# SEnDIng

## D2.1

# LEARNING OUTCOMES IN TERMS OF KNOWLEDGE, SKILLS AND COMPETENCES



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## PROJECT SUMMARY

SEnDIng project aims to address the skills' gap of Data Scientists and Internet of Things engineers that has been identified in the ICT and other sectors (e.g. banking and energy) in which Data Science and Internet of Things have broad applications. To achieve this goal, SEnDIng will develop and deliver to the two aforementioned ICT-related occupational profiles two learning outcome-oriented modular VET programmes using innovative teaching and training delivery methodologies.

Each VET programme will be provided to employed ICT professionals into three phases that include: (a) 100 hours of online asynchronous training, (b) 20 hours of face-to-face training and (c) 4 months of work-based learning. A certification mechanism will be designed and used for the certification of the skills provided to the trainees of the two vocational programmes, while recommendations will be outlined for validation, certification & accreditation of provided VET programmes.

Furthermore, SEnDIng will define a reference model for the vocational skills, e-competences and qualifications of the targeted occupational profiles that will be compliant with the European eCompetence Framework (eCF) and the ESCO IT occupations, ensuring transparency, comparability and transferability across European countries.

Various dissemination activities will be performed – including the organization of one workshop in Greece, Bulgaria and Cyprus and one additional conference in Greece in the last month of the project – in order to effectively disseminate project's activities and outcomes to the target groups and all stakeholders. Finally, a set of exploitation tools will be developed, giving guides to stakeholders and especially companies and VET providers, on how they can exploit project's results.

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## Used definitions

**qualification framework** – "an instrument for the classification of qualifications according to a set of criteria for specified levels of learning achieved, which aims to integrate and coordinate national qualifications subsystems and improve the transparency, access, progression and quality of qualifications in relation to the labour market and civil society" [1]

**qualification** - "a formal outcome of an assessment and validation process which is obtained when a competent body determines that an individual has achieved learning outcomes to given standards" [1]

**certification** – "Certification is the process of formally validating knowledge, know-how and/or skills and competences acquired by an individual, following a standard assessment procedure. Certificates or diplomas are issued by accredited awarding bodies."[2]

**standard** – "1. A required or agreed level of quality or attainment; 2. something used as a measure, norm, or model in comparative evaluations"[1]

**competence** – "means the proven ability to use knowledge, skills and personal, social and/or methodological abilities, in work or study situations and in professional and personal development. In the context of the European Qualifications Framework, competence is described in terms of responsibility and autonomy" [1]

**competency –** "an ability or skill"[2]

**learning/ educational outcome –** "statements of what a learner knows, understands and is able to do on completion of a learning process, which are defined in terms of knowledge, skills, and competence".[1]

**profile** – "A description of a particular work function that includes the elements deemed necessary to perform the post effectively. Specifically, a job profile developed by the personnel department of a business might include such things as job responsibilities, required qualifications, advancement prospects..."[3]

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[1] Oxford Dictionaries, http://www.oxforddictionaries.com/definition/english/standard. More about differences between "standard" and "framework" can be find here: http://blog.sukad.com/20130114/differences-between-standard-framework-methodology/

[2] Merriam Webster Dictionary

[3] Business Dictionary.com

**proficiency** – "1. advancement in knowledge or skill. 2. the quality or state of being proficient"[4]

**skill** – "the ability to apply knowledge and use know-how to complete tasks and solve problems. In the context of the European Qualifications Framework, skills are described as cognitive (involving the use of logical, intuitive and creative thinking) or practical (involving manual dexterity and the use of methods, materials, tools and instruments)" [1]

**knowledge** – "the outcome of the assimilation of information through learning. Knowledge is the body of facts, principles, theories and practices that are related to a field of work or study. In the context of the European Qualifications Framework, knowledge is described as theoretical and/or factual."[1]

[4] Merriam Webster Dictionary

# 1 Introduction

## 1.1 Objectives

**The main goal of this deliverable is to develop the learning outcomes for Internet of Things and Data Science vocational trainings that will be piloted during the project.** The learning outcomes provide clear requirements about what learners should know and be able to implement in practice at the end of the training cycle. The learning outcomes should be compliant with the good practices in both the pedagogical theory applicable in VET and the technical domains of IoT and DS. They should be clear and understandable for all relevant stakeholders involved in the process, namely:

- Companies that represent the industry demand for IoT and DS qualified employees;
- Learners who will participate in the trainings;
- Educators including VET who will design and implement the trainings; and
- Policy makers who will define the framework of the VET programs.

In order to achieve the main goal, the team had to accomplish the following objectives:

- To perform a desktop review of existing studies in IoT and DS and to formulate the scope of the trainings in the respective domains (see Section 2)
- To perform a desktop review of good practices applied for the definition of learning outcomes in VET education and to apply them to the process of formulating the Learning outcomes of DS and IoT vocational trainings (see Section 3)
- In close communication with the relevant stakeholders to define a draft version of the Learning outcomes and to validate them (see Section 4)
- To formulate the final version of the Learning outcomes that will be used and continuously improved during the design and implementation of the trainings (see Sections 5 and 6)

## 1.2 Dependencies with Other WPs and Deliverables

This deliverable is directly connected to the following deliverables within WP2 - D2.2 Reference model of skills, e-competences and qualifications needs of DS and IoT Engineers; D2.3 Vocational curricula educational modules for Data Science and Internet of Things VET program; D2.4 Training methodology and D2.5 Training monitoring and assessment methodology. The deliverables in WP3 describing the content of the training or training materials on DS and IoT also depends on DLV 2.1 where the selection of topics and assessment methods will be conformed with the learning outcomes. The result of this task is related also to the pilots of the DS and IoT training in WP5. As far as the learning outcomes affect all actors in the educational value chain [3], we may conclude that to some extent the quality of the entire SEnDIng project depends on the clear and comprehensive definition of the learning outcomes.

This report complies with the requirements provided by the current versions (at the time of report finalization) of D6.1 Quality Assurance Plan and D6.4 Impact evaluation methodology.

# 2 Existing Studies or Projects related to DS and IoT Skills Needs

A review of the **identified attempts to define and/or classify skills in IoT and DS domains** is the main purpose of this section.

## 2.1 Existing studies for IoT and DS skills needs

Both fields - Internet of Things and Data Science - are still in their early stages of realization, but at the same time, they bare the potential to bring enormous benefits to organizations and, likewise, to disrupt existing business models and processes. Many academic and VET institutions attempt to catch up with the new wave and compete in providing relevant academic programs and OERs. Based on the desktop research conducted, we can conclude that VET institutions have not been very active to define and execute specialized IoT and DS trainings. The taxonomy problems that the curriculum designers face in choosing modules/topics, defining learning objectives, developing assessment methods, are evoked due to the complexity of the DS and IoT scientific domains and their applications. This is well illustrated by a number of ESCO search results for Data Science and Internet of Things related skills and knowledge - over 450 for Internet of Things searches and more than 550 searches for Data Science.

The factors, which might be causing the high level of complexity are:

- variety of the industry sectors that exploit IoT and data analytics for business needs,
- variety of applications of IoT and Data Science,
- variety of end-users of the solutions,
- variety of technical tools that operate in these fields.

The above-mentioned are of utmost importance when attempting to create a kind of classification of this wide interconnected and diverse set of scientific domains and disciplines. At the same time, this spectrum implies consensual problems for all stakeholders in the value chain of education - future professionals in their career orientation, curriculum designers in all educational levels, the business as recruiter of specialists. Hence, a more generic approach should be perceived in closing the skills gap.

While in the field of Data Science there are achievements in defining the needed skills and competences, regarding the Internet of Things, the professors Alexander van Deursen and Karen Mossberger speak about a "new digital divide in skills" [5] Their article "AnyThing for Anyone? A New Digital Divide in Internet-of-Things Skills" raise multi-aspect questions about the definition of IoT, the demand of new (ambiguous) skills, the environmental and individual factors that influence IoT technology and systems, but also outlines the research agenda on the IoT and skills. Although the focus of the research agenda is on better understanding the individual skills within social contexts or how end-users can improve their own lives using IoT systems, the authors suppose that the improved competence of IoT developers in **user experience design** will reduce the demand for technical and higher order skills. On a policymaker level, van Deursen and Mossberger propose building of **skills to assess potential outcomes of the IoT use** - adopting and implementing better privacy and security practices, greater transparency and disclosure of how personal data is used. As the definition of learning outcomes for the needs of the project affects mainly the IT professionals who intend to enrich their competences in IoT, these specific skills will not be the focus of the learning outcomes but they will be considered within their broader aspects when the needs of IoT skills are explored.

## 2.2 DS and IoT definition

On the 25th of May 2015 IEEE published an exhaustive research on the initiatives and white papers contributed for the definition of "Internet of Things". The document follows the state of the art definitions and architectural models for IoT offered by standardization organizations, IoT projects, academia, national initiatives, white papers, books and related industries. As the research gives an all-inclusive definition of IoT that covers from small to large global systems. For the project purposes we adapted a simplified practical definition of IoT:

"IoT is a system of distributed networks that facilitate the communication and collaboration between various IT enabled objects (things) including but not limited to software systems and applications, sensors, controllers, computers, machines, etc."

For the definition of the learning outcomes for IoT, we researched the IoT scope and definitions (e.g. Towards a definition of the Internet of Things (IoT), Revision 1, IEEE), generic needs for IoT skills (e.g. Alexander J. A. M. van Deursen, Karen Mossberger, Any Thing for Anyone? A New Digital Divide in Internet-of-Things Skills), relevant taxonomies (e.g. The Internet of Things Body of Knowledge, IOT Community of Engineers Australia) and well-recognized models on EU level (e.g. eCompetence Framework and ESCO). The team reviewed programs and curricula with analogous scope in terms of course duration, age and proficiency level, developed by leading educational institutions such as University College of London, MIT, Malmo University, and others.

As mentioned before, the definition and classification of the Data Science domain is rather more completed than that of the Internet of Things.

We accepted a definition for the role of a data scientist as follows:

"A data scientist is a practitioner who has sufficient knowledge in the overlapping regimes of business needs, domain knowledge, analytical skills, and software and systems engineering to manage the end-to-end data processes in the data life cycle."

This definition was published in the first release of Big Data Interoperability Framework in 2015 by the National Institute of Standards and Technology (U.S Department of Commerce) Big Data Public Working Group (NIST BD-PWG), Volume 1, Definitions[5]. The NBDIF Volume 1 describes in details the scientific and applied domains of Data Science and Big data together with their boundaries. The document also provides an overview of other definitions of Data Science from IDG, McKinsey, O'Reilly reports and popular blog articles published by experts in this new technology.

Furthermore, this definition was influenced by Data Science profiles of CEN ICT skills Workshop in the second version of the European ICT Professional Profiles[6].[12] Skills and knowledge examples provided in related e-competences (in e-CF). Together by applying Bloom's taxonomy, it can be used for outlining the scope of the Data Science curriculum defined as learning outcomes within the SEnDIng project.

When we did our research, we paid special attention to the EDISON project[7] [11] as one of the most exhaustive taxonomies on Data Science on a EU level. In July 2017 the following were released:

- Data Science Competences Framework (CF-DS)
- Data Science Body of Knowledge (DS-BoK)
- Data Science Model Curriculum (MC-DS)
- Data Science Professional Framework (DSPP)

[5] https://bigdatawg.nist.gov/

[6] http://www.ecompetences.eu/wp-content/uploads/2018/01/180126_EU_ICT_Profiles_v2_DRAFT_CWA_JB.pdf

[7] http://edison-project.eu/library

The above-mentioned frameworks, incorporated under a common title *Competence framework for Data Science* (CF-DS), are an extended analysis of the existing frameworks for Data Science and ICT competences and skills. CF-DS identifies competence groups, knowledge areas, and skills, based on an extensive analysis of the actual Data Scientist job market profession in industry and research alike. The EDISON project's results can support the design and development of higher education curricula on Data Science and Data Analytics. Extended analysis of the structure and users of different competence *frameworks and models for IoT and Data Science* will be provided in Deliverable 2.2 Reference models of skills, e-competences and qualifications of DS and IoT Engineers.

In conclusion, we did an extensive research on IoT and DS studies, models, taxonomies and programs in order to define the Learning Outcomes for IoT and DS specialists. In this section, we pointed out the key sources of information used to define the IoT and DS Learning outcomes. We will continue the research for identification of the relevant reference models and concrete curricula within the target domains.

## 2.3 Projections for creation of new DS and IoT jobs

The development of inter-connected information technologies and the decreasing price of the connected systems and storage resulted in an enormous number of IoT devices and exponentially growing amount of data. By 2020, it is estimated that the total number globally used of Internet connected 'things' will be between 25 and 50 billion [5].

The growing IoT development and the need to analyse the data produced, creates new challenges to the European job market. PwC researched the impact of Internet of Things (IoT) on jobs in Europe in a study commissioned by the European Commission on "Cross-cutting business models for IoT"[8] for DG CONNECT of the European Commission. The study focuses on existing and possible IoT cross-cutting business models and their implementation in Europe. The study outlines increasing demand for IoT jobs in two major directions:

- Traditional jobs related to IoT in other industries ("hybrid vehicles") - It is expected that existing jobs such as product managers, software developers, hardware engineers will grow. In addition to the engineering focus, the jobs will rely on specific human skills such as creativity, problem-solving skills, design thinking, systems thinking and communications skills.

[8] http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=49849

- New jobs related to IoT in other industries ("hybrid vehicles") - Those jobs are interdisciplinary in their nature and reflect IoT and DS in rapidly growing domains such as: medical robot designers, personified medical device consultants, grid modernization managers, intermodal transportation network engineers, agricultural technologists, 3D printing engineers, wearable tech designers, cloud computing specialists and e-discovery investigators. Those jobs will require knowledge and skills in specific industry domains and new technologies, as well as hard skills (e.g. software development) together with soft skills (e.g. team management, communication skills).

It is expected that the new trends such as IoT and DS will support the creation of about 2.1 million jobs in the time period from 2015 until 2020[6].

We have considered the aforementioned trend in the development of the Learning Outcomes through defining both technical knowledge and skills, as well assoft skills applicable to IoT and DS. The cross-industry theme was researched in the Learning Outcomes Survey and it will be applied in the curricula development.

# 3 Approach towards Writing Learning Outcomes

## 3.1 Context

In 2008 the European Parliament provided recommendations for the European Qualification Framework (EQF) [1] that defined learning outcomes as '… statements of what an individual should know, understand and/or be able to do at the end of a learning process'. The European Qualifications Framework calls for a shift towards learning outcomes in primary and secondary schools throughout the EU. Students are expected to learn skills that they will need when they complete their education. It also calls for lessons to have a stronger link to employment through work-based learning. Work-based learning for students should also lead to recognition of vocational training for these students. Furthermore, EQF developed 8 levels by a set of descriptors indicating the learning outcomes relevant to qualifications at that level in any system of qualifications. At each level knowledge, skills and competences are determined. In the context of EQF, each element is described as follows:

- Knowledge - theoretical and/or factual. 'Knowledge' means the outcome of the assimilation of information through learning. Knowledge is the body of facts, principles, theories and practices that is related to a field of work or study.

- Skills - cognitive (involving the use of logical, intuitive and creative thinking) and practical (involving manual dexterity and the use of methods, materials, tools and instruments). 'Skills' means the ability to apply knowledge and know-how to complete tasks and solve problems.
- Competence is described in terms of responsibility and autonomy. 'Competence' means the proven ability to use knowledge, skills and personal, social and/or methodological abilities, in work or study situations and in professional and personal development.

In 2012 the European Commission presented the new Rethinking Education strategy with strong focus on transversal skills and basic skills, improving the recognition of qualifications and skills (including those gained outside of the formal education), and the modernization of the assessment methods. In the subsequent policies and initiatives for the improvement of the quality of education of the European Commission the learning-outcomes-based approaches are becoming increasingly influential. "Learning outcomes are commonly used to define the levels of qualifications frameworks, set qualification standards, describe programs and courses, orient curricula, and define assessment specifications. Learning outcomes are also influencing teaching methods, learning environments and assessment practices. At European level, both in the Bologna and Copenhagen processes, learning outcomes are viewed as the 'glue' binding diverse policy initiatives and instruments together. The use of learning outcomes is also seen as contributing to permeable education and training systems, such as supporting links between vocational and academic programmes. This growing influence of learning outcomes in most European countries, and in (almost) all education and training sectors, reflects a strong political consensus on the perceived usefulness of this approach." [3]

We should assume that the shift to a learning-outcome-based system is not a universal tool for having a better quality of education and convergence of the industry expectations with the results of educational systems. All stakeholders should be motivated to participate and to understand their role and benefits within this process. An illustration for a failure changing the content-based with outcome-based approach is Australia. When in the early 1990s all states and territories in Australia developed intended curriculum documents largely based on learning outcomes for their primary and secondary schools the teachers felt overwhelmed by the amount of expected achievement outcomes. Educators believed that the curriculum outcomes did not correspond to the needs of the students or teachers. Critics pointed out that too many expected outcomes left students with shallow understanding of the material. Many of Australia's current education policies have moved towards a focus on fully understanding the essential content, rather than learning more content with less understanding [7].

The main factors that define the successful shift are the purposes, for which we write outcome statements and who of the stakeholders are assigned to implement this process. "While qualifications frameworks provide a general reference for comparing qualifications and distinguishing levels, learning-outcomes-based qualifications standards, curricula and assessment specifications have to be defined and written in a way that 'speaks to' learners and teachers and adds value to the learning process" [3].

Learning from the experience mentioned above, we put a special focus on defining the learning outcomes in practical terms, meaning they could be easily understood by professionals and instructors. In addition, we validated the defined learning outcomes with the industry through comprehensive review in direct meetings with domain leaders and through a specially designed survey among more than 30 organizations.

The next part considers the main principles observed in writing the learning outcomes for different purposes and the project deliverable *2.2 Reference model of skills, e-competences and qualifications* describes the frameworks on EU level that are relevant to the domains of Data Science and Internet of Things.

## 3.2 Definition and writing of Learning Outcomes

"*Learning outcomes statements help to clarify program and qualifications intentions and make it easier for those involved – learners, parents, teachers or assessors – to work towards these expectations*" - CEDEFOP.

Recognizing the learning-outcomes based approach in the design and development of a VET curricula, together with the specific principles in this context as well as the relevant content, we need to further bear in mind the assessment methods and the national qualification system. As the SEnDIng project is a multinational initiative, the proposed definitions should be conformed with the wider geographical scope and different (unknown) proficiency level of the learners, therefore they are rather **generic and wide-ranging for the competence** than exhaustive or specific for any industry or market or use case. Taking into account these assumptions, the structure and methodology of the training, content and assessment methods will be developed accordingly within the Deliverable 2.3 Vocational curricula modules for both competences - Data Science and Internet of Things.

Having into account the resources available within the project and the duration of the trainings, our goal is that a learner achieves level 4 of the EQF. The relevant outcomes to level 4 as they are defined in EQF are:

- Knowledge: factual and theoretical knowledge in broad contexts within a field of work or studySkills: a range of cognitive and practical skills required to generate solutions to specific problems in a field of work or studyCompetence: exercise self-management within the guidelines of work or study contexts that are usually predictable, but are subject to change; supervise the routine work of others, taking some responsibility for the evaluation and improvement of work or study activities

Using the learning outcomes approach within the SEnDIng project strengthens the focus on the results for the individual learners in the context of the organizational responsibilities and the business objectives of the organization.

As the European Handbook on Defining, writing and applying learning outcomes of CEDEFOP states, "*the simplicity is important when writing learning outcomes. Too much detail and overly complex statements prevent learners, teachers and assessors from relating to the statements:*

*(a) defining and writing learning outcomes should be treated as an iterative process, starting from overall objectives and moving stepwise towards specific statements for units and assessment. Having arrived at specific statements, overall objectives could be reviewed and changed. Soulsby (2009) describes this iterative process as designing backwards (from broad institutional objectives to specific assessment criteria) and delivering forwards (using experiences from teaching learning and assessment to orient and reorient broader institutional objectives);"*

The team responsible for this deliverable conducted a desktop research on the State of Art in Data Science and Internet of Things and extracted the most relevant to the project objectives and indicative topics definitions. They reflect the overall objectives of a learner who wants to gain the given competence. The definitions were discussed with specialists in both domains and disseminated among DS and IoT related companies and organizations in Bulgaria, Greece and Cyprus and other countries in order to receive feedback from potential participants in the pilot trainings and the users of the training results. We consider the defined Learning Outcomes as a "living" document and we will continuously improve it throughout the whole project life cycle.

*"(b) when writing learning outcomes to orient a qualification/program or a qualification unit/course, carefully consider the number of statements used. When defining a course or*

*unit it is generally recommended limiting the number of statements (perhaps four to six statements)"*

The number of the pre-defined statements in the initial definition of the Learning outcomes is within the range of 9 in the domain of Data Science (for approximately 5 units) and 11 within the Internet of Things domain (for approximately 5 units).

*"(c) when defining and writing learning outcomes for a full qualification or a programme it is generally recommended to keep the number of statements as low as possible. The purpose should be to identify the overall scope and profile, not to list all technical details*"

The project team decided to use the ICT professional role profiles developed by CEN ICT Skills Workshop as a starting point in the definition of the learning outcomes and outline only the features of the profession, instead of listing programming tools and languages relevant to the corresponding domain.

*"(d) limiting the number of statements makes it easier for the learner to relate to the intentions and engage in the learning;"*

The target group of the Data Science and Internet of Things curricula are employed/self-employed IT professionals and IT companies as direct beneficiaries. Hence, taking into account the duration of the pilot training, the unknown level of competences of the target group and the scope of the content, we have used definitions from Fundamentals of both domains that are enough unequivocal in order to support the learners in building the competence.

*"(e) limiting the number of statements makes it easier to plan teaching, to facilitate learning and eventually to carry out assessments"*

The task to define the learning outcomes replies to the need to address both the learners and the trainers. Moreover, both the learning and the teaching process will be aligned to the proposed statements. In fact, on the one hand, the learning outcomes should assist teachers in identifying and combining teaching methods as well as promoting reliable and valid assessment based on clear and common criteria. On the other hand, the learning outcome statements should help learners in identifying and reflecting on the personal expectations, shaping personal learning paths and linking them to the competences and abilities actually deployed in a real-life context.

*"(f) when writing a learning outcomes statement, focus on the learner and start with an action verb, followed by the object of the verb as well as a statement specifying the*

*depth/breadth of learning to be demonstrated, and complete with an indication of the context (which can be related to learning, work or other relevant social contexts)"*

In course of the development of the learning outcome statements, we took into account the suggested action verbs from Bloom's taxonomy[9] and the present guidelines by Cedefop for defining and writing learning outcomes for VET.

*"(g) in general there should not be more than one action verb for each learning outcome".*

In most cases, we used only one action verb to describe the respective learning outcome element. The verbs we used were compliant to the Bloom's taxonomy measurable verbs.

# 4 Validation of Learning Outcomes by Relevant Stakeholders

## 4.1 Verification and Validation Process

Once the first draft of the learning outcomes was developed, the team used a four-level process in order to verify and validate the Learning Outcomes among the project partners (verification) and companies in their role as target users of the trainings (validation).

**Level 1 Verification of the Approach**

Before initiating any further work on the deliverable, ESI CEE discussed with the project partners the overall approach for defining learning outcomes at a Skype meeting. During the meeting, the project partners provided valuable requirements, advice and suggestions about the approach and the development process of the Learning Outcomes.

**Level 2 Verification of the first draft of the Learning Outcomes**

The first draft of the learning outcomes was reviewed by all interested project partners and a dedicated meeting was held to discuss the provided comments, notes, and suggestions. During the meeting, the project partners reached consensus on the proposed changes and ESI CEE then implemented the changes within the second draft of the learning outcomes. After that, ESI CEE developed a survey to be used to assess the potential value (usefulness) of the learning outcomes for the companies that represent the target client of the project.

**Level 3 Validation of the Learning Outcomes and the Survey format with leading experts in DS and IoT**

[9] https://www.apu.edu/live_data/files/333/blooms_taxonomy_action_verbs.pdf

ESI CEE arranged meetings with leading international experts in DS and IoT, holding managerial positions at the Data Science Society and at Bosch Software Innovations EOOD, Bulgaria. The objectives of the discussions were two-fold: (i) to assess the potential value (usefulness) for the companies that would employ IoT and DS students, and (ii) to check and improve the format and content of the survey questionnaires. The meetings were very fruitful and they resulted in a number of improvements of both the Learning Outcomes and the corresponding questionnaires. At the end of the iteration, the survey questionnaires were reviewed by the project partners and were approved for final release.

**Level 4 Validation of Learning Outcomes through a Survey**

At this final stage, the learning outcomes were validated with a survey among different types of organizations. A strong emphasis was put on representatives of the IT industry in their role as an end client of the trainings that will be completed by the project partners. The goal was to receive feedback by organizations that are knowledgeable and experienced in IoT and DS rather than to cover many in number organizations.

In conclusion, ESI CEE established and maintained a comprehensive process to verify and validate the learning outcomes. As part of levels 1 to level 3 of this process, ESI CEE received, discussed and implemented 21 improvements on the form and/or the content of the learning outcomes and the respective questionnaires for the survey (See Appendix 1).

At Level 4 of the process, ESI CEE obtained and analysed quantitative and qualitative data from more than 40 respondents. The aggregated results from the survey are presented in the next sections.

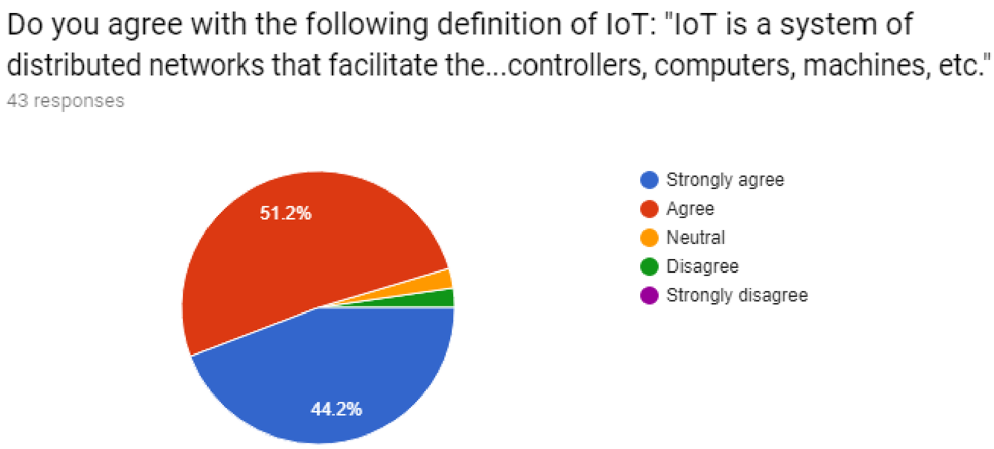
## 4.2 Learning Outcomes Survey Results IoT

The final version of the survey questionnaires for IoT is provided under Appendix 2 of this report.

The proposed definition for IoT was well accepted by a vast majority of the respondents. 41 out of 43 respondents (95%) either strongly agreed or agreed with the definition. The only respondent who disagreed with the definition requested that it would include more details on "technologies, protocols, standards (early) to ease interoperability between sensors, machines, edge gates, cloud and apps and provides an infrastructure to collect millions of measurements for further analysis". The project team will take into account those details when developing the curriculum.

*Figure 1 Survey results about IoT definition*




We can assume that the respondents well represent the interest of the IoT community both as expertise and as need for qualified IoT employees. Most of them, 36 out of 43 respondents (84%) are experienced in IoT (81%) and almost all of the respondents (98%) are planning to develop IoT projects. 35 out of 43 respondents (81%) are planning to train their current employees in IoT and 32 out of 43 respondents (74%) plan to employ a new technical specialist in IoT.

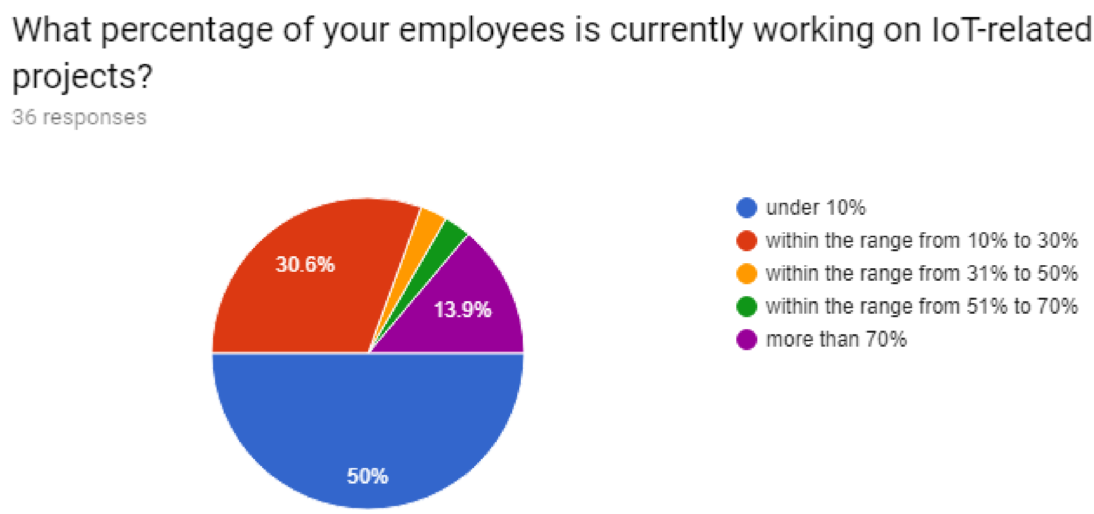
The respondents have pointed out experience in different sectors. The sectors in which most respondents have experience were:

- Smart cities –10 of 36 (28%) respondents;
- Utilities - 10 of 36 (28%) respondents;
- Health - 9 of 36 (25%) respondents;
- Energy and renewable - 9 of 36 (25%) respondents;
- Agriculture - 8 of 36 (22%) respondents;
- Transport - 7 of 36 (19%) respondents; and
- Wearable - 7 of 36 (19%) respondents.

The team will take into account this information and the specific needs of the respective economic sectors for the development of the curricula and, more importantly, the content of the trainings.

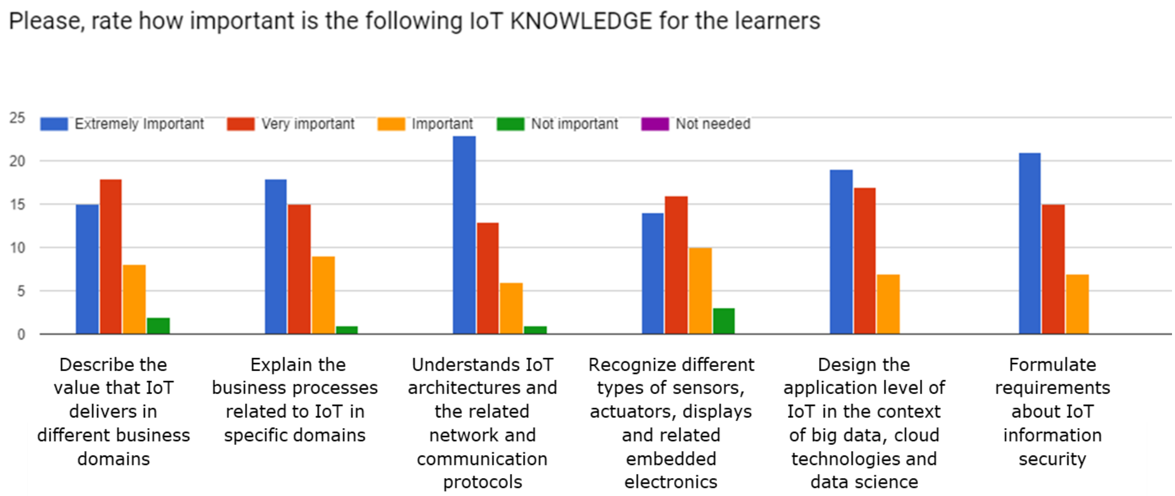
29 out of 36 respondents (81%) reported that less than 30% of their employees are currently working on IoT projects. One can assume that there is a good potential for training and requalification of the remaining employees in IoT.

*Figure 2 Survey results about the share of employees who are working on IoT projects*




A vast majority of the respondents (79%-83%) found all of the proposed IoT Knowledge as extremely important or very important.

*Figure 3 Survey results about the importance of the proposed IoT knowledge*



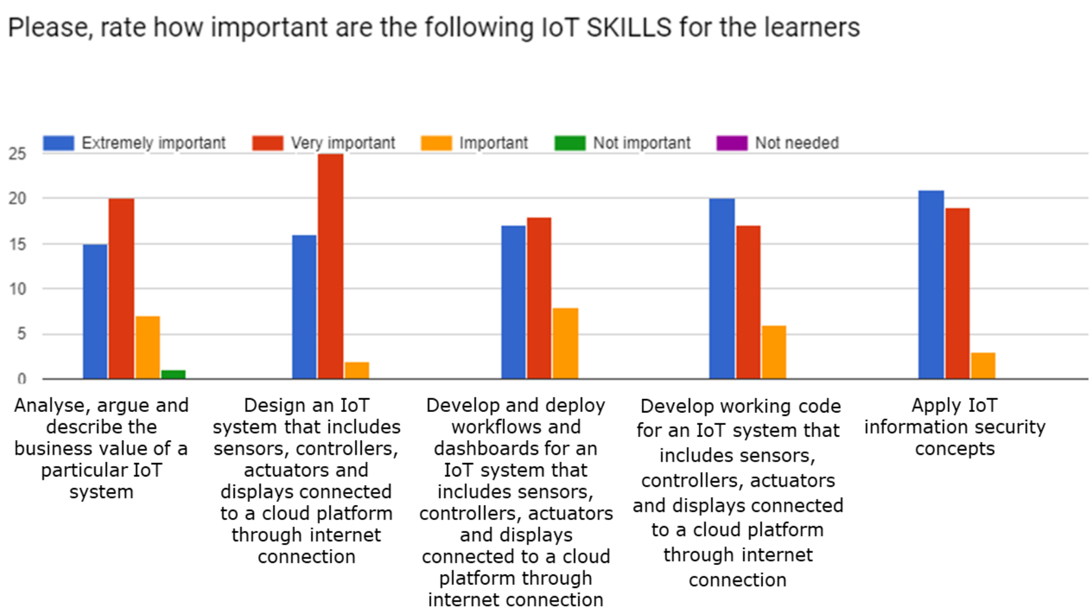
In addition to the proposed IoT knowledge the respondents noted:

- Deployment of IoT solutions;
- Deploy applications and knowledge from other fields of R&D to IoT solutions.
- Cyber security understanding and design;
- Item 6 should also include all issues arising, so as to meet GDPR regulation requirements;
- The answers represent the needed knowledge for technical specialists and not for presales, sales and project management;
- Programming languages Java and C/C++;
- Understanding IoT at the Network Edge 2;
- The role of analytics and AI in IoT;
- Standards and standard organizations.

The comments, with the exception of one, are applicable on content level to the training program and will be taken into account when the training content is being developed.

Similarly to the knowledge, a vast majority of the respondents (84%-95%) found all of the proposed IoT skills extremely important or very important.

*Figure 4* Survey results about the importance of the proposed IoT technical skills



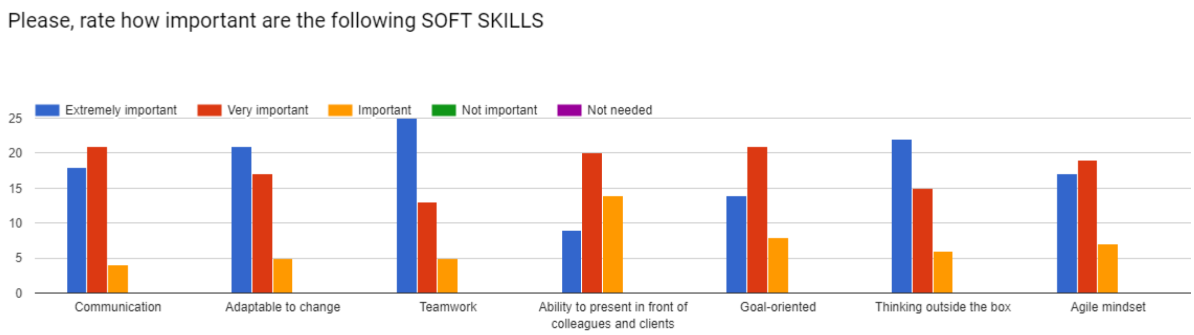

Three of the respondents provided additional comments:

- Continuous integration and verification; Network analysis tools knowledge; Soft skills: Client oriented, open and honest;
- Operate IoT system;
- Analytics.

The proposed skills: continuous integration and verification, network analysis, and operate IoT system can be considered as valid proposals and will be taken into account for the final definition of the learning outcomes.

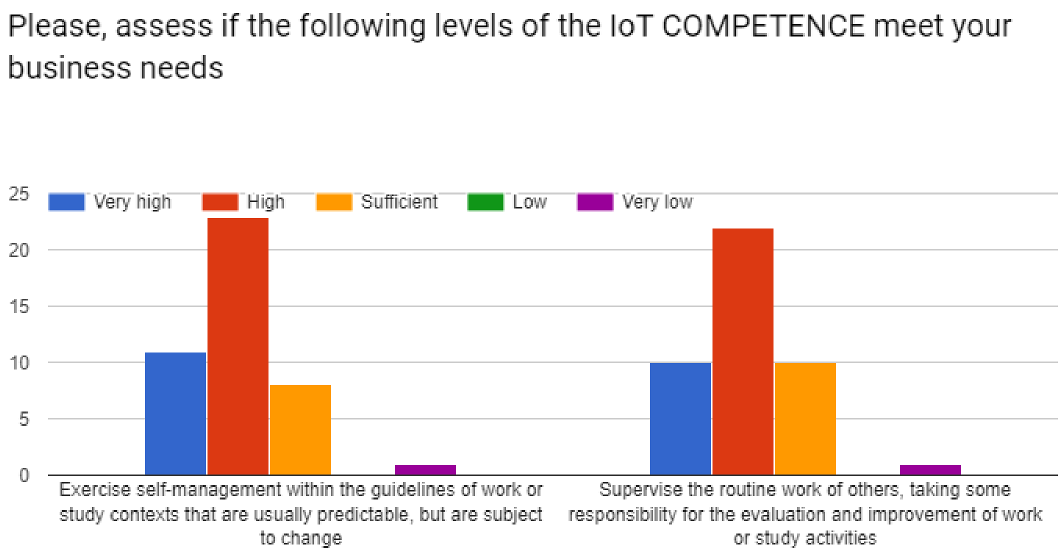
The proposed soft skills, with one exception, were also evaluated as extremely important and very important by 81%-90% of the total number of the respondents. The only exception was "Ability to present in front of colleagues and clients", which was evaluated as extremely important or very important by 67% of the respondents.

*Figure 5* Survey results about the importance of the proposed IoT soft skills




74%-79% of the total number of respondents assessed the proposed competence as very high or high while only about 18%-23% of the total number of respondents assessed the proposed competence level as sufficient. Having into account that the majority of the respondents assessed the proposed competence as very high or high the project partners could consider changing the competency level from EQF 4, as originally proposed, to EQF 3.

*Figure 6* Survey results about the proposed competence level



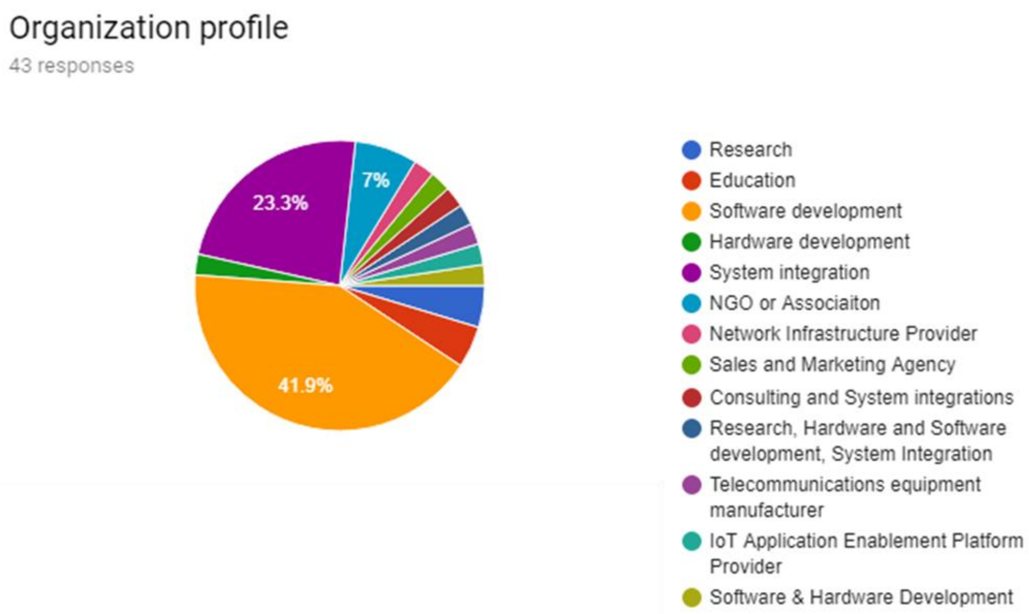

Although the number of respondents is not big (43 entries), the quality of the answers could be considered high. Most of the respondents in the survey (67%) hold a high-level management position (CEO, Deputy CEO, Director, and others) and determine the strategic perspective of the organizations. The remaining respondents hold technical, academic or mid-management roles such as developer, project manager, professor, and team-lead, etc., which could represent the learners in the program.

Most of the respondents are from Bulgaria (21), followed by Greece (7) and Cyprus (6). In addition, there were respondents from Finland, India, Italy, Malaysia, Saint Lucia, , South Africa, Turkey, UK and the Former Yugoslav Republic of Macedonia.

18 out of 43 respondents represent companies from the software development sector (42%), followed by System Integration (2%). All relevant stakeholders on organizational level - companies and educators - are represented in the sample.

*Figure 7* Survey *respondents* by profile




In summary, the survey conducted across 43 organizations assessed the proposed learning outcomes for IoT as valid and important for the potential clients of the training.

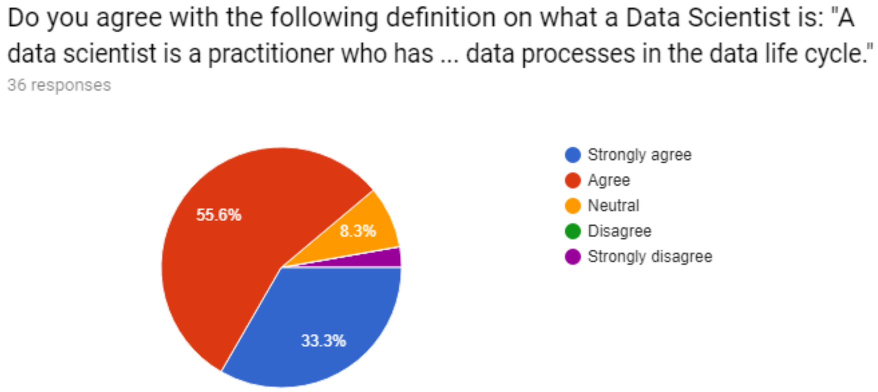
The detailed results per responder are kept in an electronic table format and are available for further research. Personal data such as names or e-mail addresses was removed.

## 4.3 Learning Outcomes Survey Results Data Science

The final version of the survey questionnaires for DS is provided as an Appendix 3 to this report.

The proposed definition for Data Scientist was well accepted by a vast majority of the respondents. 32 out of 36 respondents (90 %) either strongly agreed or agreed with the definition. 3 respondents were "neutral" to the definition. One respondent strongly disagreed with the proposed definition. The respondent did not provide any comments supporting his opinion.

*Figure 8* Survey results about Data Scientist definition




Five respondents provided comments about the Data Scientist definition:

- A data scientist is someone who can mine a myriad of data sets to make sense, which can be utilised effectively.
- My understanding is that software and system engineering is out of scope.
- There is a limited reference to data and data models in the definition.
- I strongly agree, the image in the link gives good overview https://imgur.com/O5AVwGF
- A person employed to analyse and interpret complex digital data, such as the usage statistics of a website, especially in order to assist a business in its decision-making.

We can assume that the respondents well represent the interest of the DS community both as expertise as well as needs for qualified DS employees. 27 out of 36 respondents are experienced in DS (75%) and 34 out of 36 (94%) are planning to develop DS projects. 24 out of 36 respondents (67%) are planning to train their current employees in DS and 22 out of 36 respondents (61%) plan to employ a new technical specialist in DS. Compared to IoT the results are lower but still high enough to demonstrate strong interest in the DS domain.

The respondents have pointed out experience in different sectors. The sectors in which most respondents have experience in were:

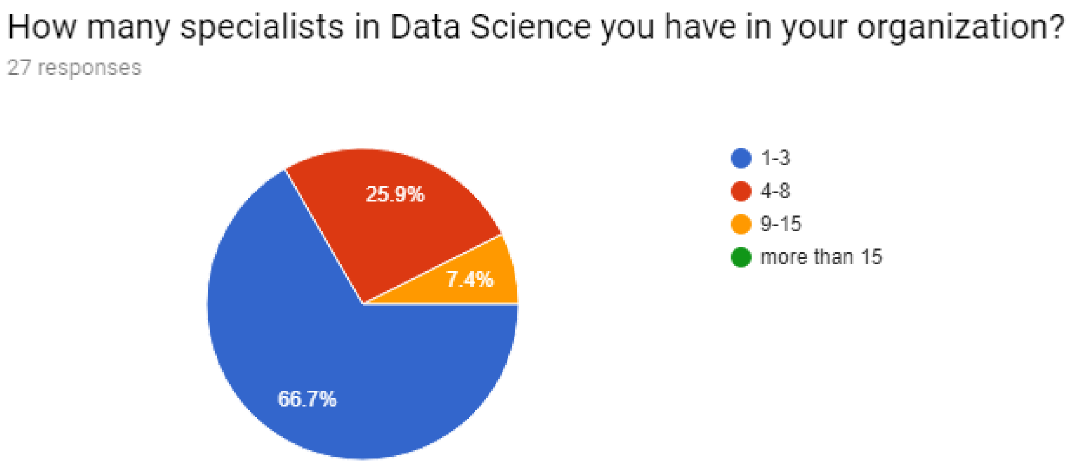
- Communication media and entertainment – 8 out of 27 respondents (30%);
- Energy and utilities - 7 out of 27 respondents (26%);
- Finance and banking - 7 out of 27 respondents (26%);
- Healthcare - 5 out of 27 respondents (19%);

- Manufacturing and natural resources - 5 out of 27 respondents (19%); and;
- Retail and wholesale trade 5 out of 27 respondents (19%).

The team will take into account this information and the specific needs of the respective economic sectors for the development of the curricula and, more importantly, the content of the trainings.

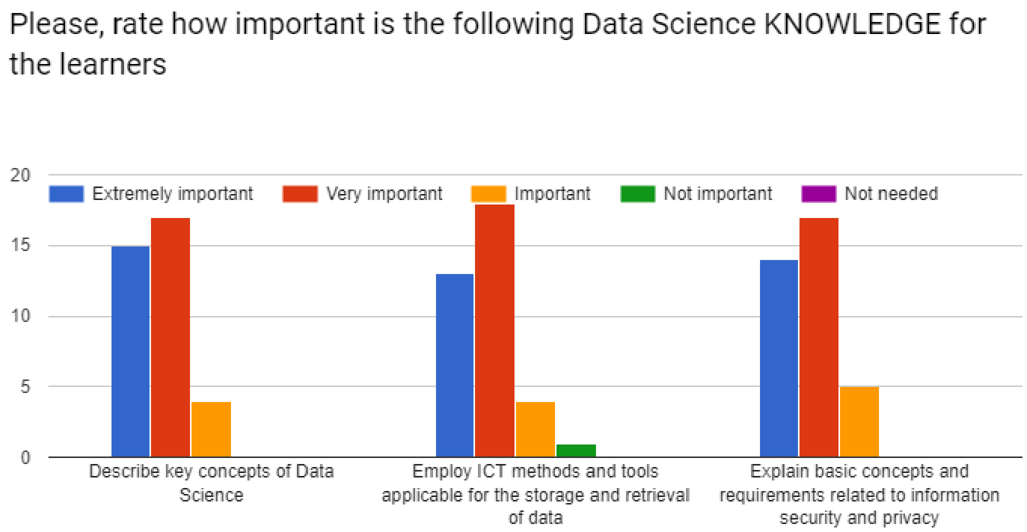
18 out of 27 respondents (67%); reported that 1-3 of their employees are currently working in DS field.

*Figure 9* Survey results about the number of employees who are specialists in DS




A vast majority of the respondents found all of the proposed DS Knowledge as extremely important or very important. The proposed areas of knowledge were evaluated as extremely important or very important - in the range of 70%-83% of the total number of respondents for the various areas of knowledge.

*Figure 10* Survey results about the importance of the proposed DS knowledge



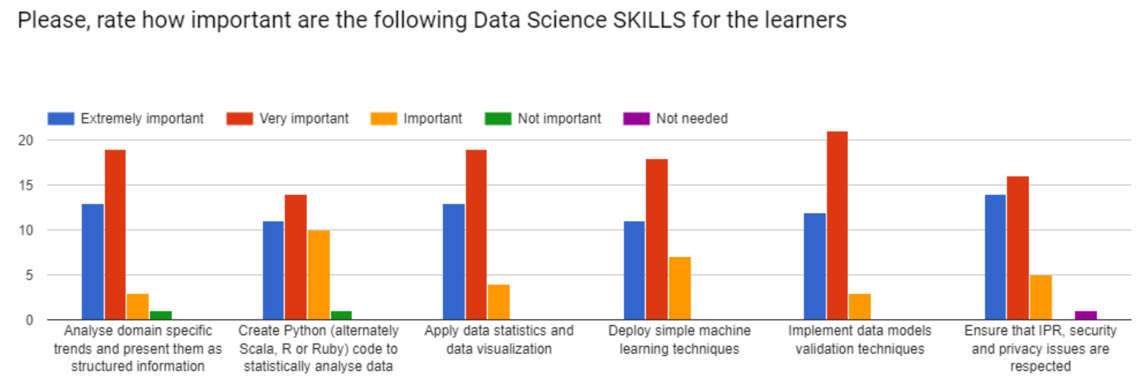

In addition to the proposed IoT knowledge the respondents noted:

- Understanding of business requirements;
- Different approaches and different problems, solvable through DS;
- Maths and statistical models;

The comments provided a valid input for extension of the knowledge already defined by the team. Those knowledge areas were considered important in the final version of the learning outputs.

Similarly, to the knowledge, a vast majority of the respondents (69%-92% of the respondents) found all of the proposed IoT skills as extremely important or very important.

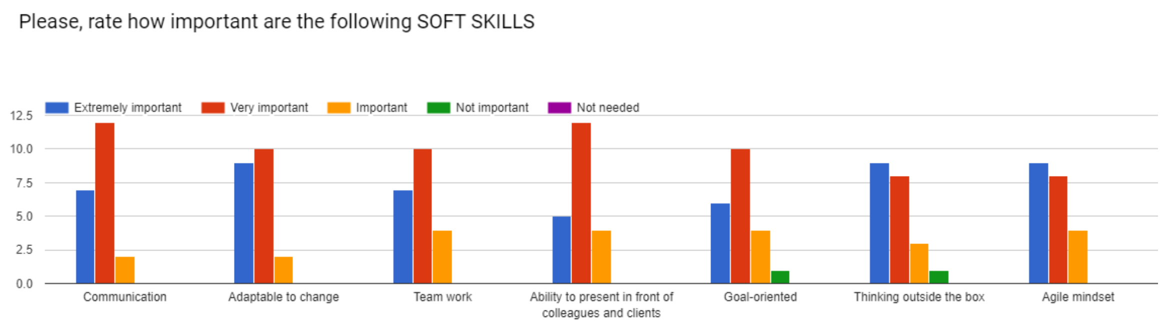
*Figure 11* Survey results about the importance of the proposed DS skills




One of the respondents provided additional comments related to the skills: data engineering, Hadoop, Database/memory/file systems optimization and architecture, big data, spatial data, data modelled by graphs, graph databases. Those elements will be further considered for developing the curriculum and for the training content.

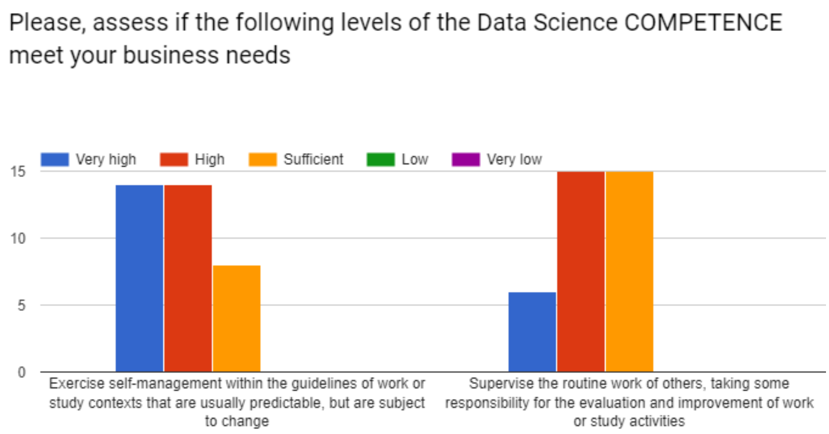
The proposed soft skills, with one exception, were also evaluated as extremely important and very important by 74%-93% of the respondents.

*Figure 12* Survey results about the importance of the proposed DS soft skills




78%-58% of the total number of respondents assessed the proposed competence as very high or high while only about 22%-42% of the total number of respondents assessed the proposed competence level as sufficient. Having into account that many of the respondents assessed the proposed competence as either very high or high, the project partners could consider to change the competency level from EQF 4, as originally proposed, to EQF 3.

*Figure 13* Survey results about the proposed competence level

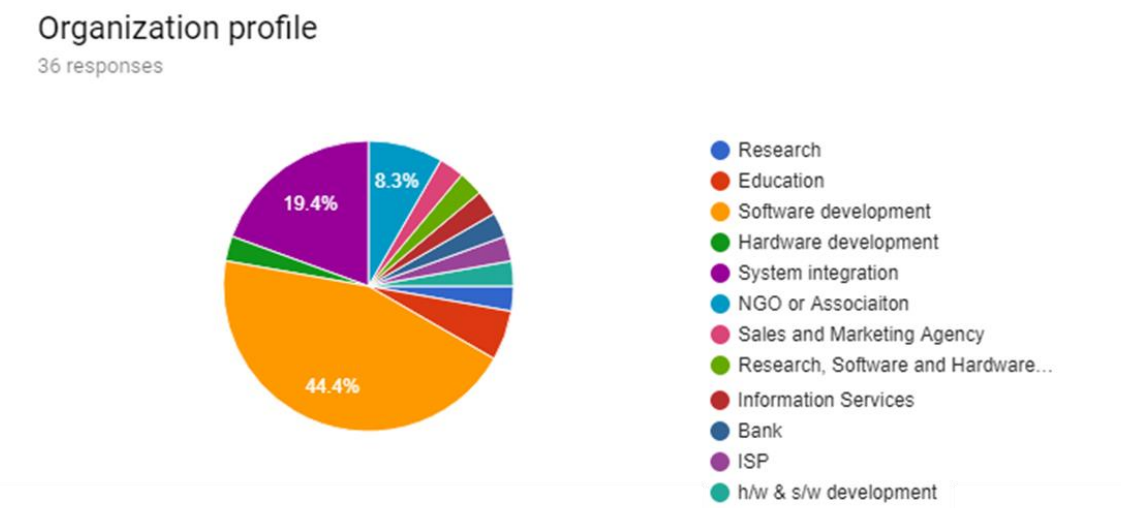



Although the number of respondents is not big (36 entries), the quality of the answers could be considered high. 25 out of 36 respondents in the survey (69%) hold a high-level management position (CEO, Deputy CEO, Director, and others) and determine the strategic perspective in the organizations. The remaining respondents hold technical, academic or mid-management roles such as developer, project manager, professor, team lead, etc., who can represent the learners in the program.

Most of the respondents are from Bulgaria (16), followed by Greece (7) and Cyprus (5). In addition, there were respondents from Finland, India, Italy, Saint Lucia, South Africa, Turkey, UK and Former Yugoslav Republic of Macedonia.

Most of the respondents represent companies from the software development sector (44%), followed by System Integration (19%). All relevant stakeholders on organizational level - companies and educators - are represented in the sample.

*Figure 14* Survey respondents by profile DS




As a conclusion, the survey, conducted among 36 organizations, assessed the proposed learning outcomes for DS as valid and important for the potential clients of the training.

The detailed results per respondent are kept in an electronic table format and are available for further research. Personal data such as names or e-mail addresses was removed.

# 5 Learning Outcomes for Internet of Things

## 5.1 Scope

Defining Internet of Things and outlining clear boundaries of this application domain is a very complex task due to the variety of technological and social perspectives that compound the concept and its applications. An extensive review of the existing research and attempt to consolidate the definitions is made by the Institute of Electrical and Electronics Engineers (IEEE), IoT Initiative [14]. We adapted and simplified a definition as follows:

"IoT is a system of distributed networks that facilitate the communication and collaboration between various IT enabled objects (things) including but not limited to software systems and applications, sensors, controllers, computers, machines, etc."

This formulation presents in general the 3 main interacting and indispensable elements of the IoT concept from technological perspective:

- network and connectivity

- collaboration
- IT system (hardware and software).

In addition, the only social aspect included within the scope of the SEnDIng project is *security,* but as far as it is ensured by technical means, information security could be also considered as a technical matter.

## 5.2 Knowledge

The major goal in the formulation of a set of knowledge in IoT for IT professionals is to tailor it to the variety of the proficiency levels of the potential learners and keep them simple and consistent. We used the action verbs from Bloom's taxonomy and the EQF level description. In addition, we revised the related competences that are described in academic programs, similar in terms of scope and target groups. We propose the following definitions of knowledge:

- Describe the value that IoT delivers in different business domains;
- Explain the business processes related to IoT in specific domains;
- Understand IoT architectures and the related network and communication protocols;
- Recognize different types of sensors, actuators, displays and related embedded electronics;
- Design the application level (e.g. use protocols that support different IoT applications) of IoT in the context of big data, cloud technologies and data science;
- Formulate requirements about IoT information security;

## 5.3 Skills

On the skills level, we assumed the same starting point - the variety of proficiency levels of the potential learners, Bloom's taxonomy, EQF and OERs in Internet of Things.

- Analyse, argue and describe the business value of a particular IoT system;
- Design an IoT system that includes sensors, controllers, actuators and displays, connected to a cloud platform through internet connection;
- Develop and deploy workflows and dashboards for an IoT system that includes sensors, controllers, actuators and displays, connected to a cloud platform through internet connection;

- Develop working code for an IoT system that includes sensors, controllers, actuators and displays, connected to a cloud platform through internet connection;
- Apply IoT information security concepts;

Optional skills added by survey respondents:

- Maintain continuous integration and verification;
- Develop network analysis;
- Operate IoT system;

## 5.4 Competences

- Exercise self-management within the guidelines of work or study contexts that are usually predictable, but still are a subject to change;
- Supervise the routine work of others, taking some responsibility for the evaluation and improvement of work or study activities;

## 5.5 Key Competences in Terms of Soft Skills

In addition to the specific learning outcomes, the authors of the survey defined the key competences, as part of the results from the interviews with specialists and employers in the domain.

- Communication skills;
- Adaptable to change;
- Teamwork;
- Ability to present in front of colleagues and clients;
- Goal-oriented;
- Thinking outside the box;
- Agile mindset;

# 6 Learning Outcomes for Data Science

## 6.1 Scope

For the purposes of the SEnDIng Project, the authors of this report use the following definition of a Data Scientist: *"A data scientist is a practitioner who has sufficient knowledge in the overlapping regimes of business needs, domain knowledge, analytical* *skills, and software and systems engineering to manage the end-to-end data processes in the data life cycle."*

The definition is formulated by the National Institute of Standards and Technology (U.S Department of Commerce) Big Data Public Working Group (NIST BD-PWG) in NIST Big Data Interoperability Framework: Volume 1, Definitions.

In the proposed definition the 3 groups of competences can be highlighted (according the definition of EDISON project[10] [11]): Data Science Analytics (including Statistical Analysis, Machine Learning...), Data Science Engineering (including Software and Applications Engineering...) and Domain Knowledge and Expertise (Subject/Scientific domain related). For the first two competence groups, training materials for online learning will be developed within WP3 of the SEnDIng project. Regarding the last competence group, the learners will acquire specific domain knowledge during the work-based learning period, implementing real-life use cases and applying competences obtained through the online training.

As the learning outcomes designed within the SenDing project will be used as an input for the definition of the reference model and curricula comprising educational modules, each of the deliverables will be produced with the active participation of the potential learners.Theproposed set of skills, knowledge and competences covers wider and more generic definitions than those, used in the EDISON project. The definitions of the CEN ICT Workshop (European ICT Professional Role Profiles) and e-CF (Data Scientist related competences D10. Information and Knowledge Management, E1. Forecast development and E8. Information Security Management) are used in defining the skills, knowledge and competences in the present report.

## 6.2 Knowledge

The major goal in the formulation of a set of knowledge in Data Science for IT professionals is to tailor it to the variety of the proficiency levels of the potential learners and keep them simple and consistent. We used the action verbs of Bloom's taxonomy and EQF level description. In addition, we revised the definitions in e-CF and European ICT Professional Role Profiles. We proposed the following definitions of knowledge:

- Describe the key concepts of Data Science;
- Describe ICT methods and tools applicable for the storage and retrieval of data;
- Describe methods and tools applicable for the statistical analysis of data;

[10] http://edison-project.eu/library

- Explain basic concepts and requirements related to information security and privacy (e.g. how to deal with people profiling in the context of GDPR);

Optional knowledge suggested by the survey respondents:

- Describe business requirements;
- Describe different approaches and different problems, solvable through DS;
- Explain maths and statistical models;

## 6.3 Skills

On the skills level we assumed the same starting point - the variety of proficiency levels of the potential learners, Bloom's taxonomy, EQF and e-CF (including European ICT Professional Role Profiles). We considered also the classification made within the EDISON's Data Science Competence Framework.

- Analyse domain specific trends and present them as structured information;
- Create code to statistically analyse data;
- Apply data statistics and data visualization;
- Deploy simple machine learning techniques;
- Deploy data storage and retrieval techniques;
- Implement data models validation techniques;
- Ensure that IPR, security and privacy issues are respected;

## 6.4 Competences

In the formulation of the competences, we used only the EQF level description, aswe assume that the potential learners will come from different professional positions. For the SEnDIng project objectives, being able to assess the level of autonomy that learners will acquire following the training completion, is more important than defining specific tasks and tools within the domain of Data Science. Hence, the defined competences are:

- Exercise self-management within the guidelines of work or study contexts that are usually predictable, but are still a subject to change;
- Supervise the routine work of others, taking some responsibility for the evaluation and improvement of work or study activities;

## 6.5 Key Competences in Terms of Soft Skills

In addition to the specific learning outcomes, the authors of the survey defined the key competences as a result of interviews with specialists and employers in the domain.

- Communication skills;

- Adaptable to change;
- Team work;
- Ability to present in front of colleagues and clients;
- Goal-oriented;
- Thinking outside the box;
- Agile mindset;

# 7 Conclusions and Recommendations

This report presents the first version of the learning outcomes that have been defined in terms of knowledge, skills and competences of the two occupational profiles targeted: Data Scientists and Internet of Things specialists. The learning outcomes are the starting point for the design and development of a curriculum for IT professionals who want to enrich their competences in DS and IoT.

A desktop research on existing Data Science and Internet of Things curricula and courses has been implemented and definitions of skills and knowledge have been extracted and tailored to the context of the target group. The draft version of the DS and IoT Learning outcomes was discussed among project partners and key experts in the respective fields. The team designed and distributed an online survey among CIOs of IT companies to explore on their plans and needs (skills and knowledge) in the IoT and the Data Science domains (more than 140 companies and organizations). The received data validates the defined skills and knowledge. The SEnDIng partners assume that before the onset of the pilot courses, one more validation of the learning outcomes and selected topics will be necessary. The SEnDIng project received 36 responses for Data Science learning outcomes and 43 responses for Internet of Things learning outcomes from companies all over the world. Based on the above, we are confident that the report provides validated Learning Outcomes relevant to the current trends in DS and IoT, along with the needs of the industry.

We can formulate the following recommendations for the work that will be based on the learning outcomes defined in this report:

- Due to the high dynamics of IoT and DS, the LOs must be continuously improved throughout the entire lifecycle of the trainings design and formulation.
- IoT and DS are applicable to a variety of domains. Therefore, the content of the trainings should be aligned with the specific needs of the potential employers.
- The DS and IoT domains are new and awareness among all relevant stakeholders is needed.

# 8 Quality and Impact Indicators

The work reported in this deliverable produced the following impact among relevant stakeholders:

- 42 stakeholders were involved in the evaluation process in the form of surveys and interviews about WP2; The stakeholders were informed about the project objectives and they contributed to the defining of learning outcomes that are aligned with the needs of ICT industry
- 21 improvement suggestions by the relevant stakeholders about WP2 were discussed and implemented, which contributed to ensuring high quality of the deliverable;
- 2 Skype project meetings were organized between project partners to discuss D2.1, which contributed to ensuring the high quality of the deliverable;
- The deliverable supports the development of IoT and DS learning outcomes and curricula applicable to VET centers in EU.

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## ABBREVIATIONS

CEDEFOP - European Center for the Development of Vocational Training

CEO - Chief Executive Officer

CF – Competence Framework

DS - Digital Science

e-CF - e-Competence Framework (standard)

ECVET - European Credit system for Vocational Education and Training (credit system)

EQAVET - European Quality Assurance in VET (framework)

EQF – European Qualification Framework

EQF - European Qualification Framework (framework)

ESCO - European Skills, Competences, Qualifications and Occupations (taxonomy)

GDPR - General Data Protection Regulation

ICT – Information and Communication Technologies

IEEE - Institute of Electrical and Electronics Engineers

IoT - Internet of Things

IT – Information Technologies

OER - Open Educational Resource

OERs - Open Educational Resources

R&D - Research and Development

VET - Vocational Education Training