	2,65
· Cloud computing	2,47
· Augmented Reality (AR)	2,24
· Horizontal and vertical system integration	2,06
· Additive manufacturing	2,18

*Table 3: knowledge in automation 4.0 Teachers/Professors**

*Items highlighted in **green** are the ones with the highest rating, whilst the ones highlighted in **red** are the less rated ones.

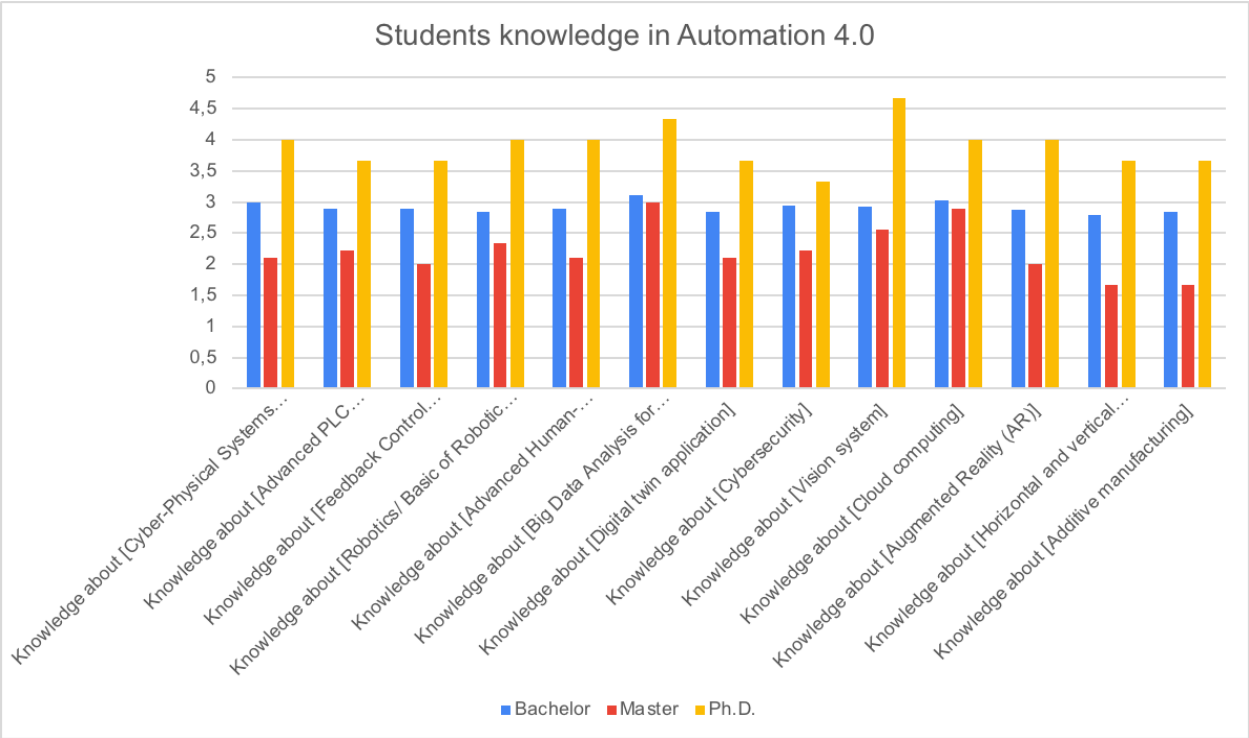

Figure 5: knowledge in automation 4.0 contingent on the student's degree

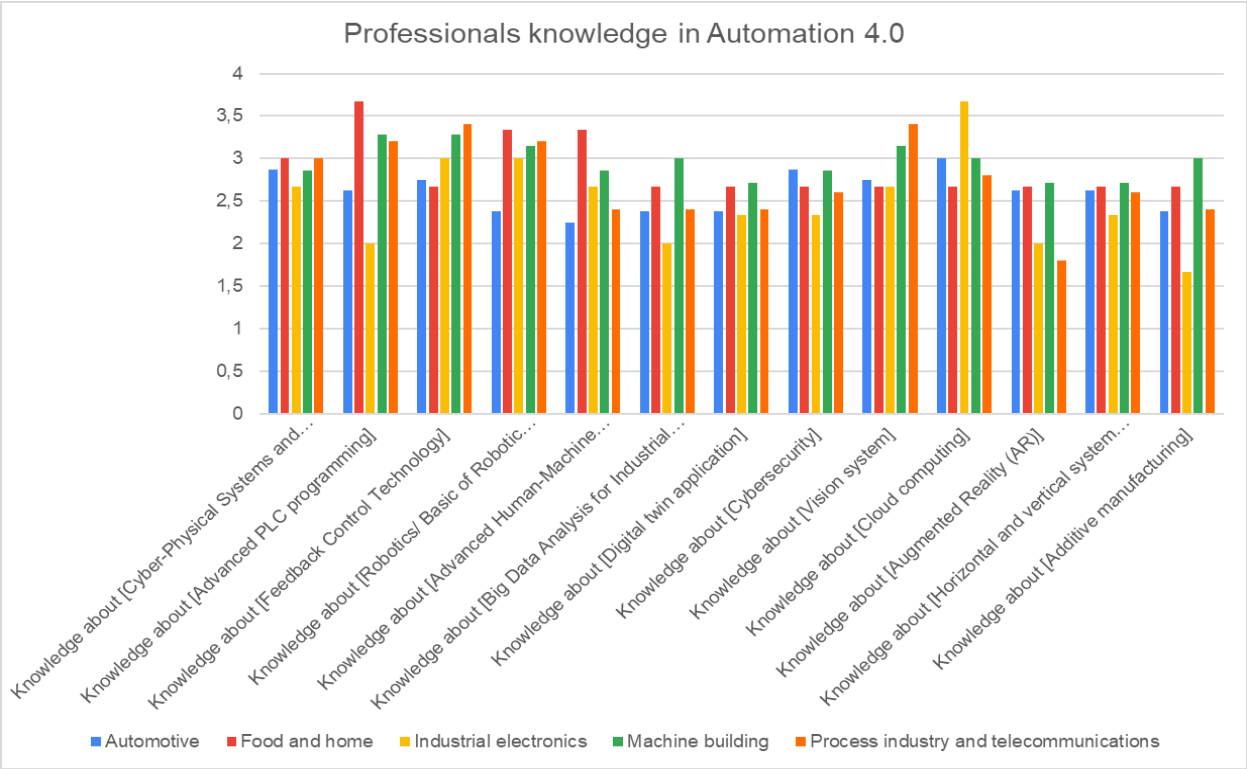

Figure 6: knowledge in automation 4.0 contingent on the company´s sector

Section 3 - Students Questionnaire

Part 1: General Needs in Qualification

In the first part of the third section of the survey, the opinion of students about general needs in qualification is investigated. The majority of the students appear to be more likely not satisfied (23/50) or more likely satisfied (20/50), while 4 out of 50 students said to be not satisfied at all and 3 reported to be fully satisfied. Students assessed that establishing the basis of a theoretical training is the most problematic aspect of training (18/50), followed by knowledge of modern automation equipment (12/50) and knowledge of modern industrial communication technology (10/50). The second and the third issues listed among the problematic aspects of training appear to be related to not being up-to-date with the latest technologies and products available on the market.

The chance to upgrade the laboratory base at the graduation department of the university of the responding students resulted to be very relevant, as the vast majority of student opted for this answer (33/50).

Students ask for IoT technology and PLC facilities in the laboratories of their department. In addition, cloud computing, along with data analysis capabilities are required too. This feedback can be linked to the type of knowledge that has been expressed by students and reported in the previous section.

***Q1**: How satisfied are you with the quality of your qualification as specialists in industrial automation and control?*

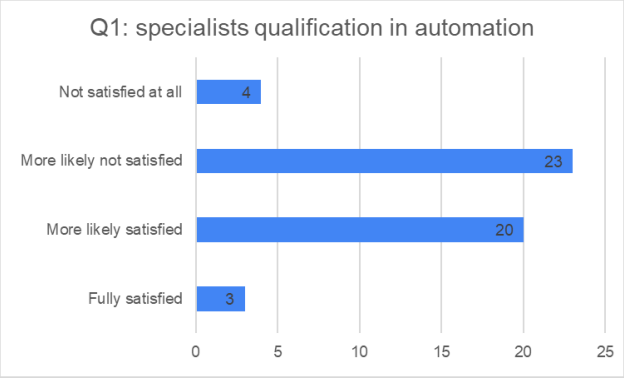

Figure 7: Q1 specialists qualification

***Q2**: Which aspects of the training would you identify as the most problematic?*

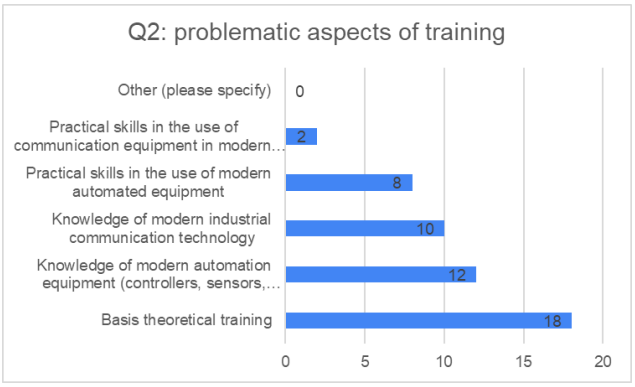

Figure 8: Q2 problematic training aspects

***Q3**: Assess the degree of relevance of upgrading the laboratory base at your graduation department.*

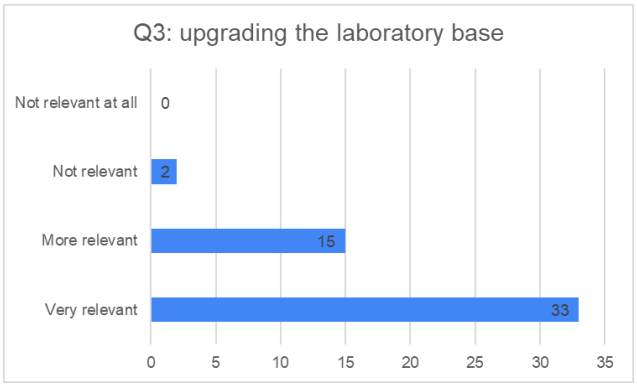

Figure 9: Q3 upgrading the laboratory base

Q4: List your training courses in automation and control that you think require a new laboratory facility.

The most frequent answers are (ranked in order of frequency):

- IoT;
- PLC;
- Cloud Computing;
- Data Analysis.

Part 2: Specific Needs related to Automation 4.0 Technologies

In the second part of section three the specific needs related to Automation 4.0 technologies are going to be inspected from students' perspective.

Students show a quite good knowledge about Thailand enterprises as they give similar answers to the other two groups (teacher and professionals). Ethernet IP appears to be the most spread technology for the implementation of networks in automation, but also PowerLink, IO-Link and AS-Interface show considerable degrees of spreading.

ProfiBus and DeviceNet are the communication technologies that students consider to be important for the knowledge of an automation specialist. Other technologies such as Profinet, Interbus, CAN and ASI are considered important too. For what concerns the communication topic, wireless technologies are the considered to be very important. In this regard, students expressed the opinion that Wi-Fi is the most promising wireless technology, followed by Bluetooth and GSM technologies.

Students use to exploit a number of different Human-Machine Interaction (HMI), such as touch screen (27/50), smartphones and tablets (24/50) and PC-SCADA applications developed with commercial tools (20/50).

General Electric (23/50) and Mitsubishi (23/50) appear to be the manufacturers which products are present the most in student's laboratories for what concerns automation and control. Other manufacturers, such as Delta, Omron, Owen, Schneider Electric and Siemens share an average value of 11/50.

For students it is observed that it is very important to take a course on modern automation and control technology in the context of Industry 4.0.

When considering different kinds of methodologies for designing and developing advanced automation and control system applications, students that are currently undergoing Bachelor courses show a higher interest in the relevance of such kinds of technologies with respect to what expressed by Master students and Ph.D.s. The proposed methodologies share the same interest among the same students' subgroup.

Students are particularly interested in trainings about the IEC 61131-3 programming standard for their future careers. They do not have a well-defined preference when asked to choose a particular programming language based on the above mentioned standard. In general, students are interested in structured and object-oriented programming languages, probably due to their good knowledge of those coding paradigm. In addition, they are said to be very interested in new PLC programming languages.

For what concerns IoT communication protocols, students are more interested in REST API (29/50) and MQTT (27/50) communication protocols, but also in OPC UA (20/50).

Along with students' expression of knowledge of cloud-based control systems, they assess that they consider this type of technology very important. In this field, the services that are estimated as more

useful for students are Google Cloud (37/50) and Azure (25/50). Other services such as IBM Cloud, Proficloud, MindSphere.

Students prefer specific manufacturer training materials. This could be related to the fact that increasing material standardization and homogeneity the learning process could be facilitated.

Students do not show a preference for what concerns learning methods, even though a slight preference for in-lab experiences and case-studies, whereas the preferred activities are programming, analysis and design and simulation.

The questions of this part of the survey are listed below.

***Q5**: Which of the modern technologies and protocols of industrial telecommunications are most widespread at the enterprises of Thailand? (Multiple answers possible)*

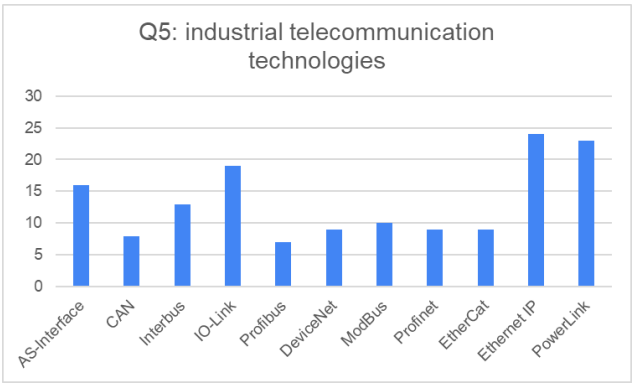

Figure 10: Q5 telecommunication technologies

***Q6**: How important is it for an automation specialist to know the following communication technologies and protocols?*

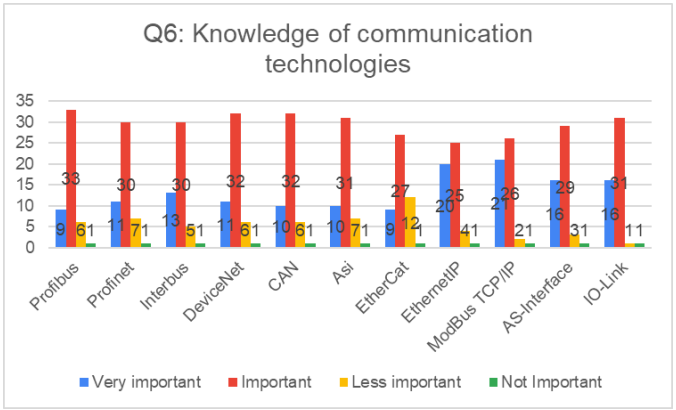

Figure 11: Q6 knowledge of communication technologies

***Q7**: How relevant is the development of wireless communication facilities in the field of industrial automation and control?*

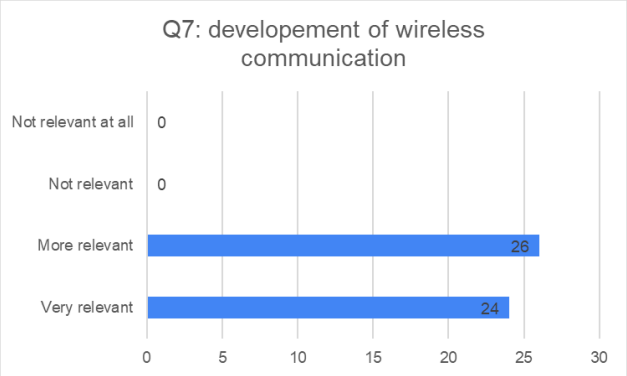

Figure 12: Q7 development of wireless communication

***Q8**: In your opinion, which of the presented wireless technologies are the most promising from the point of view of their use in automation systems? (Multiple answers possible)*

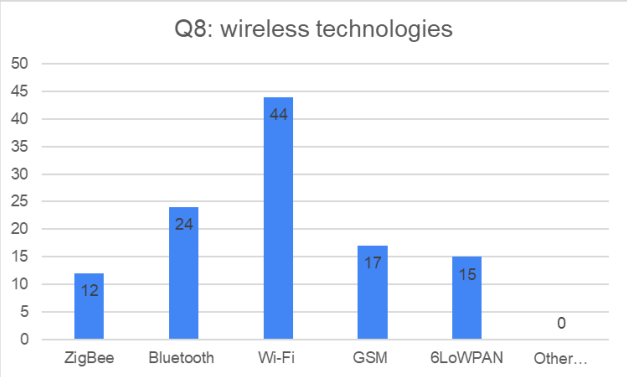

Figure 13: Q8 wireless technologies

***Q9**: Which of the modern technologies of industrial telecommunications or their combinations seem to be the most promising for you in the future? (e.g. CAN-Bluetooth-Modbus TCP/IP)*

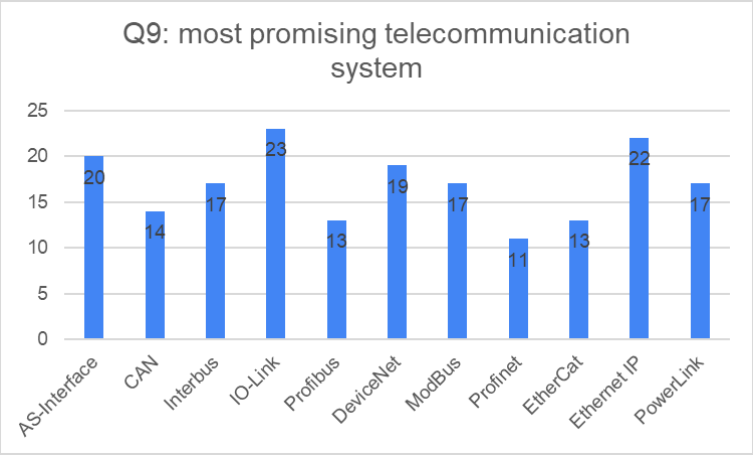

Figure 14: Q9 promising telecommunication system

***Q10**: What type of Human-Machine Interaction (HMI) systems do you usually use? (Multiple answers possible)*

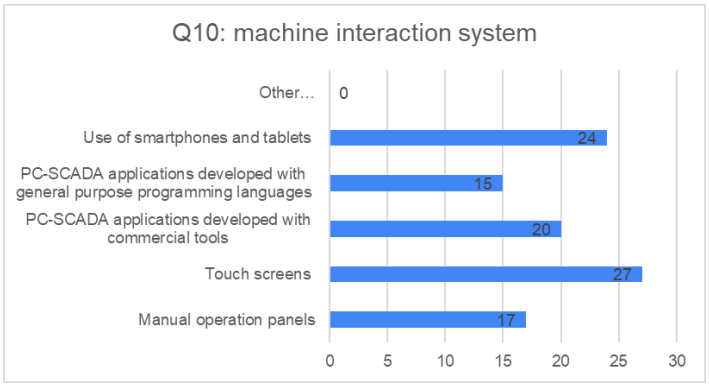

Figure 15: Q10 machine interaction system

***Q11**: Which manufacturers are used in your department in laboratory courses on automation and control? (e.g. PLC)? The manufacturers are listed alphabetically. (Multiple answers possible)*

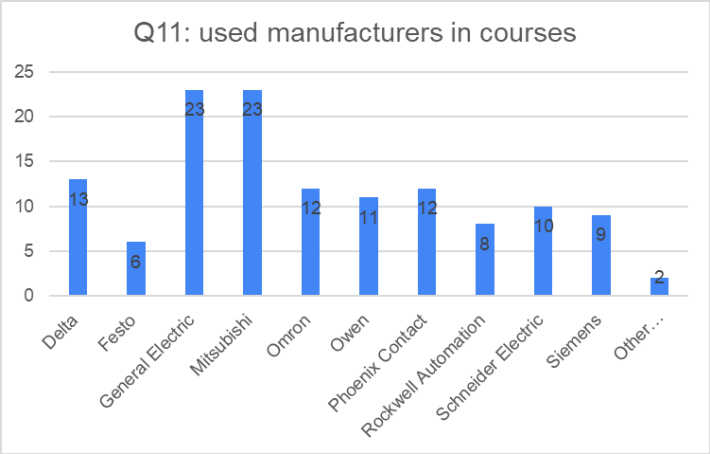

Figure 16: Q11 used manufacturers

***Q12**: How relevant is it for you to take a course on modern automation and control technology in the context of industry 4.0?*

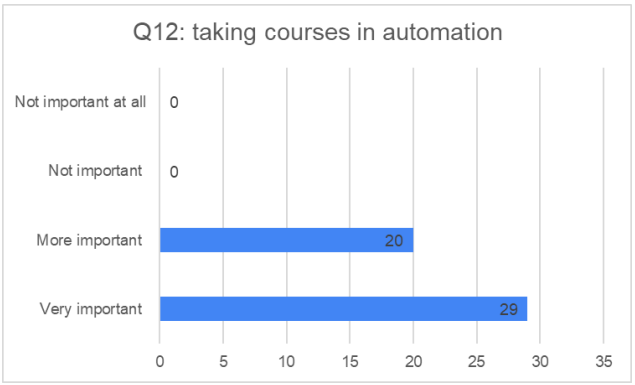

Figure 17: Q12 courses in automation

***Q13**: Do you use and/or are interested in some kind of methodology for design and development of advanced automation and control system applications like the following ones?*

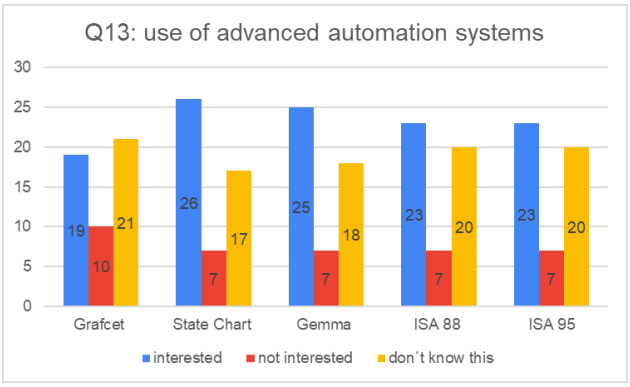

Figure 18: Q13 advanced automation systems

***Q14**: How important is training in the IEC 61131-3 programming standard for your future career?*

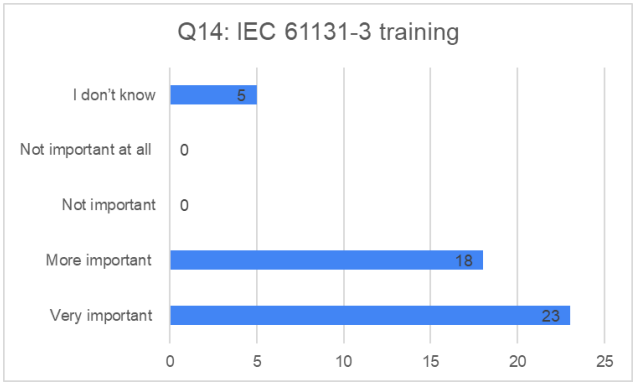

Figure 19: Q14 IEC 61131-3 training

***Q15**: Which other programming languages based on IEC 61131-3 standard are most appropriate in your future career? (Multiple answers possible)*

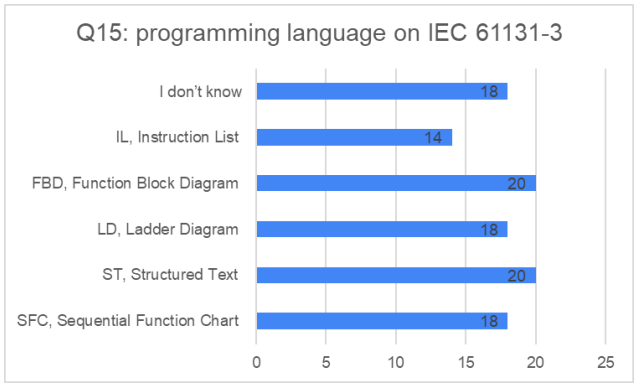

Figure 20: Q15 programming language on IEC 61131-3

***Q16**: What other programming languages do you consider for your future career of interest for the integral development of automation and control systems? (Multiple answers possible)*

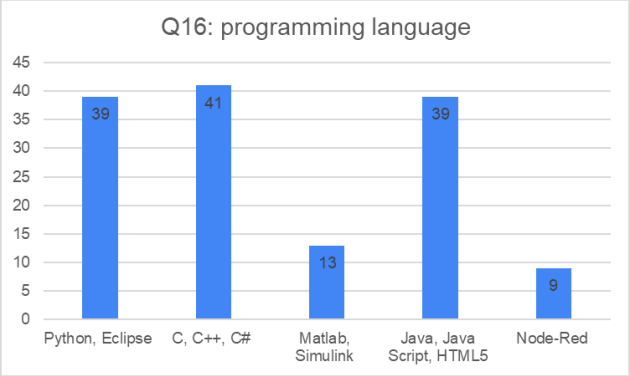

Figure 21: Q16 programming language

***Q17**: What IoT communication protocols do you consider of interest to your future career? (Multiple answers possible)*

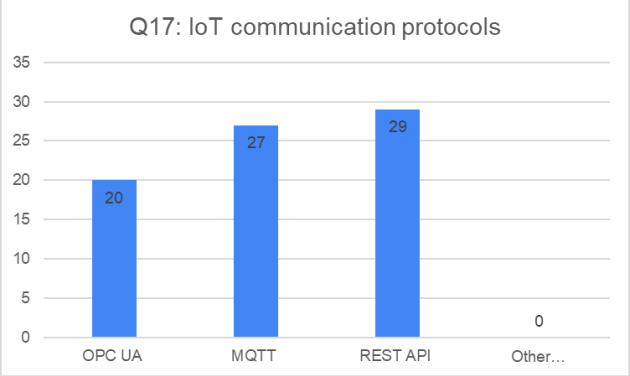

Figure 22: Q17 IoT communication protocols

***Q18**: Do you think the integration of Mathcad/Simulink and/or classic programming languages (C/C ++, C #, Java…) into a PLC in the future is important for you?*

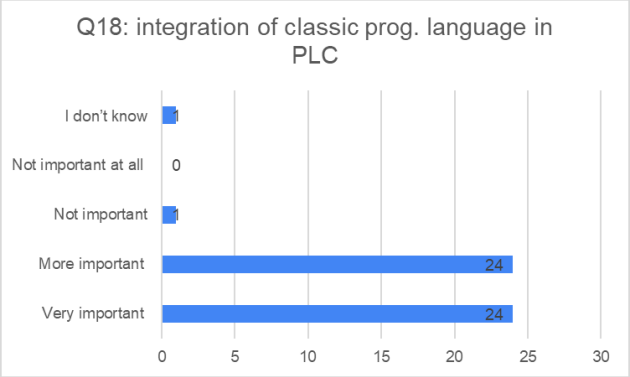

Figure 23: Q18 integration of classic prog. Language in PLC

***Q19**: Do you consider that using cloud-based control systems will be important in the future?*

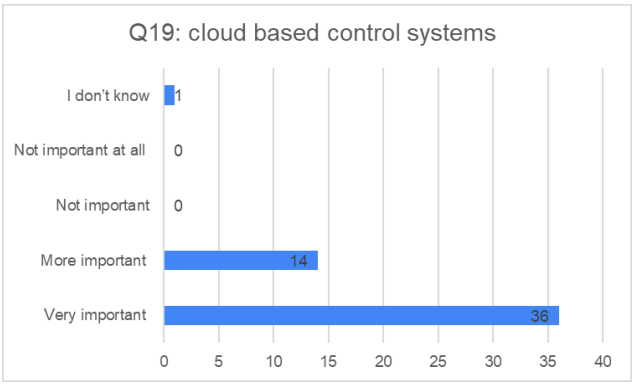

Figure 24: Q19 cloud based control systems

***Q20**: Which cloud system do you estimate is more useful for you? (Multiple answers possible)*

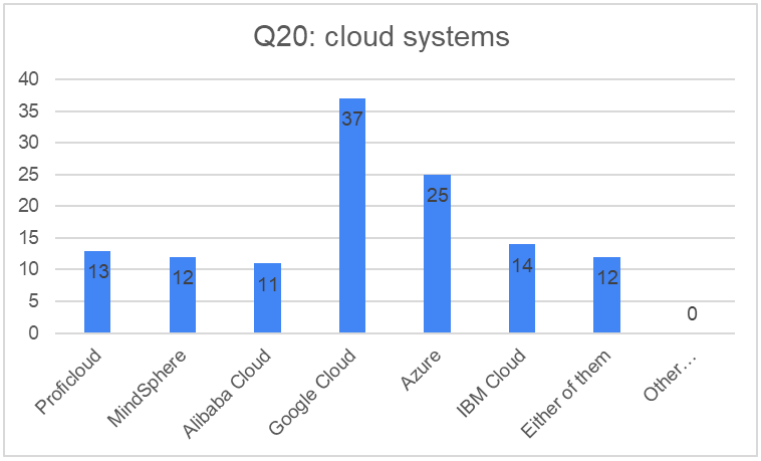

Figure 25: Q20 cloud systems

***Q21**: How important is it for you to use open and flexible PLCs that also support an ecosystem with user groups, apps and open source software?*

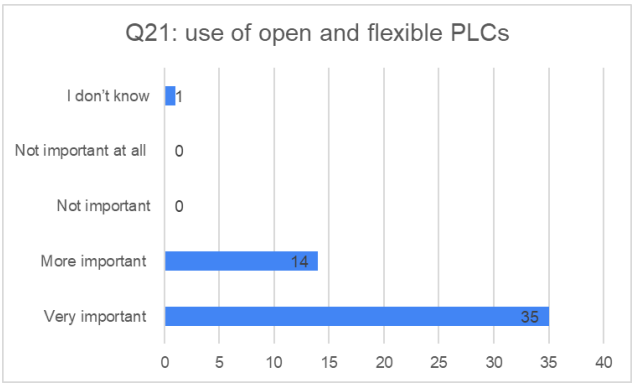

Figure 26: use of PLCs

***Q22**: Regarding training materials, how important do you think it is for you to be based on a specific manufacturer?*

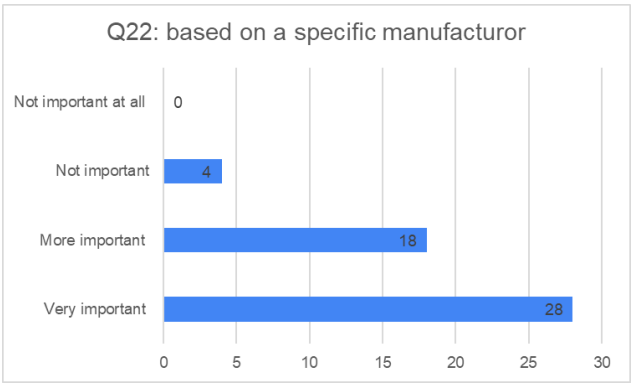

Figure 27: Q22 use of a specific manufacturer

***Q23**: What learning methods do you prefer? (from 1 to 5, with 1 being the expression of minimum level and 5 the maximum)*

Learning methods	Average (1-5)
E-learning (online)	4,02
Lecture (face-to-face)	4,18
Group work (face-to-face)	3,92
Laboratory / Case-study work	4,46

Table 4: Q23 learning methods

***Q24**: Which kind of activities are more interesting for using the training equipment? (Multiple answers possible)*

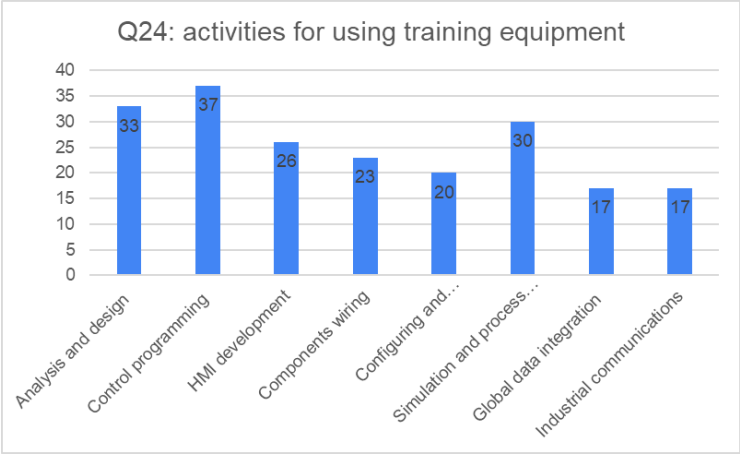

Figure 28: Q24 activities for using training equipment

Section 4 – Teacher/Professor Questionnaire

Part 1: General Needs in Qualification

In the first part of the fourth section of the survey, the opinion of teachers and professors about general needs in qualification is studied.

Foremost, it has to be said that most of teachers are not satisfied with their qualification and need to improve their specialized knowledge, and update the control equipment. They identify two mostly problematic aspects of training: the lack of practical skills in the use of modern automated equipment (5/17) and the lack of knowledge of modern automation equipment (controllers, sensors, actuators) (5/17).

The relevance of upgrading the laboratory facilities in teachers' and professors' department/institution is very important for the majority of the respondents (10/17). Thanks to upgraded laboratory facilities, courses about IoT, PLC, Cloud and robots may be positively influenced, as teachers and professors assessed in the survey.

The questions of this part of the survey are listed below.

> ***Q1**: How satisfied are you with the quality of your qualification as specialists in industrial automation and control?*

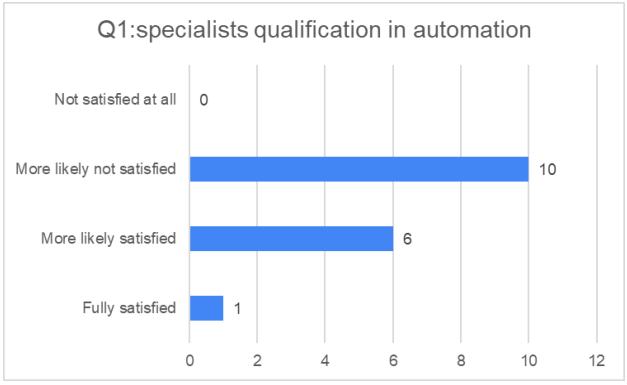

Figure 29: Q1 specialists qualification

***Q2**: Which aspects of the training of these specialists would you identify as the most problematic?*

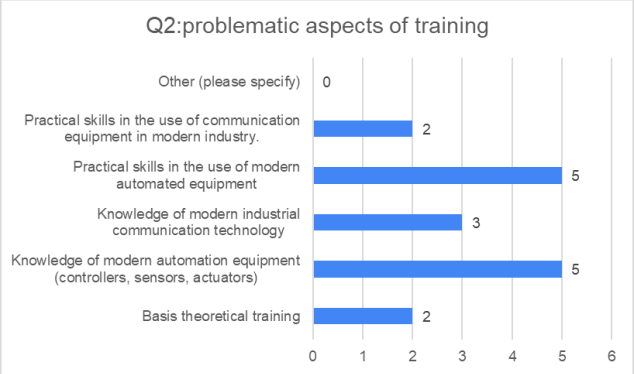

Figure 30: Q2 problematic training aspects

***Q3**: Assess the relevance of upgrading the laboratory facilities in your department/institution.*

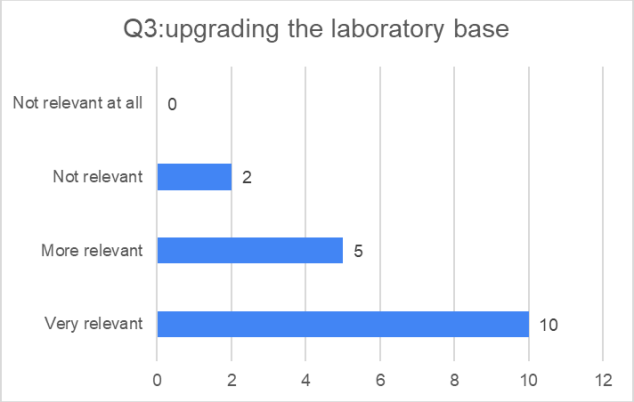

Figure 31: Q3 upgrading the laboratory base

***Q4**: List the students' training courses in automation and control that you think need a new laboratory facility.*

The Most frequent answers are (ranked in order of frequency):

- IoT,
- PLC,
- Cloud,
- Robot.

Part 2: Specific Needs related to Automation 4.0 Technologies

In the second part of section four the specific needs related to Automation 4.0 technologies are going to be inspected from teachers' and professors' perspective.

Observing the results of this part of the survey, it is that the more extended telecommunication technologies at the enterprises of Thailand and the more useful ones for the future are Profibus, Modbus and Ethernet-IP. Profinet is also quite relevant as a telecommunication technology.

Teachers and professors consider very important to develop wireless communication facilities in the field of industrial automation and control. In particular, they think that Wi-Fi is of particular interest.

Teachers and professors use any kind of HMI system, with remarkable exploitation of touch screens (11/17) and of smartphones and tablets (9/17).

In teachers' and professors' department automation and control courses, manufacturers such as Mitsubishi (12/17), Omron (9/17) and Siemens (7/17), among others.

In teachers' and professors' opinion it is very important:

- to use equipment linked to a specific manufacturer;
- to learn programming using IEC 61131-3 standard; all languages except IL are considered relevant;
- to program in Python, Eclipse and C varieties, integrated in the PLC;
- to use flexible PLCs, with the aid of Apps and Open source software;
- to implement automation Safety applications.

For what concerns teaching/learning methods, teachers and professors assessed that:

- the teaching staff needs advanced courses in modern automation and control technologies;
- the number of participants (students or professionals) in different courses could be more than 10;
- laboratory usage and case studies as a learning method or face to face work in several applications about Automation 4.0 are preferable;
- the most interesting training activities are around analysis and design, control programming, HMI development, simulation and process control and industrial communications.

The questions of this part of the survey are listed below.

***Q5**: Which of the modern technologies and protocols of industrial telecommunications are most widespread at the enterprises of Thailand? (Multiple answers possible)*

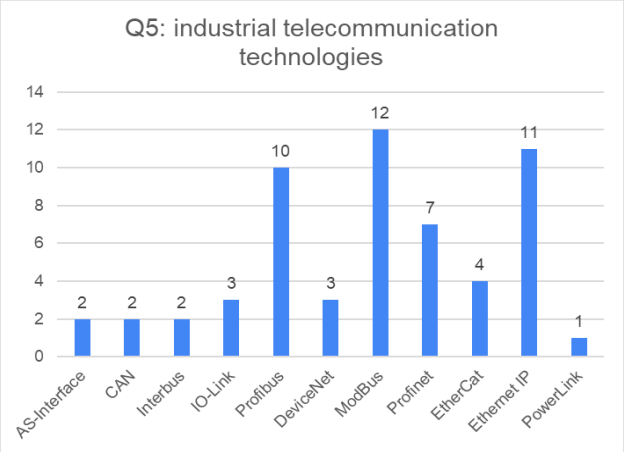

Figure 32: Q5 telecommunication technologies

***Q6**: How important is it for an automation specialist to know the following communication technologies and protocols?*

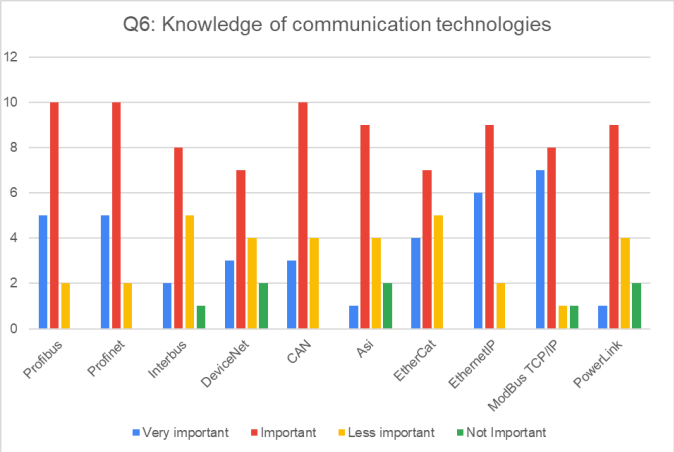

Figure 33: Q6 knowledge of telecommunication technologies

***Q7**: How relevant is the development of wireless communication facilities in the field of industrial automation and control?*

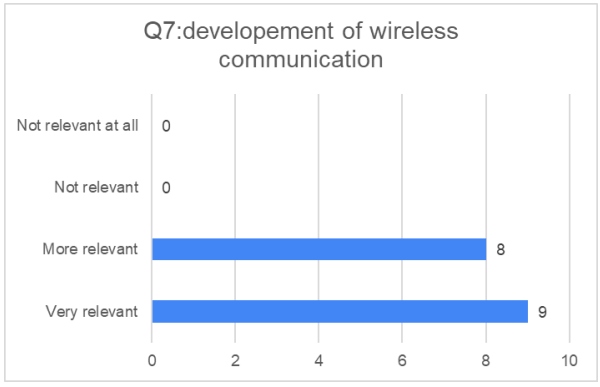

Figure 34: Q7 development of wireless communication

***Q8**: In your opinion, which of the presented wireless technologies are the most promising from the point of view of their use in automation systems? (Multiple answers possible)*

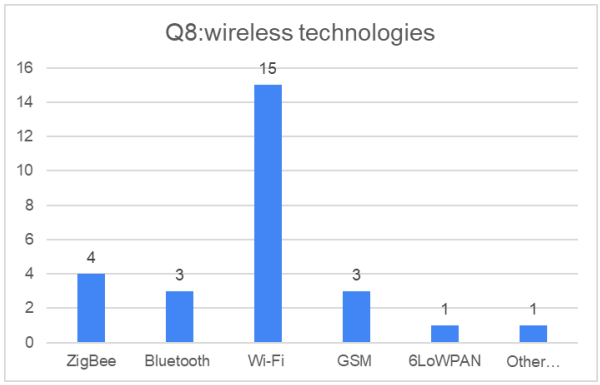

Figure 35: Q8 wireless technologies

***Q9**: Which of the modern technologies of industrial telecommunications or their combinations seem to be the most promising in the future? (e.g. CAN-Bluetooth-Modbus TCP/IP)*

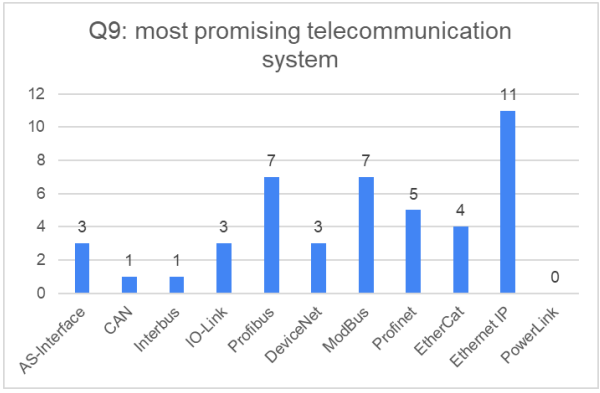

Figure 36: Q9 most promising telecommunication system

***Q10**: What type of Human-Machine Interaction (HMI) systems do you usually use? (Multiple answers possible)*

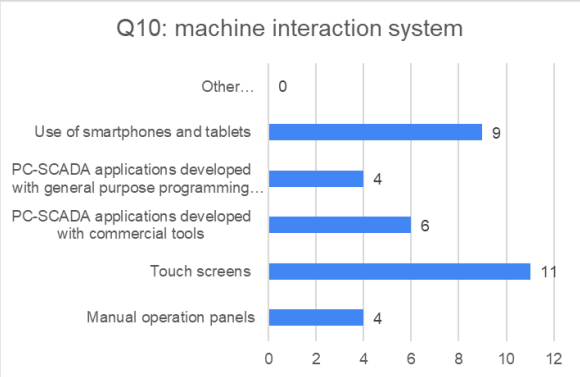

Figure 37: Q10 machine interaction system

***Q11**: Which manufacturers do you use in your department's automation and control courses? (e.g. PLC)? The manufacturers are listed alphabetically. (Multiple answers possible)*

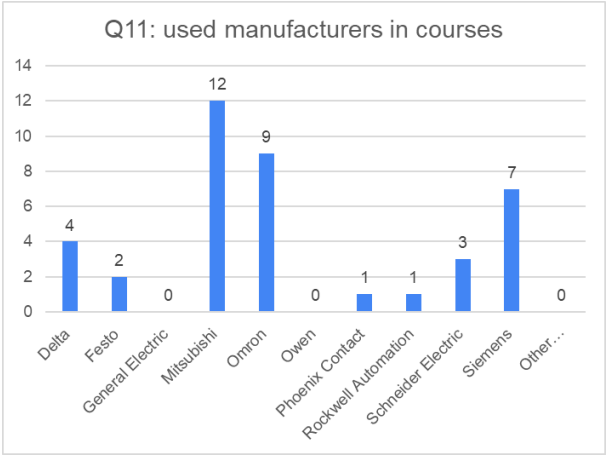

Figure 38: Q11 used manufacturers in courses

***Q12**: How important is the binding to the equipment of a certain manufacturer when organizing courses on modern automation technologies?*

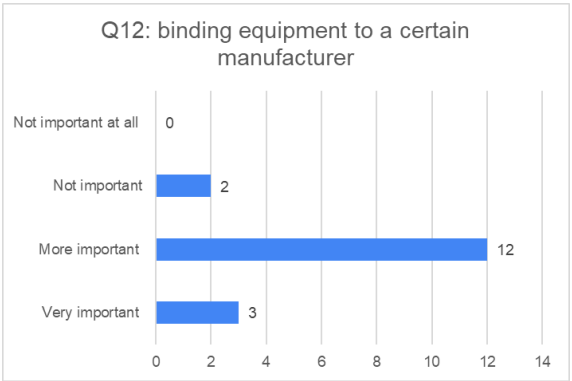

Figure 39: Q12 use of specific manufacturers

***Q13**: Do you use and/or are interested in some kind of methodology for design and development of advanced automation and control system applications like the following ones?*

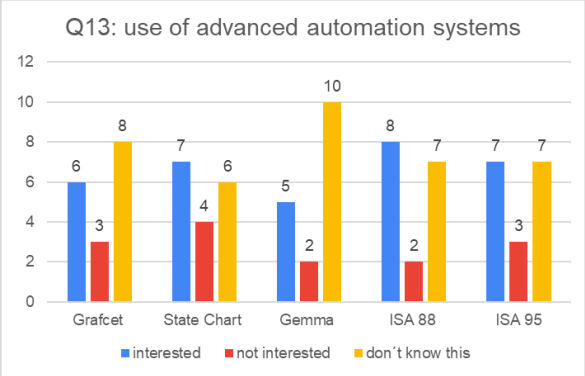

Figure 40: Q13 use of advanced automation systems

***Q14**: How important is training in the IEC 61131-3 programming standard for your course/teaching facility?*

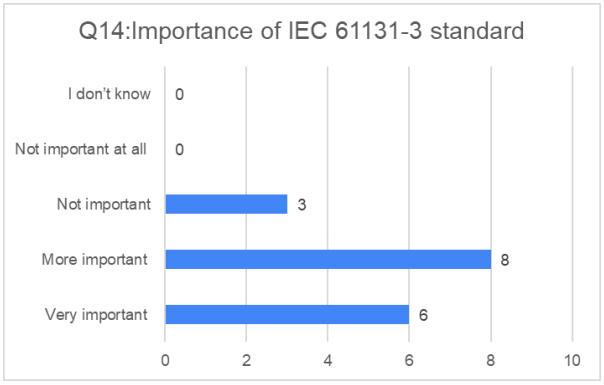

Figure 41: Q14 IEC 61131-3 standard

***Q15**: Which other programming languages based on IEC 61131-3 standard are most appropriate in your course/teaching facility? (Multiple answers possible)*

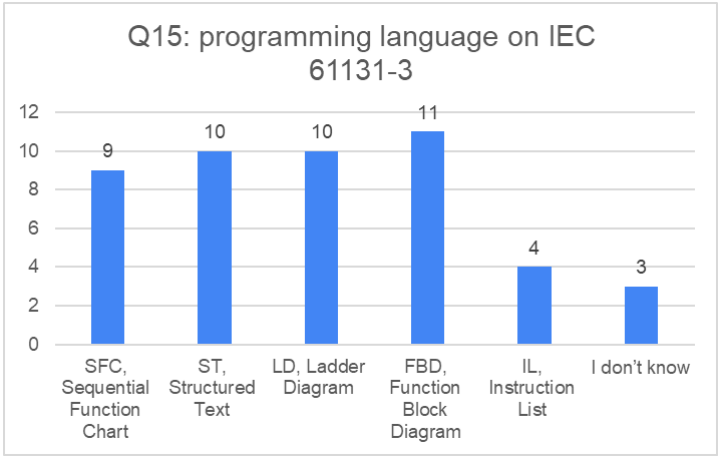

Figure 42: Q15 prog. language on IEC 61131-3

***Q16**: What other programming languages do you consider in your course/teaching facility of interest for the integral development of automation and control systems? (Multiple answers possible)*

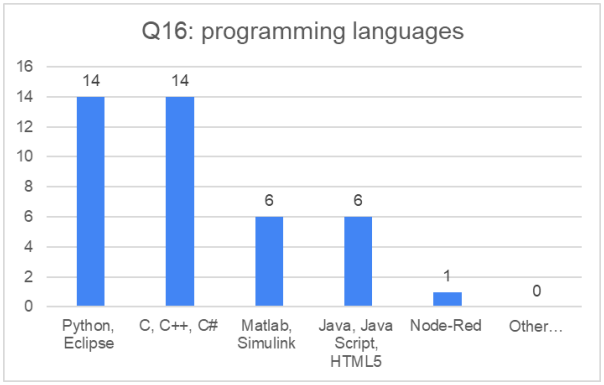

Figure 43: Q16 programming languages

***Q17**: What IoT communication protocols do you consider of interest to your course/teaching facility? (Multiple answers possible)*

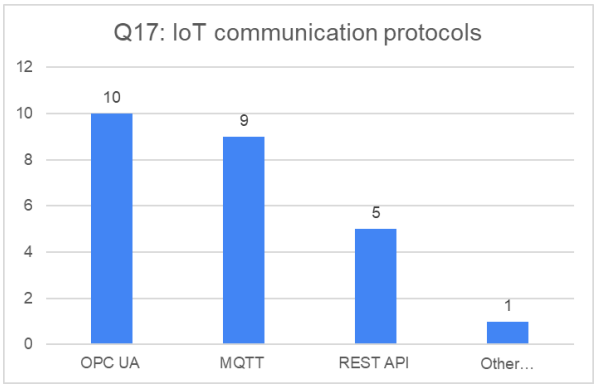

Figure 44: Q17 IoT communication protocols

***Q18**: Do you think the integration of Mathcad/Simulink and/or classic programming languages (C/C ++, C #, Java…) into a PLC in the future is important for you?*

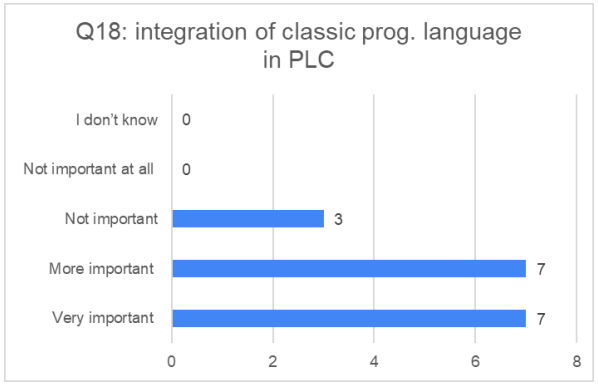

Figure 45: Q18 integration of classic prog. language in PLC

***Q19**: Do you consider that using cloud-based control systems will be important in the future?*

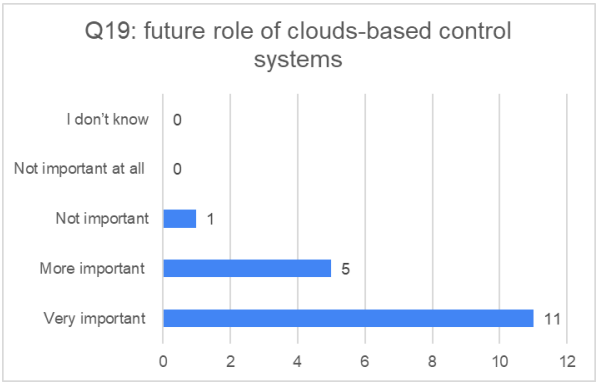

Figure 46: Q19 cloud based control systems

***Q20**: Which cloud system do you estimate is more useful for you? (Multiple answers possible)*

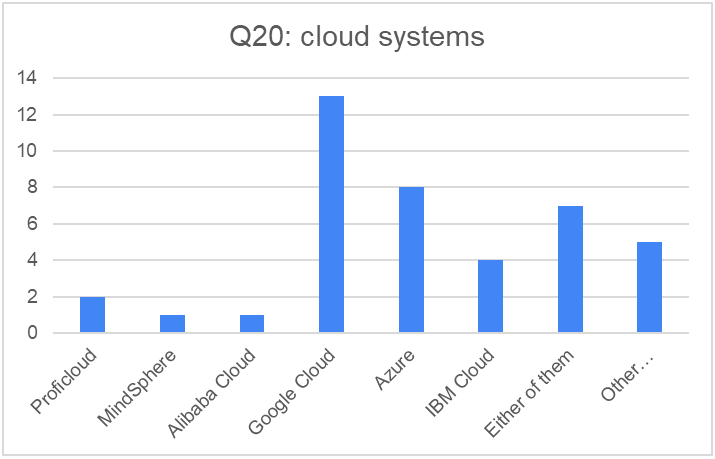

Figure 47: Q20 cloud systems

***Q21**: How important is it for you to use open and flexible PLCs that also support an ecosystem with user groups, apps and open source software?*

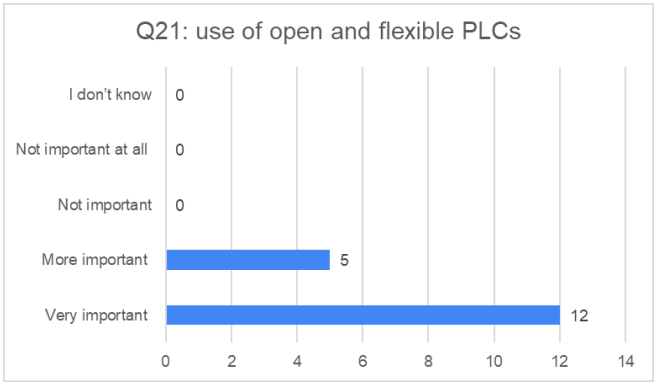

Figure 48: Q21 use of PLCs

***Q22**: How important is it in the courses on industrial automation technologies to address the issues of implementation of safety automation means?*

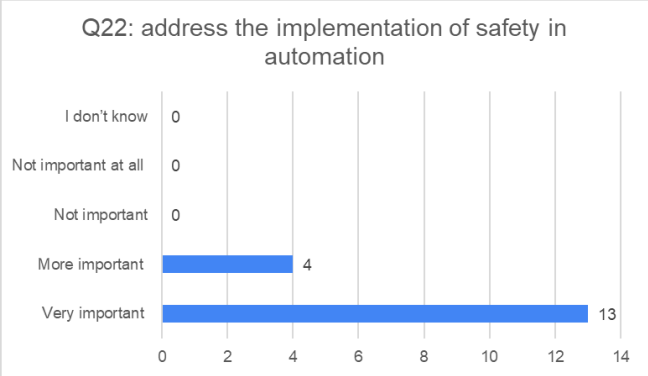

Figure 49: Q22 safety in automation

***Q23**: Regarding training materials, how important do you think it is for you to be based on a specific manufacturer?*

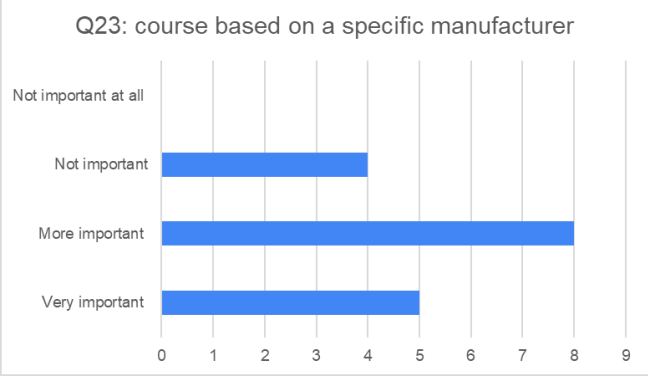

Figure 50: Q23 use of a specific manufacturer

***Q24**: How relevant is it for the staff of your department to take advanced courses in modern automation and control technologies?*

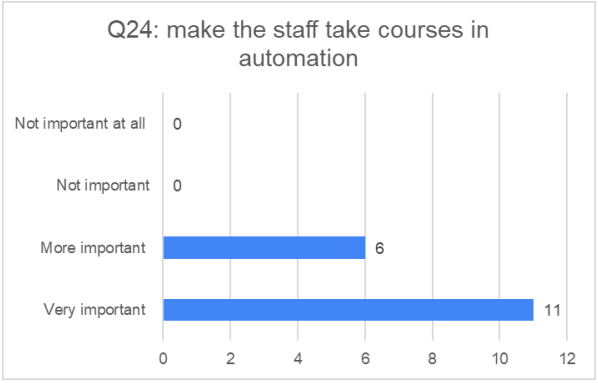

Figure 51: Q24 courses in automation for staff

***Q25**: How many participants (students or professionals from industry) could attend trainings on modern automation technologies in your laboratory facilities?*

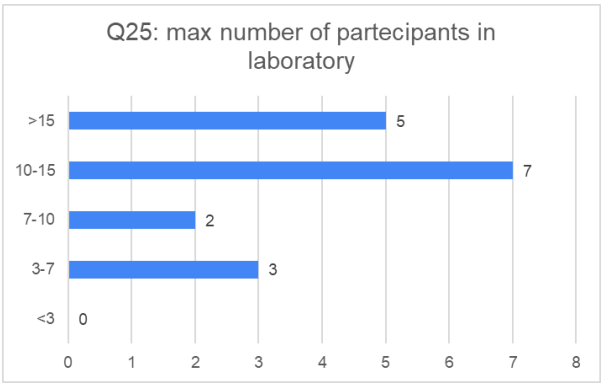

Figure 52: Q25 number of participants in laboratory

***Q26**: What learning methods do you prefer? (from 1 to 5, with 1 being the expression of minimum level and 5 the maximum)*

Q26: learning methods	**Average(1-5)**
E-learning (online)	2,07
Lecture (face-to-face)	2,67
Group work (face-to-face)	2,59
Laboratory / Case-study work	2,96

Table 5: Q26 learning methods

***Q27**: What kind of application would you prefer for demonstrators on Automation 4.0? (from 1 to 5 with 1 being the expression of minimum level and 5 the maximum)*

Q27: applications Automation 4.0	Average(1-5)
Robotic station	2,74
Conveyor belt	2,41
Tank system	2,37
Assembling System	2,56
Home automation system	2,89
Smart Farming	2,74

Table 6: Q27 applications automation 4.0

***Q28**: Which kind of activities are more interesting for using the training equipment? (Multiple answers possible)*

Figure 53: Q28 activities for using training equipment

Section 5 – Professionals Questionnaire

Part 1: General Needs in Qualification

In the first part of the fifth section of the survey, the opinion of professionals about general needs in qualification is assessed. In general, professionals are quite satisfied with the qualification of specialists (16-11), although a not negligible part of this subgroup is not satisfied at all (5/27).

The points identified as most problematic in the training by professionals are the practical skills and knowledge of modern automation equipment.

Professionals consider the degree of importance of the modernization of the automation and control equipment in their companies to be very high-high.

The questions of this part of the survey are listed below.

***Q1**: How satisfied are you with the quality of qualification of specialists in industrial automation and control?*

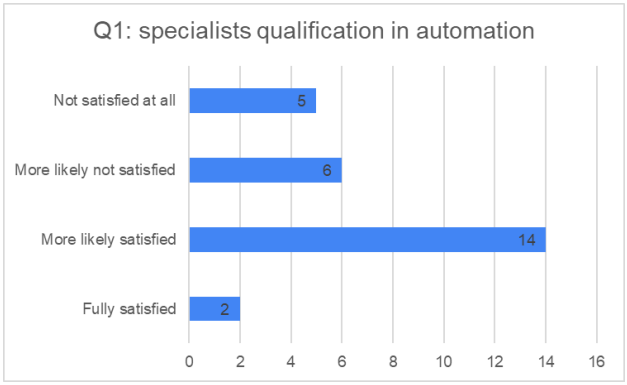

Figure 54 :Q1 specialists qualification

***Q2**: Which aspects of the training of these specialists would you identify as the most problematic? (Multiple answers possible)*

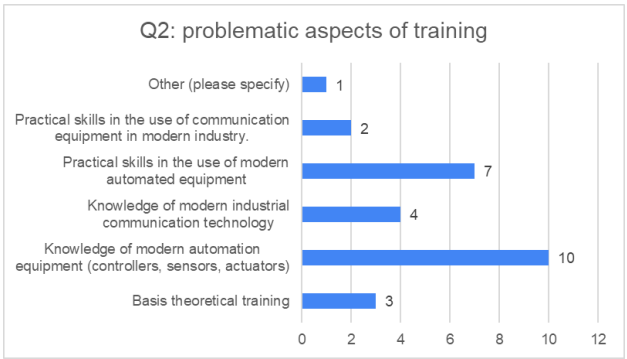

Figure 55: Q2 problematic training aspects

***Q3**: Estimate the degree of relevance of the modernization of automation and control equipment in your company.*

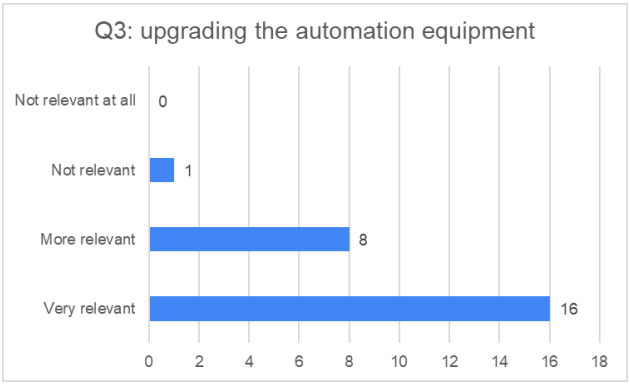

Figure 56: Q3 upgrading the laboratory equipment

Part 2: Specific Needs related to Automation 4.0 Technologies

In the second part of section five the specific needs related to Automation 4.0 technologies are going to be researched from professionals' perspective.

Professionals think that it is important, for an automation specialist, to know a number of different communication protocols, most notably DeviceNet, Profibus, Profinet and AS-I. On the other hand, the communication protocol most widely used by them is Ethernet-IP (20/27), followed by Modbus (8/27), DeviceNet (7/27) and Profinet and IO-Link (6/27), even though the most promising telecommunication technologies in their opinion are by far Ethernet-IP followed by Modbus.

Development of wireless communications is considered to be very relevant and Wi-Fi is seen as the most promising wireless technology from the point of view of its use in automation systems (25/27).

Touch screens are the most used HMI (23/27) and to a certain extent also smartphones and tablets (9/27) and manual operation panels (8/27) are employed for HMI.

Regarding PLC brands, the most used is OMROM (17/27). Mitsubishi (15/27), Siemens (15/27) and Schneider Electric (11/27) are also common in industrial facilities.

Professionals consider the link to the manufacturer to be very important when organizing courses on new automation technologies.

Two thirds of them do not know any automation methodology and one third is interested in.

They consider the training in the IEC 61131-3 standard to be important. Ladder diagram and SFC are the PLC programming languages that better suit their needs and C (C++, C#), Python are chosen as languages of interest for the integral development of automation and control systems. Integration of other programming languages in the PLC in the future is seen as important and the use of open and flexible PLCs is important too.

Professionals found MQTT to be the most interesting IoT protocol for their companies. The use of cloud-based control systems (mainly Google Cloud) is considered also very important.

Regarding automation courses, professional from industry think that:

- the issue of safety very important;
- training should be at the university outside of work hours or at the company during work hours;
- it is very important that training material is based on a specific manufacturer;
- between 3-7 employees could attend the training courses;
- courses should last about 4 days;
- the preferred method of work is laboratory/case study.

Regarding training equipment, professionals from industry think that:

- they prefer mixing active/passive learning;
- the most demanded application are robotic stations, conveyor belts the least;
- the most interesting activities are control programming, analysis, and HMI design and development.

The questions of this part of the survey are listed below.

***Q4**: Which of the modern technologies and protocols of industrial telecommunications are used at your enterprise? (Multiple answers possible)*

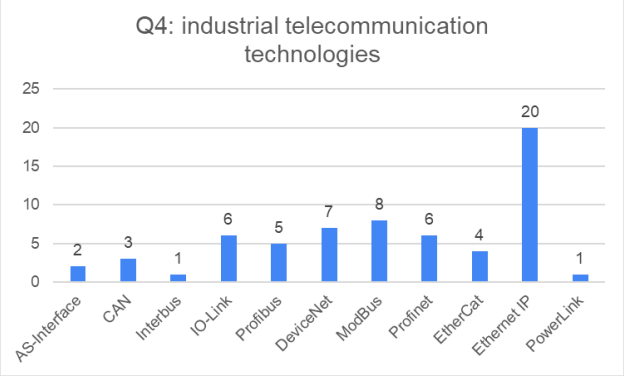

Figure 57: Q4 telecommunication technologies

***Q5**: How important is it for an automation specialist to know the following communication technologies and protocols?*

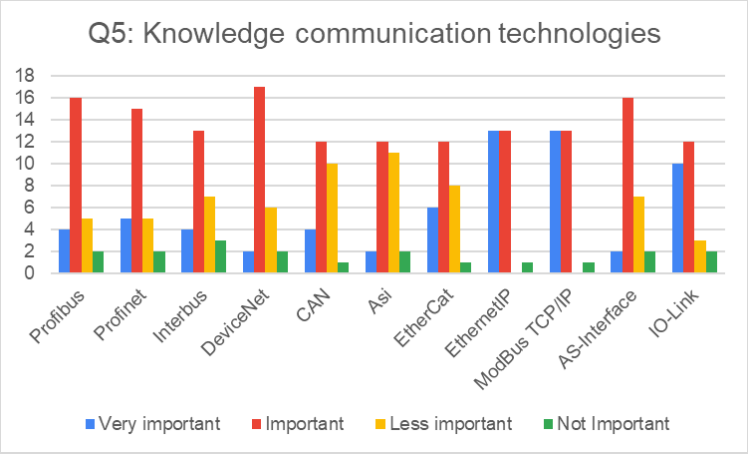

Figure 58: Q5 knowledge of communication technologies

***Q6**: How relevant is the development of wireless communication facilities in the field of industrial automation and control?*

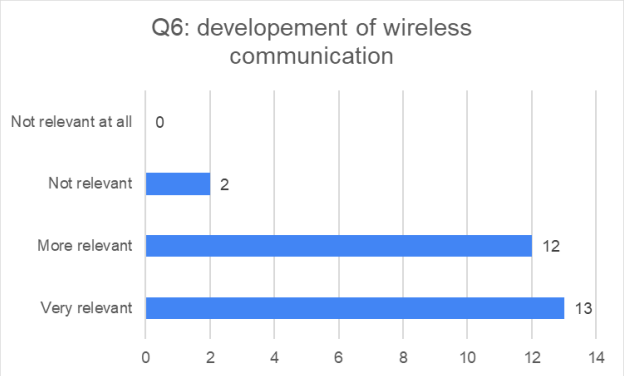

Figure 59: Q6 development of wireless communication

***Q7**: In your opinion, which of the presented wireless technologies are the most promising from the point of view of their use in automation systems? (Multiple answers possible)*

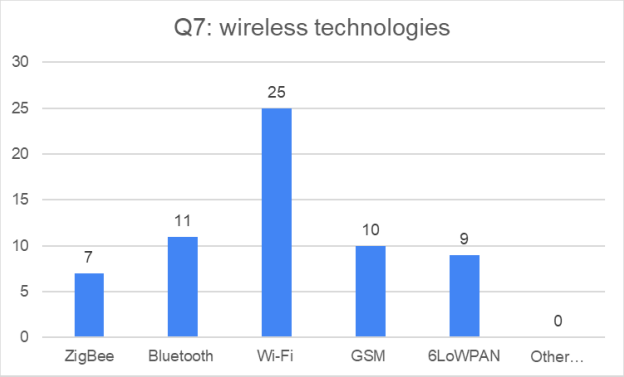

Figure 60: Q7 wireless technologies

***Q8**: Which of the modern technologies of industrial telecommunications or their combinations seem to be the most promising for you in the future? (e.g. CAN-Bluetooth-Modbus TCP/IP)*

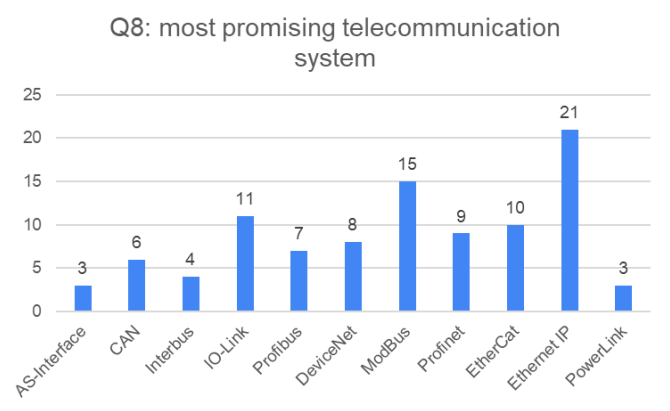

Figure 61: Q8 promising telecommunication system

***Q9**: What type of Human-Machine Interaction (HMI) systems do you usually use? (Multiple answers possible)*

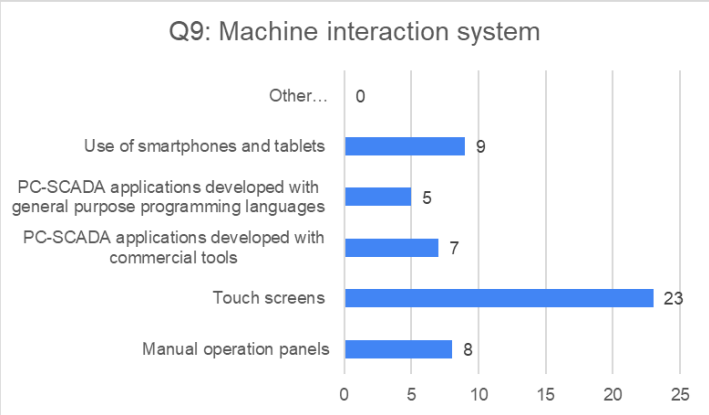

Figure 62: Q9 machine interaction system

***Q10**: What manufacturers/brands are used at your enterprise for industrial automation (e.g. PLC) and HMI? The manufacturers are listed alphabetically. (Multiple answers possible)*

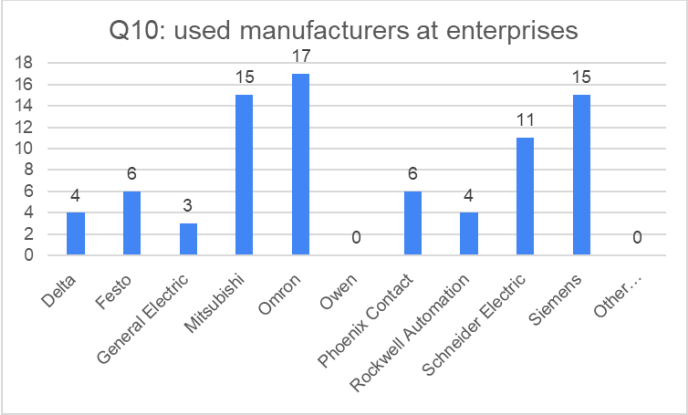

Figure 63: Q10 used manufacturers in enterprises

***Q11**: How important is the binding to the equipment of a certain manufacturer when organizing courses on modern automation technologies?*

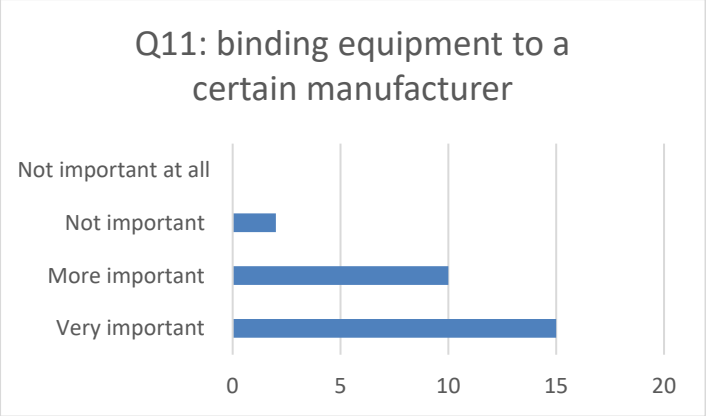

Figure 64: Q11 use of specific manufacturer

***Q12**: Do you use and/or are interested in some kind of methodology for design and development of advanced automation and control system applications like the following ones?*

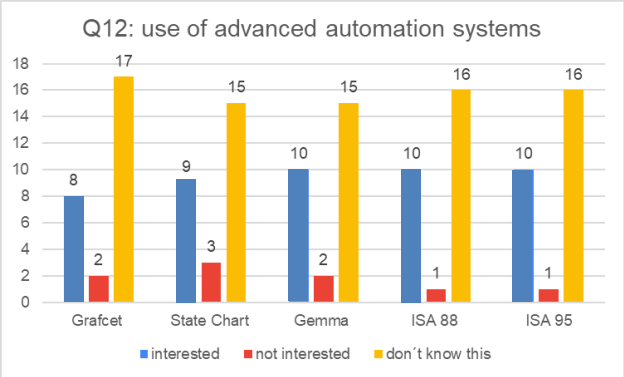

Figure 65: Q12 advanced automation system

***Q13**: How important is training in the IEC 61131-3 programming standard for your company?*

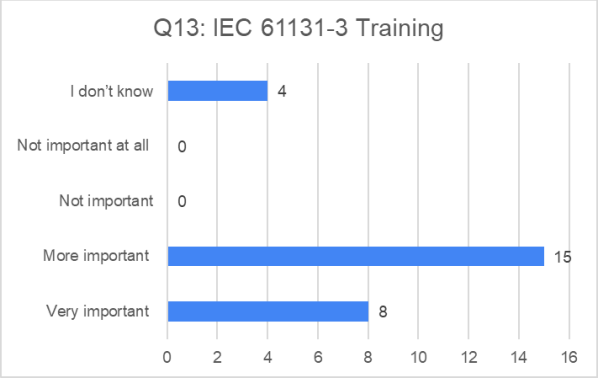

Figure 66: Q13 IEC 61131-3 Training

***Q14**: Which other programming languages based on IEC 61131-3 standard are most appropriate in your company? (Multiple answers possible)*

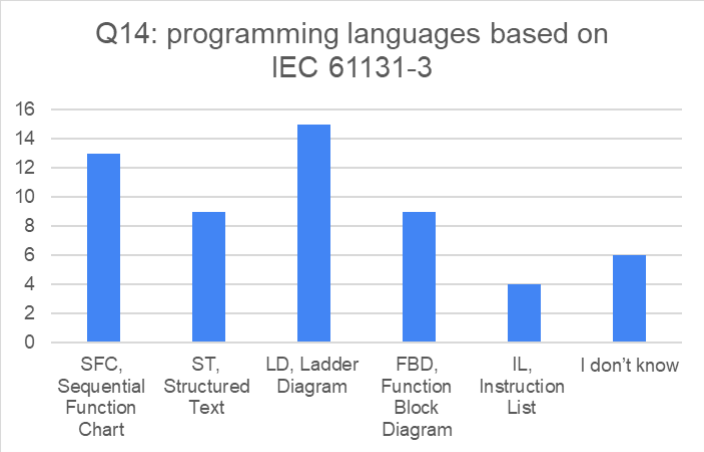

Figure 67: Q14 programming languages based on IEC 61131-3

***Q15**: What other programming languages do you consider in your company of interest for the integral development of automation and control systems? (Multiple answers possible)*

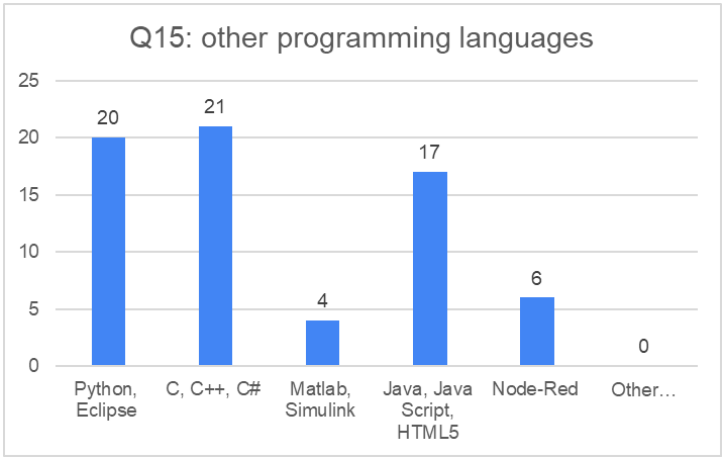

Figure 68: Q15 programming languages

***Q16**: What IoT communication protocols do you consider of interest to your company? (Multiple answers possible)*

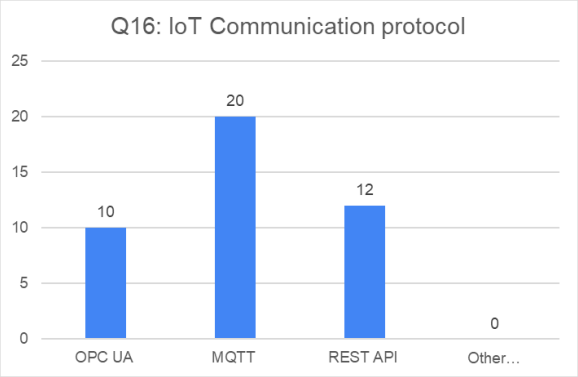

Figure 69: Q16 IoT communication protocols

***Q17**: Do you think the integration of Mathcad/Simulink and/or classic programming languages (C/C ++, C #, Java…) into a PLC in the future is important for you?*

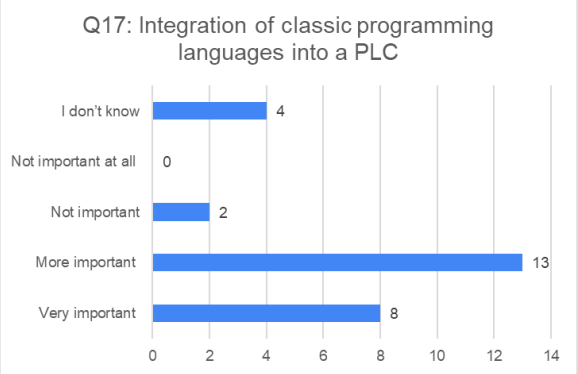

Figure 70: Q17 integration of classic prog. languages in PLCs

***Q18**: Do you consider that using cloud-based control systems will be important in the future?*

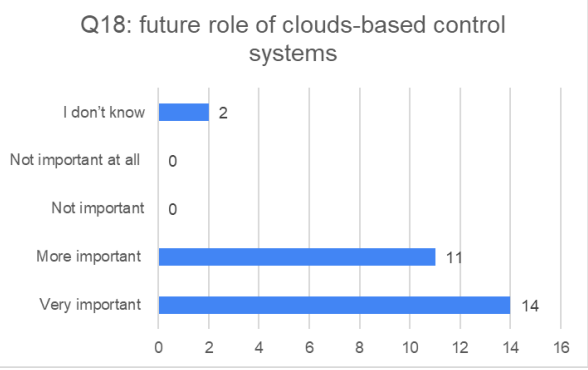

Figure 71: Q18 cloud based control systems

***Q19**: Which cloud system do you estimate is more useful for you? (Multiple answers possible)*

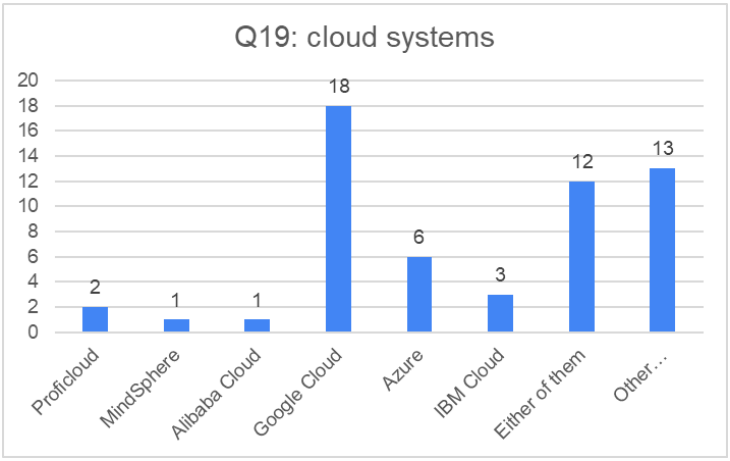

Figure 72: Q19 cloud systems

***Q20**: How important is it for you to use open and flexible PLCs that also support an ecosystem with user groups, apps and open source software?*

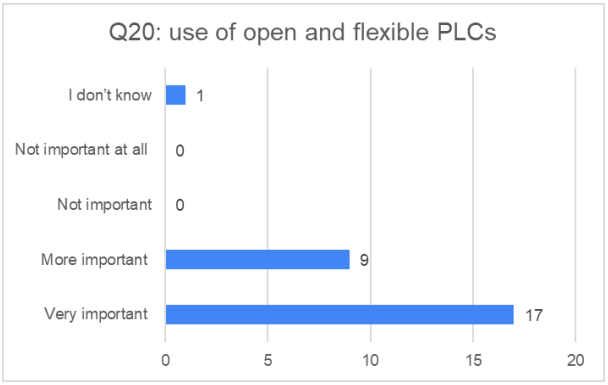

Figure 73: Q20 use of PLCs

***Q21**: How important is it in the courses on industrial automation technologies to address the issues of implementation of safety automation means?*

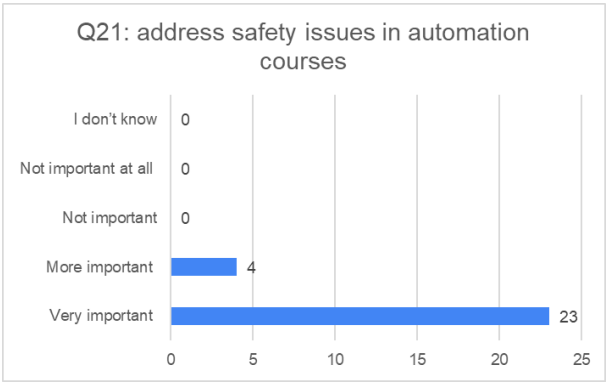

Figure 74: Q21 address safety issues in automation courses

***Q22**: How relevant is the organization of professional courses for specialists in the field of industrial automation and control for your company?*

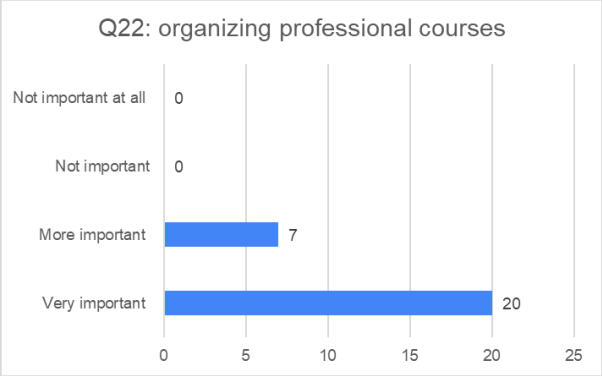

Figure 75: Q22 organizing professional courses

***Q23**: Choose the most appropriate form of further training for your company.*

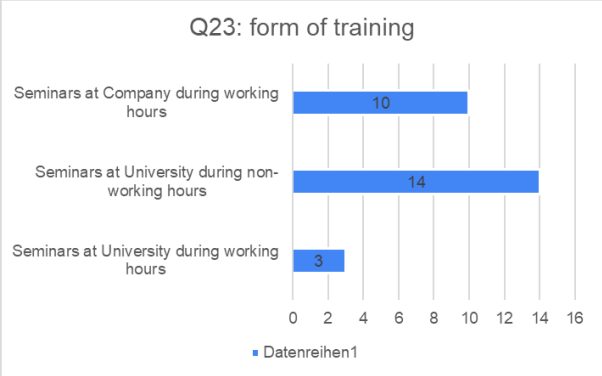

Figure 76: Q23 form of training

***Q24**: Regarding training materials, how important do you think it is for you to be based on a specific manufacturer?*

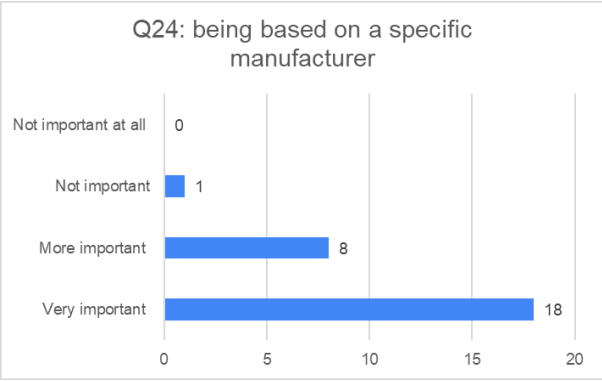

Figure 77: Q24 use of specific manufacturer

***Q25**: How many employees of your enterprise could attend trainings on modern automation technologies?*

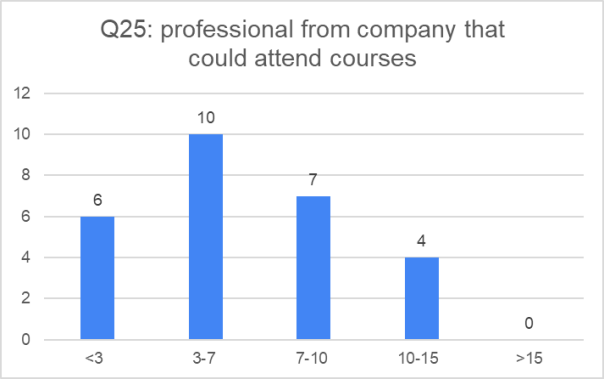

Figure 78: Q25 professionals attending courses

***Q26**: Select the most appropriate length of training.*

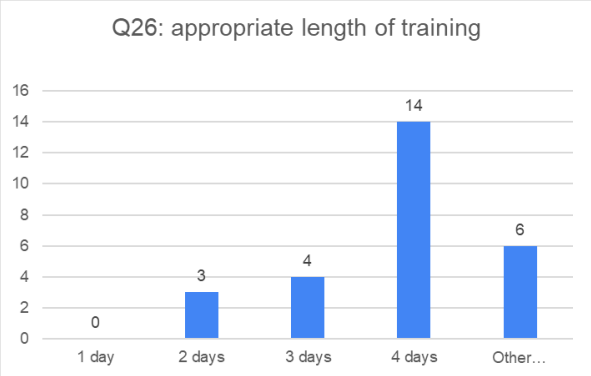

Figure 79: Q26 length of training

***Q27**: What learning methods do you prefer? (from 1 to 5, with 1 being the expression of minimum level and 5 the maximum)*

Q27: training methods	**Average(1-5)**
E-learning (online)	3,33
Lecture (face-to-face)	4,41
Group work (face-to-face)	4,48
Laboratory / Case-study work	4,81

Table 7: Q27 training methods

***Q28**: Would you prefer a passive demonstrator where participants watch or would you prefer an active experiment unit where they interact with the equipment?*

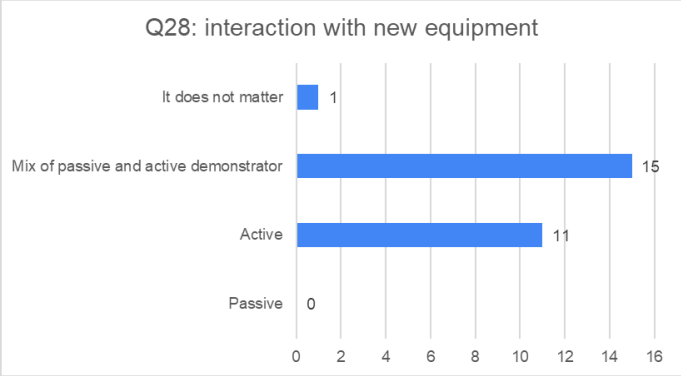

Figure 80: Q28 interaction with new equipment

***Q29**: What kind of application would you prefer for demonstrators on Automation 4.0? (from 1 to 5 with 1 being the expression of minimum level and 5 the maximum)*

Q29: application on automation 4.0	**Average(1-5)**
Robotic station	4,67
Conveyor belt	4,04
Tank system	3,74
Assembling System	4,26
Home automation system	4,33
Smart Farming	4,30

Table 8: Q29 application on automation 4.0

***Q30**: Which kind of activities are more interesting for using the training equipment? (Multiple answers possible)*

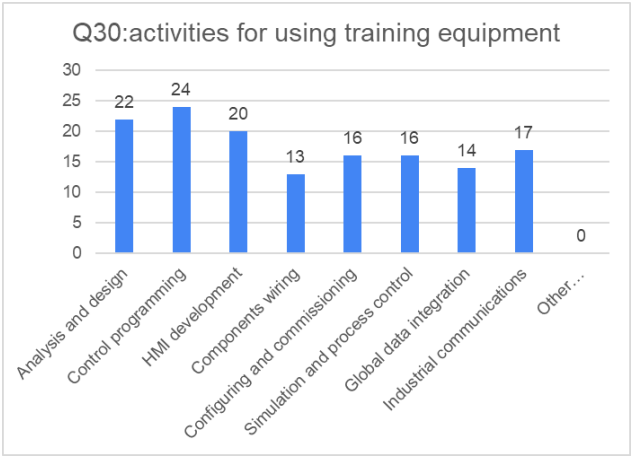

Figure 81: Q30 activities for using training equipment

Section 6. Comparative Analysis

In this section a comparative analysis will be presented, based on the answers given by the three subgroups to the same question. Thanks to this analysis, it will be possible to identify the different needs and points of view of each subgroup. When absolute comparisons are performed among the number of answers from each group, percentage values will be employed in order to make the comparison reliable.

About the degree of familiarity of each subgroup with respect to a number of different Automation 4.0 technologies and aspects, it is possible to say that the average preparation of the participants to the survey, no matter the subgroup they belong to, is found around the middle of the scale. This first comparison brings to light the fact that students appear to be more confident with respect to professors and professionals for the majority of the topics proposed. Based on the average of the values for all three target groups, they see a good background in robotics, PLC programming, Industrial IoT. There is a medium-level knowledge in vision systems, cloud computing, feedback control, big data analytics and human-machine systems. The lowest impression of knowledge has been identified for cybersecurity, augmented reality, additive manufacturing, horizontal/vertical data integration and digital twin application.

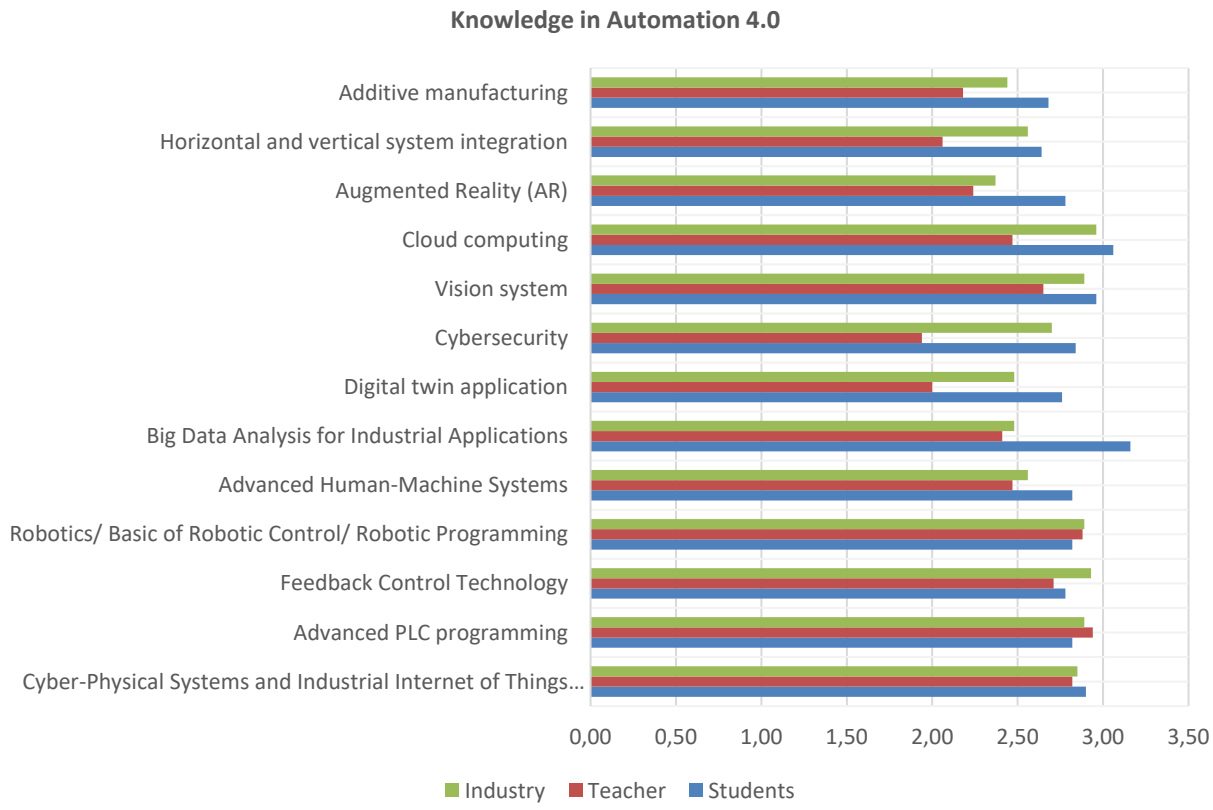

Figure 82: Knowledge in Automation 4.0 of target groups

In an analysis regarding the current state of qualification in Automation 4.0, the respondents gave slightly different answers. Generally, there is a low to medium level of satisfaction regarding the current level of qualification of specialists in Automation 4.0. The majority of students and teachers are not very well satisfied with the training quality. The specialists from the industry, however, are more satisfied with the qualification of their professionals in automation.

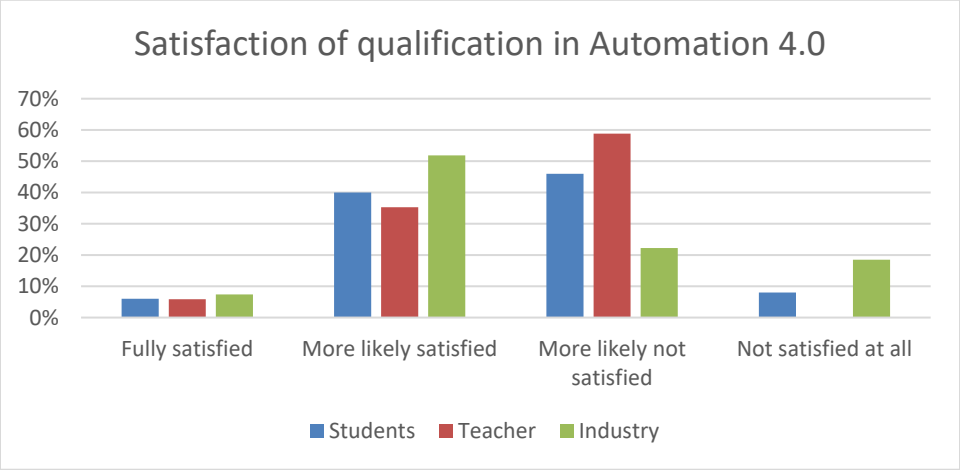

Figure 83: Satisfaction of qualification in Automation 4.0

The next comparison to be performed regards the needs and problematic aspects in teaching Automation 4.0. professional from industry and teachers have a homogeneous view, seeing the providing of knowledge and practical skills in modern automation equipment (e.g. controllers, actuators and sensors) as the most threatening issue. Evidently, students see a problematic aspect in the provision of basic theoretical training and basic knowledge in modern automation equipment as well as industrial communication technology. This radically different view could be given by the fact that students still have to terminate their studies and may still lack in theoretical knowledge in the proposed fields.

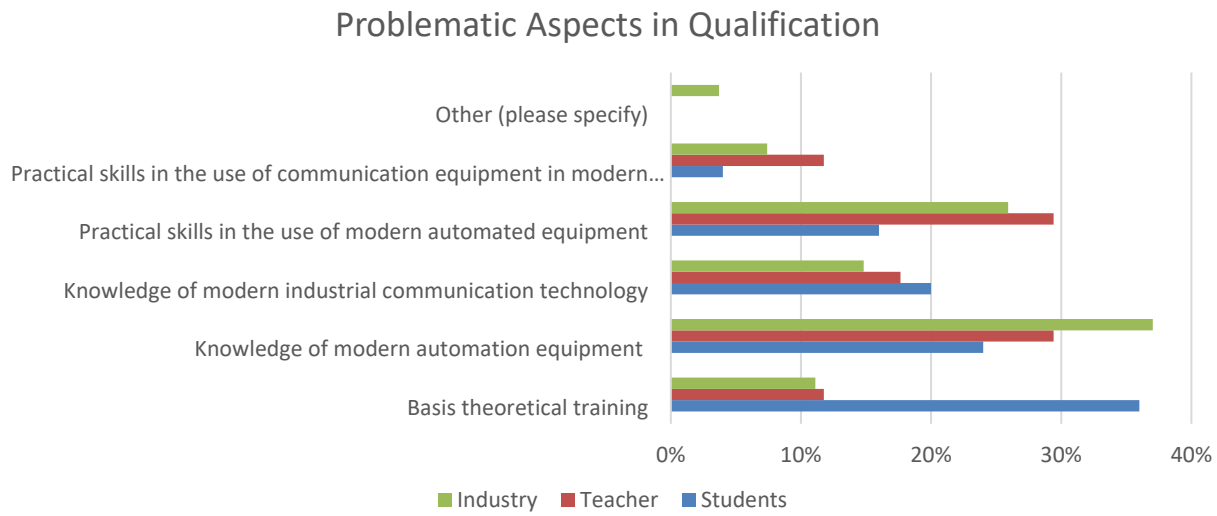

Figure 84: Problematic aspects in qualification

For what concerns the most widespread industrial telecommunication technologies in Thailand. Ethernet IP displays high interest from all the three subgroups. It has to be observed how teachers and professors generally evaluate industrial telecommunication technologies in a more moderate manner with respect to students and professionals.

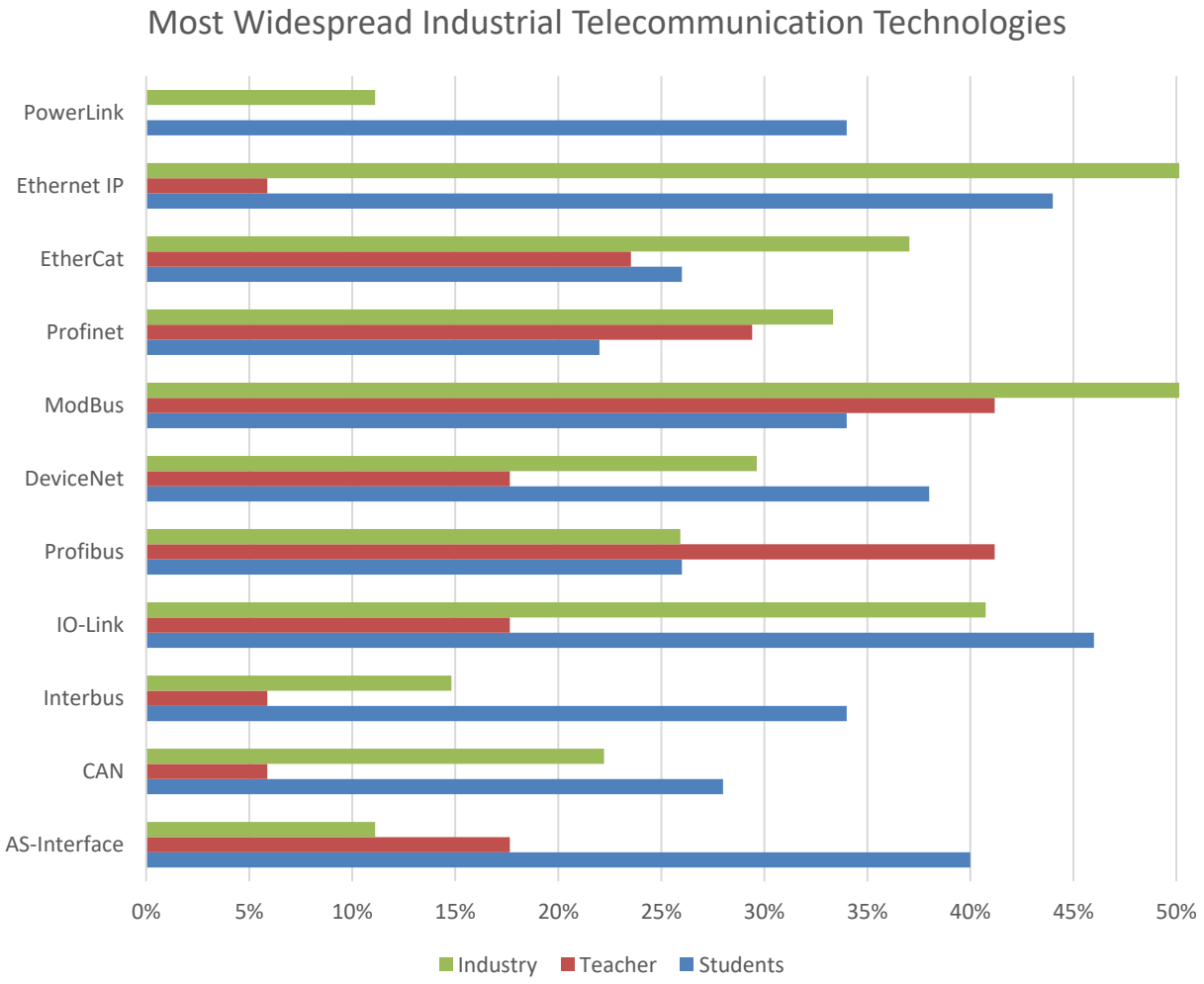

Figure 85: Most widespread industrial telecommunication technologies

For what concerns the choice of a most promising wireless technologies, students, teachers and industrials agree with each other about the fact that Wi-Fi is the most promising one. The answers recorded in this field follow the same path regardless the answering subgroup.

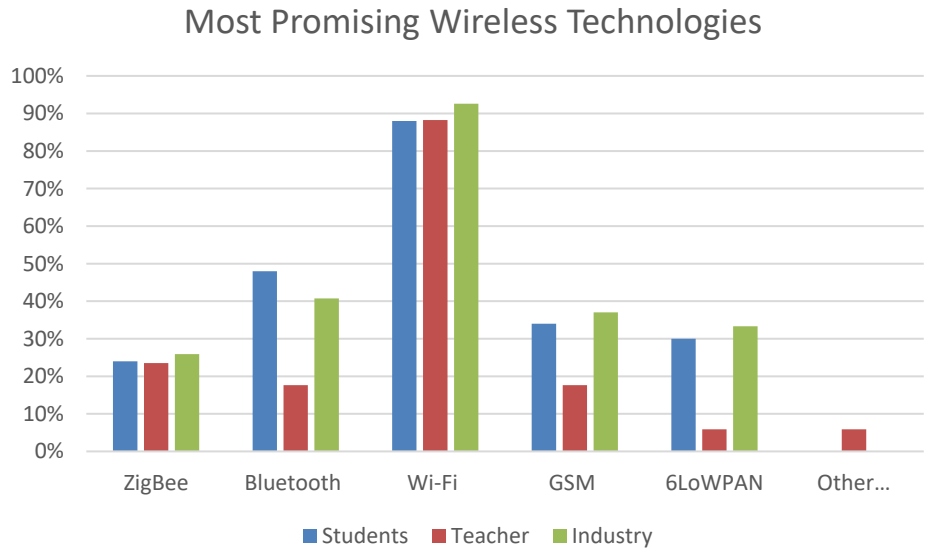

Figure 86: Most promising wireless technologies

The most important IoT communication protocols for Thai industry is MQTT, while teachers would opt for OPC UA. According to students, REST API is the most important communication protocol. In view of this, a deep difference among target groups has to be recorded for what concerns preferences of IoT communication protocols.

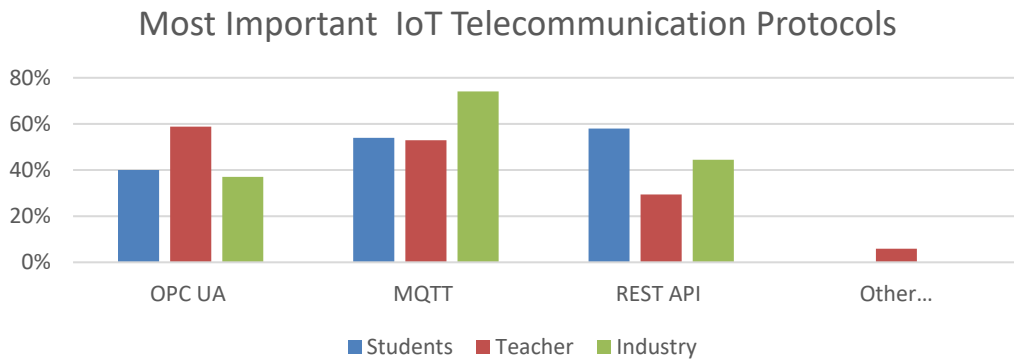

Figure 87: Most important IoT communication protocols

Most of students, teachers and industrials appear to be interested in programming languages such as Python, Eclipse and C (C, C++ C#) for a future career as Automation 4.0 specialists. Professionals from industry express particular interest also for Java (Java, Java Script, HTML 5). None of the subgroups showed a significant interest for programming languages such as Matlab, Simulink.

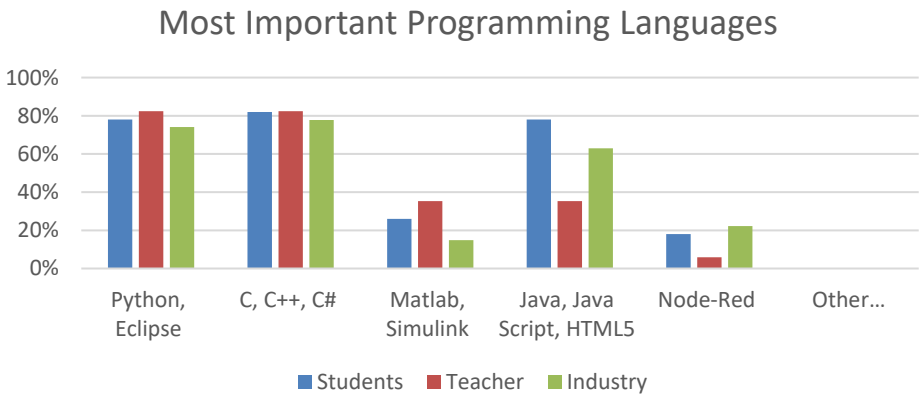

Figure 88: Most important programming languages

Students, teachers and professionals from industry agree on the fact that the observance of the IEC 61131-3 standard is considerably important.

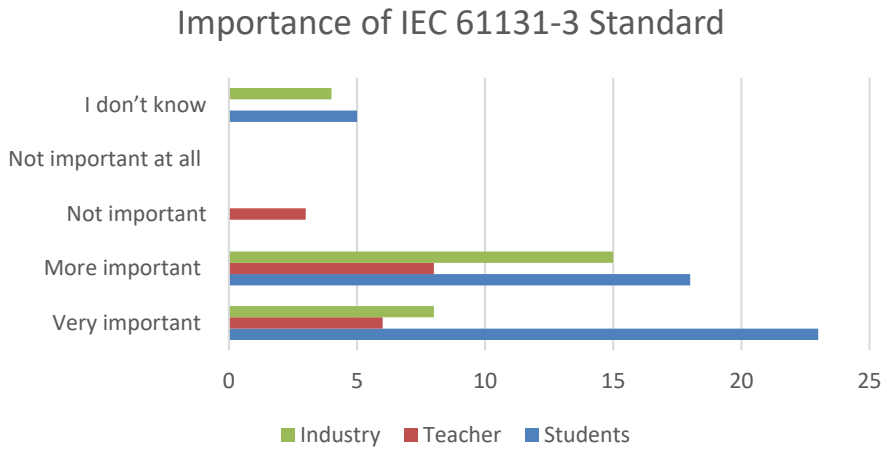

Figure 89: Importance of IEC 61131-3 standard

A clear signal is provided by the survey for what concerns the choice of the most useful cloud system. In fact, Google Cloud appears to be the most useful cloud system for students, teachers and professionals from industry. From a more general stand point, it looks like students are more confident with different cloud systems, showing a little interest also for services provided by other companies, such as Azure, Proficloud, and IBM Cloud.

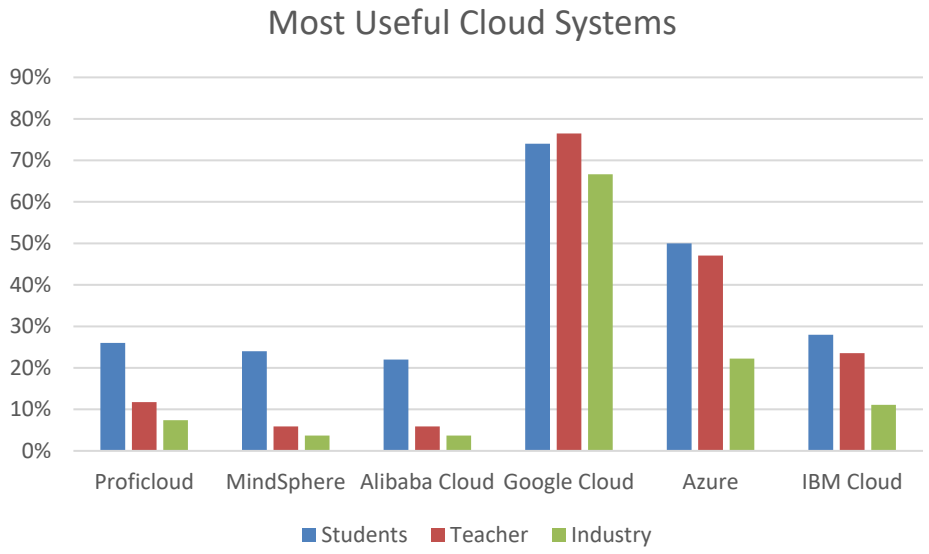

Figure 90: Most useful cloud systems

All target groups confirm that it is important that training materials are based on specific manufacturers. For professionals from industry and for students, this aspect is of high relevance, while teachers from university are more flexible in the selection of manufacturers.

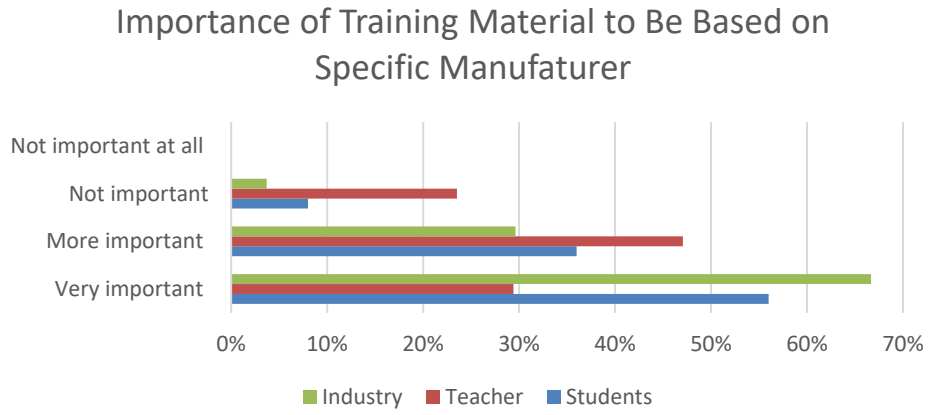

Figure 91: Importance of training materials/hardware to be based on specific manufacturer

All target groups have been asked regarding their preferences in learning methods. I emerged that students would be in favour of e-learning formats in a more technology based approach, while teachers and professionals from industry seem to be less convinced of this new learning methodology. All target groups confirms that practical experiences that occur in laboratory facilities and the conduction of case studies are promising learning methodologies. The face-to-face lecture methodology is still one of the most preferred formats for teaching.

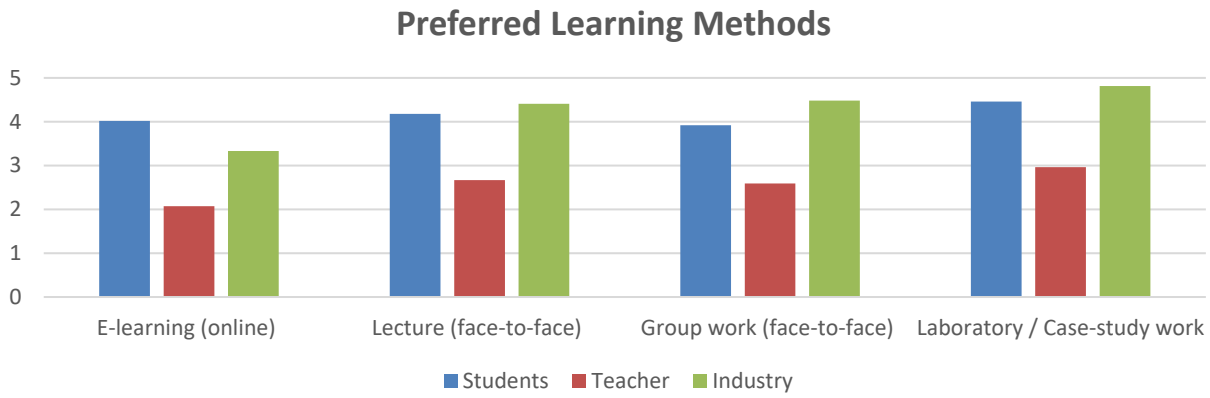

Figure 92: Preferred learning methods

Section 7. Interviews with Stakeholders-Target Groups

Methodology

This summary report uses the in-depth interviews as a qualitative research method to fulfill the quantitative method conducted WP3.1 Needs Analysis. This method is for uncovering the range of views, attitudes, opinions, and experiences that may exist in a certain group of participants. The participants are interviewed using a structured conversation and questionnaires. This interview was conducted during September 2020.

Interview Participants

The interview participants are divided into 3 groups; the students, the teachers/professors, and the industrial professionals. The overall number of the participants are 35. The participants in the first group, the students (13), are mostly undergraduate students in major of electrical engineering, machine engineering, information technology, and computer science. They have experiences with computer programming and databases. However, most of them are not familiar with Automation systems or PLC in general. The participants in the second group, the teachers/professors (9), are university lecturers who teach in the field of computer programming, information technology, electrical engineering, mechatronics, and machine engineering. Most of them are familiar with computer programming and around half of them are familiar with PLC and Automation systems. The last group is the group of industrial professionals (13) who mostly work with PLCs and semi-automation systems. While some of them have basic knowledge about Automation systems and related, the others have extensive knowledge and experiences.

Anonymity

The participants in this interview were informed about the objectives of the interview and the project. Their responses, including quotations, would be incorporated anonymously. The participants also agreed to give the candid feedback upon the anonymity.

Summary of Responses

In general, there is highly interest in participating in training workshops of Industrial Automation from the students. The given reasons show that they think this kind of technology will be performed in the industry more in the future. Even now, the technologies are used in some of big manufacturing fabrics. They also want to practice in the fields, e.g. Robotics, Artificial Intelligence, Control System, and PLC. The teachers believe that the students' skill for Automation is not enough yet. They may be used to high level programming language but not to program a PLC yet. The hands-on workshops on PLC and Automation training would be the perfect completion for the students. One of the conditions must be that it has to be a hands-on workshop where the students can practice with real equipment, even better in a real situation.

The professionals revealed the insight of working in the real situation. Some of them have problem managing different types of equipment from different manufacturers. Especially, when it comes to maintenance issue. They have to call engineers oversea and start a video conference session. What they want to improve in their fabrics at most is the waste optimization process using data analytics technique. With that, they suggest to implement an Artificial Intelligence system into the working process. They want to participate in hands-on workshops and reskill or upskill to more modern technologies in terms of preparation for future work.

Students

Q1. What is the topic of Automation that you want to know most and why?

- The students think that the most interesting and (currently) future-proof topics in Automation are Robotics, Artificial Intelligence, and Control System (PLC). They believe that these topics will be the future of Thai industry. Even right now, some of Thai companies already implemented that kind of technologies.

Q2. Are you used to use a PLC and how do you think about PLC in Automation?

- The majority of the students stated that they never get in touch with PLC or have just little knowledge about them. However, they said that they can imagine that such kind of technologies will be very important in the future or even at current situation. They would need some times to get more information about this technology but it will be worth.

Q3. What do you expect from an Automation workshop?

- Most of the students expect that workshops will be hands-on experiences where they can practice with the real equipment. Furthermore, they want to learn something that they can exploit or integrate in their future works.

Teachers/Professors

Q1. What is the most challenging task in Automation knowledge transfer and how can you improve?

- The majority of the teachers said that the most challenging task of Automation knowledge transfer is the lack of suitable equipment. Some of them have to teach their students using only simulation software. They expect that the training in hands-on workshops will help to overcome this problem. Furthermore, they concern about using high level programming languages in Automation.

Q2. Do the current PLCs suit your needs and how can you improve?

- The current in-use PLCs are just fine for this current situation. However, in the very near future, these PLCs will not be good anymore. The technologies change very fast. Therefore, it is necessary to learn new technologies and update the knowledge.

Q3. Is the students' knowledge about PLC enough and how can it be improved?

- The teachers said that the students' knowledge about PLC or Automation is currently not enough. Especially, the knowledge or skill in high level programing, communication, and integration of technologies.

Professionals from Industry

Q1. What is the most urgent task that has to be improved in the process and how can it be improved?

- Most of the industrial professionals said that the most urgent task to be improved in the manufacturing process is the waste optimization. There is a lot of waste during the production. They suggested that the use of data analytics and Artificial Intelligence in the whole process could improve this significantly.

Q2. Do the current PLCs suit your needs and what kind of technicians do you want to have?

- Some of the industrial professionals said that in the current situation there are different PLCs from different manufacturers in the same company. This leads to the problems when it comes to maintenance and the engineers from different part of the world have to be called. Furthermore, the current PLCs still cannot do many things that they should do. The modern ones can do more. In addition, they want to know more about high level programming languages for PLCs.

Q3. Does your current knowledge support your work and what is your expectation in the future?

- The industrial professionals said that their current knowledge is enough for their current job in the Thai industry. However, there is no preparation for the future yet. They want to be trained in the fields that would be needed in the near future.

Section 8. Conclusions

This report brought together the feedback gained among a pool of 94 participants (50 students, 27 professional from industry and 17 teachers or professors). Thanks to the evaluation of the results obtained thank to the fulfilment of the survey, it now possible to delineate the main characteristics of trainings and eventually of demonstrative hardware aiming at improving **Automation 4.0** knowledge.

It has been observed that students and teachers evaluate the quality of their preparation in Automation 4.0 as not sufficient for the modern industrial scenarios. For this reason, students and teachers should be the main target for improving overall Thai **Automation 4.0** qualification. Even though professionals from industry have appeared to be more satisfied with their qualification, a lot can be still done for enhancing their capabilities. Generally speaking, it has to be remarked that the average knowledge in the topics related to **Automation 4.0** is nor deficient nor excellent. The fact that there is no strong ignorance in any of the analysed fields ensures an advanced starting point, whilst the fact that no excellence has been observed ensures a strong improving potential. In view of these points, the development of trainings in the area of **Automation 4.0** results to be a bright challenge.

Thanks to the several questions that have been answered by the three subgroups, it has been possible to infer the ideal content of a training station for Automation 4.0, based on the needs of Thai students, teachers and professionals from industry. The main characteristic of an Automation 4.0 training station is the connectivity. **Wireless** connectivity should be established via Wi-Wi technology, possibly exploiting communication protocols such as **MQTT** or **REST API**. Since **Ethernet IP** has been found to be the most widespread telecommunication technology, this should be foreseen in the implementation of the project. The users of the training stations expressed the interest in programming languages like **Python**, **C** and **Java** and in view of this, these programming languages should be at the base at the functioning of the training station. Considering the programming languages aspect, the **IEC 61131-3** standard should be observed. As one of the pillars of Industry 4.0, cloud computing should also be part of the design and, in particular, **Google Cloud** should be chosen as a service in this regard.

Not only the technologies that should be involved in the training have been defined, but also the modalities of the execution of the trainings themselves. In fact, from the observation of the data gained through the survey, it emerged that trainings should be designed as **practical laboratory experiences** and that the resolution of **real-life case studies** is the most appreciated training methodology. In addition, the number of participants at the workshops should **not exceed 15**, and for professionals the workshops should **not exceed 4 days** in duration.

Thanks to the performance of interviews with subgroups, all the data gained thanks to the survey have been confirmed. Furthermore, it has been found out that particular attention should be played to the **renovation of PLCs** and to improving capabilities in **Artificial Intelligence** and **Data Analytics** in order to solve the currently most threatening problems identified by professionals, among which the production of waste during production plays a crucial role.

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