Internet of Things Security Nuggets (IoT Nuggets)

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VET Trainers Toolkit

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Introduction

Smart devices invaded our lives years ago, but nowadays we have reached to the point of a constantly developing and changing technology, that makes everyday life so much easier not only on a professional but a personal level too. Our smart phones are connected to our computers, smart devices are everywhere, and through the years we learned to understand them, use them daily and life without them seems so far behind in the past. We work on our computers, we communicate, we do online shopping, we attend webinars, send emails, have numerous applications, do payments, have online classes, only to mention a few. Our computers store so many valuable personal or corporate information as never before. From a simple hacking of a credit card, to major frauds concerning big companies, cybersecurity has become a major issue.

The advent of modern technologies such as IoT is exponentially increasing the number of connected devices to the extent that there will be around 200 billion connected devices by the end of 2020. Cyberwarriors are increasing their knowledge while hackers can now utilize artificial intelligence and machine learning to trigger automated cyberattacks that can easily compromise secure systems without any human intervention. These automated cyberattacks pose a global scare and can be done on a mass volume. Not only do nations and businesses face threats from the actions and intentions of hackers, but individuals face many risks as well. Identity theft is a huge issue, where hackers steal an individual's personal information and sell it for profit. This also puts the personal safety of an individual and his or her family at risk. (Intellectual point website)

The need for awareness on that tantalizing issue has become a reality we cannot ignore. Cybersecurity in the IoT Ecosystem is a crucial concern for employees, companies and factories. That is why the necessity of a relevant training is nowadays more urgent than ever. Training on this specific matter of Cybersecurity needs to be analytical, following all mandatory steps of professional adult trainings. The creation of a toolkit for VET trainers , provides all necessary data on understanding of IoT Ecosystems, the issues of cybersecurity, the vulnerabilities of devices and the technologies used to protect them for hacking attempts, but also the methodological steps to assist trainers for planning their individualised training, regarding each time specific target groups.

The first part of the IoT Security Nuggets toolkit contains the Syllabus which provides a broad analysis and exhaustive description of security in the field of IoT, and introduces the concept of learning nuggets. It has been developed with great level of detail, not with the objective of transferring every one of the items described to learning objectives, but to provide a broad context according to the diversity nature and level of knowledge learners. It focuses on four different target groups, with gradual levels of competence and gradual learning outcomes. Target groups are divided in the following categories: All Users, Managers, Start-Ups and Smart Factories.

The second part contains the whole method that trainers should follow in order to achieve a successful training outcome. The focus of the toolkit remains on trainers, providing them all necessary guidelines and steps, from the identification of the training needs to the efficient delivery of the training, the tools of assessment, the analysis of the microlearning technique, and the evaluation process. Trainers will fully comprehend the concept of IoT Ecosystem, the way microlearning will be implemented in the training, teaching techniques and methods, the process of assessment and the value of learners' self-assessments, methods to keep their trainees engaged and interested in the training, and the importance of evaluation.

Part 1 – Development Curriculum for Educators

Development Curriculum for Educators

The Internet has dramatically changed the world around us. Billions of computers, devices and sensors work together in so called Internet of Things (IoT). The new sets provide different services and understanding for a single item. The network evolution becomes more complex and the need for cybersecurity increases. The understanding of cybersecurity challenges is the main goal of this course. The IoT set is secure as much as the weakest link or device in it. This course delivers the awareness of SMEs staff to new IoT realm. The course will introduce the security and vulnerabilities in IoT technologies and systems as well as cybersecurity policies, practices and principles.

Every module will include learning nuggets as readings, videos, case studies, and a quiz to help make sure you understand the material and concepts. This course offers a place to learn, reflect, and plan for a smart community approach to IoT.

The IoT ecosystems have own life, technologies and principles in cybersecurity to protect end user. The connected devices, operating systems, sensors, data storage, networking and communication protocols, and system services have to be projected together.

SYLLABUS

The following syllabus is an exhaustive description of security in the field of IoT. It has been developed with great level of detail, not with the objective of transferring every one of the items described to learning objectives, but to provide a broad context according to the diversity nature and level of knowledge learners. This broad context will allow to be adapted to learning outcomes for each nugget.

Understanding the cybersecurity in each of 7 IoT layers is significant for learners. These layers are:

1	Device connection	IoT devices, IoT connectivity, Embedded Intelligence
2	Data Sensing	Capture Data, Sensors and tags, Storage
3	Communication	Focus on across, Networks, cloud, edge, Data transport
4	Data Analytics	Big data analysis, Al and cognitive, analysis at the edge
5	Data Value	analysis to action, APIs and processes, Actionable intelligence

6	Human Value	Smart Applications, Stakeholder benefits, Tangible benefits
7	Data protection regulations	*EU Data Protection Legal Framework:* General Data Protection Regulation (Regulation (EU) 2016/679); Directive on Data Protection in Police and Criminal Justice Activities (Directive (EU) 2016/680); Directive 2002/58/EC concerning the processing of personal data and the protection of privacy in the electronic communications sector; *National Legislation:* Personal Data Protection Act Electronic Communications Act other…

LEARNING OBJECTIVES

- Classify the components of the IoT ecosystem, including devices, computers, networks, operating system services, and distributed systems.
- Evaluate core cybersecurity principles from an IoT perspective
- Distinguish system, service, application, and network security and privacy threats and vulnerabilities on client and server systems.
- Analyze technologies commonly used in IoT sensors, storage, communication, and system services
- Analyze IoT devices and systems from a cybersecurity perspective
- Implement and use computer-based tools to examine IoT network and security issues
- Demonstrate techniques for exploitation and vulnerability mitigation in IoT devices and systems.

Topics

Understanding IoT Architecture

- IoT devices
- IoT connectivity (Device to device, device to cloud, device to gateway, cloud to Gateway)
- Embedded intelligence
- Data sensing (capture data, sensors and tags)

Need of Internet of Things (IoT) Security

- Main Challenges and Security Issues: poor cybersecurity awareness
- The lifecycle of an attack
- Confidentiality, integrity, availability, non-repudiation
- IoT vulnerabilities (weak authentication, unprotected communications, complex system administration, open access to organizational data).
- IoT safeguards (access control, audit, authentication, biometrics, cryptography, deception, denial of service filters, ethical hacking, firewalls, intrusion detection systems, response, scanning, security policy, threat management).
- Need for a comprehensive cybersecurity IoT policy.

IOT Communication Protocol

- Networks, Clouds, Edge, data transport.
- Application Layer Protocols (MQTT, CoAP, HTTP, Web socket, DDS, AMQP)
- Transport Layer Protocols (TCP, UDP)
- Network Layer Protocols (IPv4, IPv6, LowPAN)
- Link Layer Protocols (Ethernet, WiFi, WiMax, Cellular)

IOT Technology Standards

- Wired Communication Protocols (UART, USART, I2C, SPI, Ethernet, JTAG)
- Wireless Communication Protocols (Bluetooth, Zigbee, 6lowPAN, WiFi, Z-wave)

Security Classification & Access Control

- Data Classification and criteria (Public, Private, Sensitive, Confidential, Proprietary)
- Privacy Issues in IoT
- IoT Ecosystem Access Control

- Authentication, Authorization, Accounting
- Data Integrity

Attacks & Implementation

- Risk of IoT
- Vulnerability Exploitation
- Attacks of Privacy (Phishing, Pharming, DNS Hijacking, Defacement, Eavesdropping, Cyber Espionage)
- Web Based Attacks (Malware, Password, Access, Social Engineering, Data & Identity Theft, Reconnaissance)

Cryptology

- Cryptography
- Symmetric Key Algorithms (AES and DES)
- Asymmetric Key Algorithm (RSA)
- Attacks (Dictionary and Brute Force, Lookup Tables, Reverse Look Tables, Rainbow Tables)
- Hashing (MD5, SHA256, SHA512, RipeMD, Whirlpool)

Attack Surface and Threat Assessment

- OWASP Top 10 (IoT Hacking & Security)
- IoT Attack Surface
- Software and Cloud Components
- Firmware of the devices
- Web Application Dashboard
- Mobile Application used to Control, Configure, and Monitor Devices
- Threat Assessment

Security Management

- Identity and Access Management
- Key Management

Intrusion Detection and Prevention

- Intrusion, Physical Theft, Abuse of Privileges, Unauthorized Access by Outsider, Malware infection,
- Intrusion detection and prevention Techniques
- Anti-Malware software
- System Integrity Validation.

IoT Security and the Law

- Cybersecurity Regulations, Roles of International Law, the state and private sector in cyberspace, cyber security standards.

Case Studies and Discussion

The course will pass through some of the more common IoT devices in use in:

- Smart Homes
- Smart Retail Supply
- Smart Healthcare
- Smart Grid
- Smart Cities
- Smart Industry

and how they are used as well as security and privacy-related issues found with these devices.

Checklist according to the Competence Framework

Specific objectives for different target groups: All Users, Manager, Start Up's, Smart Factory. Their workplaces are different – office, home, street, industrial manufacturing, hotels. They have to be aware of several aspects of the IoT cybersecurity listed in the table below:

Topic	**Subtopics**	**All Users**	**Manager**	**Start Up's**	**Smart Factory**
Understanding IoT Architecture	IoT devices	x		x	x
	IoT connectivity	x		x	x
	Embedded intelligence	x		x	x

Topic	Subtopics	All Users	Manager	Start Up's	Smart Factory
	Data sensing	x		x	x
Need of Internet of Things (IoT) Security	IoT Security challenges	x	x	x	x
	Confidentiality	x		x	
	Integrity	x		x	
	Availability	x		x	
	no-repudiation	x			
	Access Control	x	x	x	
	weak authentication	x	x	x	x
	Unprotected communications	x	x		x
	biometrics	x			
	denial of service filtering		x	x	x
	ethical hacking		x	x	
	firewalls			x	x
	intrusion detection systems			x	x
	threat management		x		x
	security policy		x	x	
	audit		x	x	
IOT Communication Protocol	Networks, Clouds, Edge, data transport		x		x
	TCP/IP Reference Model			x	x
	Application Layer Protocols (MQTT, CoAP, HTTP, Web socket, DDS, AMQP)				x
	Network Layer Protocols (IPv4, IPv6, LowPAN)			x	x

Topic	Subtopics	All Users	Manager	Start Up's	Smart Factory
	Link Layer Protocols (Ethernet, WiFi, WiMax, Cellular)	x		x	x
IOT Technology Standards	Wireless Communication Protocols (Bluetooth, Zigbee, 6lowPAN, WiFi, Z-wave)	x		x	x
Security Classification & Access Control	Data Classification and criteria (Public, Private, Sensitive, Confidential, Proprietary)	x		x	x
	Privacy Issues in IoT	x	x		
	IoT Ecosystem Access Control		x		x
	Authentication			x	x
	Authorization			x	x
	Accounting			x	x
	Data Integrity		x		x
Cryptology	Cryptography	x			
	Symmetric Key Algorithms (AES and DES)				x
	Asymmetric Key Algorithm (RSA)				x
	Attacks (Dictionary and Brute Force, Lookup Tables, Reverse Look Tables, Rainbow Tables)		x	x	x
	Hashing (MD5, SHA256, SHA512, RipeMD, Whirlpool)			x	x
Attacks & Implementation	Risk of IoT	x	x	x	
	Vulnerability Exploitation	x	x		x
	Attacks of Privacy	x	x	x	x
	Web Based Attacks	x	x	x	x

Topic	Subtopics	All Users	Manager	Start Up's	Smart Factory
Security Management	Identity and Access Management				x
	Key Management			x	x
Intrusion Detection and Prevention	Intrusion, Physical Theft, Abuse of Privileges, Unauthorized Access, Malware infection	x	x		
	Intrusion detection and prevention Techniques				x
	Anti-Malware software				x
	System Integrity Validation.				x
IoT Security and the Law	Cybersecurity Regulations and standards.		x		
Case Studies and Discussion	Smart Homes	x	x	x	
	Smart Retail Supply	x	x	x	
	Smart Healthcare	x	x	x	
	Smart Grid	x	x	x	
	Smart Cities	x	x	x	

REFERENCES AND CONTRIBUTIONS

This syllabus is the result of research work on competence frameworks, specifically in the field of security carried on by the experts of the IoTnuggets project, and also the collaboration of a group of experts from the University of Deusto in the field of IoT and cybersecurity between Those of us who want to highlight Borja Sanz (University of Deusto), José Ignacio Vázquez (University of Deusto). There has been also very interesting contributions from industry, and specially, Carlos Laorden (Etxe-tar) and Carlos Polo (NTS).

In addition to their contributions, a vast internet research has been carried on, focused on basic concepts, awareness about the importance of security and threats and specific risk environments and security application. A deep search on different level training courses about cybersecurity and IoT have also been carried on in Spanish Universities o different VET training courses.

Due to the methodology used in IoTnuggets videos, use cases and short material have been focused and references taken into consideration for the composition of the syllabus and elaboration of materials are indicated below organized by themes.

Part 2- Training Modules

Module 1: Training Needs Assessment

Definition of Training Needs.

From a psychological to a philosophical level the term “need” has always been a hard one to accurately define and describe in total detail, as it is a very anthropocentric concept. In ancient Greek mythology, Penia the conceptualised deity of poverty and need, was married to Poros who was the deity of means of accomplishing, providing, symbolising contrivance. Even if that is only a more philosophical approach to the term, we can detect the general concept behind it. It proves that even in ancient years, it was understood that needs require the appropriate means to be covered and fulfilled in order to create something new.

The strict definition of need can be summed up as lack of the means of subsistence and also a lack of something requisite, desirable, or useful (Merriam-Webster Online Dictionary). Need is like the missing piece in a puzzle. If found, the whole image will be complete, and we will have achieved a perfect result. By realising and covering our needs we get to the next level of fulfilment and adequacy.

There is a lot of discussion on the clarification of training needs as opposed to wants and even maybe interests. Needs versus wants is one of the most common dualities analysed through the years. Training needs refer to something absolutely essential for an organisation to survive and thrive, whereas wants to refer to something attractive and desirable, but not crucial for the existence of the subject. As far as interests go, they are even less vital and describe more personal preferences than actual vital needs.

To determine the exact and objective training needs on IoT Cybersecurity, of individuals, companies, start-ups or organisations, there has to be a system helping to establish them, in a clear and coherent way, based on research and evaluation. Training needs’ analysis is the methodological tool used to pinpoint, highlight and confirm the training needs of organisations, enterprises, groups of people, companies or institutions. The final goal of a training needs’ assessment is to provide the appropriate information so to improve the current state of the facility for which it was conducted. To make it even more clear, the first step is to understand and pinpoint the training needs, and then through the results produced, to find the right resources to cover them.

Training needs’ analysis is extremely useful for the constant empowerment of skills and the adaptability that organisations must have in order to succeed in the future, and secure their IoT Ecosystems. No matter if the analysis is conducted for an educational institution or a colossal

enterprise, the substance of the procedure stays intact, and the ways to establish the needs more or less too.

Training Needs in adult education

Needless to say that adult education is different to children's education, that would be naïve even to mention. Children are obliged to go to school and learn, at least for some years, depending on the educational system of each country, whereas adults choose to learn more and empower their already existing knowledge, in order to create a better future for themselves or the company they work for, or the institution they are part of. Adult training must be in accordance with the rapidly changing pace of the world we live in, and help individuals adapt in the ever progressed technologically advanced era we go through.

There are certain needs that must be taken under consideration regarding adult education.

1. Adults come into any educational training bringing all of their life experience, their accomplishments, their academic degrees or years of work. They are not a material easily changed or adjusted, like children. That means that each training should be created accordingly, acknowledging that fact, and providing accurate and interesting training tools.
2. Most often than not, adult learners have an already established life, and many responsibilities. They might face personal issues, or family emergencies and unexpected twist and turns. The more responsibilities they have, the harder might be to focus on the training time wise but also interest wise, hence the training should be flexible in terms of its use, and provide the mental stimulation needed.
3. No matter how educated and experienced adults are, there are always gaps in knowledge, as changes in financial and technological level are rapid and sometimes extreme. The way people work today is no similar to the way they worked

five or ten years ago, or even one in some cases. Especially, after the event of the pandemic, working conditions have entered a whole new chapter, and there are always new things to learn, and new challenges to face. Adult training should follow the constantly changing conditions and cover the occurring needs.

4. Adults, like children in this case, can get easily bored, so the training should offer a variety of tools and methods in order to be successful and useful. The combination of exciting ways to learn and at the same time, covering a specific need, is the way for an adult training to accomplish the best results.
5. The clearer the goal of the training, the better adults understand and acknowledge its value, and its practical use. Adults need to see the final target of the training, so they can get more involved and engaged with the process.
6. Due to all their responsibilities and busy schedules, adults value their time a lot, and definitely do not want to miss any of it, on something uninteresting or extremely time consuming. Trainings of any kind should provide all necessary information in the most efficient and time- effective way, so to ensure that learners will not just bail out or get easily tired.

Training Needs' Analysis as the Basis for Planning a Learning Programme

The fundamental principle of planning a learning programme is one; the programme must be created in order to cover existing and established needs. Training Needs Analysis is the methodological research and identification of needs within specific organisations, or target groups. It is part of the whole process that implements educational trainings in order to provide the required level of competences, comparing to the current level.

Training need's analysis is the foundation on which any educational programme will be built and expand. Especially in adult education, training need's assessment is a crucial tool, in order to create the most useful and profitable learning programme. Enterprises and organisations, established companies or start-ups, realise and experience practically the possible gaps in their knowledge, as they daily face new challenges and use more and more advanced technological equipment. Obviously, it is understood that training need's analysis is a methodological tool, and as such can be used for various different subjects and on many different fields of expertise. The training needs and the results may differ, but the process and method stay the same, adjusted if needed to very personalised aspects.

Conclusively, training needs' analysis:

1. Identifies the gaps in current knowledge and the desirable future level of it, regarding skills, competences, resources and capabilities.

2. Guarantees the most sufficient transformation of a gap in knowledge, into a training programme.
3. Becomes the foundation on which the training will be based on.
4. Evaluates resources, competences and current abilities in order to create the most suitable learning programmes based on current skills and personalised needs.
5. Pre-empts future problems and unexpected needs.

6. Enhances creativity and outside the box thinking.
7. Strengthens critical thought and offers the chance for personal articulation of possible issues.
8. Promotes innovation and expertise.
9. Offers solutions to existing problems, and ensures a future improved performance.
10. Highlights the willingness for general and personal improvement.
11. Confirms to stakeholders the importance of adaptability and adjusting to new conditions.
12. Ensures the relevance and adequacy of the training programme.
13. Adjusts the training to specific and individualised needs.
14. Diminishes the chances for a programme failure.
15. Enhances team spirit, as people work together towards a common, beneficial for everybody goal.
16. Becomes the foundation for the future programme evaluation.

Training Needs' Analysis and Cybersecurity in IoT Ecosystem

(to be developed, when the training programme is ready.)

The Internet of Things concept was first introduced to our world in 1999 by Kevin Ashton, when he chose that term as a title for his presentation in work, wanting to attract his managers' attention and also because it kind of made sense to him. "*I was talking about the supply chain*

being a 'Network of Things,' and the Internet being a 'Network of Bits,' and how sensor technology would merge the two together. Then I thought of an 'Internet of Things,' and I thought, 'That'll do – or maybe even better.' It had a ring to it. It became the title of the presentation." (Jeff Elder August 2019, avast blog)

The IoT concept was born that day, but it took years until the term became largely popular. The definition itself has evolved throughout the years, changed, became more detailed and accurate, following the technological progress, until today.

IoT is a system of interrelated computing devices, digital equipment, even animals or people that are provided with identifiers and have the ability to transfer data, without the requirement of a human to human or to computer interaction. Some years ago it would seem crazy that even a human, if having a heart monitoring implant, or an animal with a biochip, or our car would be a part of the IoT Ecosystem.

IoT has become vital to companies, start-ups and enterprises globally, but also its use is largely expanded in basically all areas of expertise. From agriculture to medicine IoT is making our life simpler, reduces labour cost and provides high quality services. It enhances creativity and rises employees' productivity resulting to more financial growth and prosperity. The more it expands, though, the more vulnerable has become to cyber-attacks and hacking. As it is said, IoT is as vulnerable as its most weakest link, its most vulnerable device that is. The more devices connected, the more fragments of information are shared and the more appealing to hackers IoT becomes. Companies deal with an immense number of devices, which can lead to losing control over managing all of them, and create problems to their security.

The need for cybersecurity is apparent and obvious, nevertheless there has to be a specific training needs' analysis to determine the existing gaps and provide the tools to define them based on the following issues:

1. Poor cybersecurity awareness and little knowledge on the part of the demand.
2. The lifecycle of an attack
3. Confidentiality, integrity, availability, non-repudiation
4. IoT vulnerabilities (weak authentication, unprotected communications, complex system administration, open access to organizational data).
5. IoT safeguards (access control, audit, authentication, biometrics, cryptography, deception, denial of service filters, ethical hacking, firewalls, intrusion detection systems, response, scanning, security policy, threat management).
6. Comprehensive cybersecurity IoT policy.

Concerning the crucial issue of IoT Cybersecurity, a training needs' analysis is a prerequisite, in order to form a suitable training programme. Individual users, managers, start-ups or smart factories detect their needs and through the following methodological steps, can reach the desirable level of competence.

Step 1**. Identification of training needs in various possible contexts.**

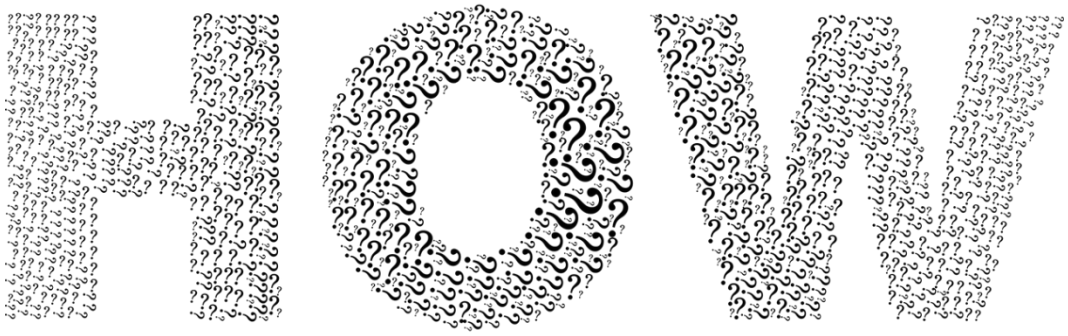
By that we mean, that there might be a gap in knowledge on a specific matter, occurring more and more often in different working settings, and different professional fields, for example the use of more complicated digital equipment, or new applications of IoT, or new skills required. The realisation and identification of the need, in various levels or forms, is what will create the next steps, in order to have in the end a very specific learning programme.

Step 2. **Clarification of the existing level of knowledge and skills.**

In order to plan the training programme, you have to take under consideration the level of skills of individuals or organisations, at this current time. Each target group might have different levels of knowledge, different hard or soft skills, and all that has to be carefully considered and measured in the most accurate way. The more information you gather on future learners, the more data you collect, the more precise the training need's analysis will be, and the more adequate the training programme.

Step 3. **Specification of the needs' analysis methodology.**

In order to collect information most accurately you must decide on the tools you will use to achieve the most complete and spherical outcome, which will be extremely helpful later



on for the design of the learning plan. Obviously, someone will conduct the analysis, so the very first step is to find the most appropriate person to hold that role. After this very first step, follows the selection of the target groups that will participate, the ways to gather information through questionnaires and other tools, the duration of the process, and how the results will be dealt with and presented.

Step 4. **The implementation of training needs' analysis.**

Following the methodology of your choice, you have to execute the training needs' analysis using the methodological tools of choice, bringing the most accurate results. You can use questionnaires and interviews, surveys or tools like checklists, choose focus groups or directly observing certain target groups in order to detect in person the needs occurring. The more in depth the questions in surveys and the more observant you are, the more targeted the interviews and the more specific the analysis is, the better outcome you will get in the end.

Step 5. **Identification of the gap between reality and optimum outcome.**

It is very important to understand and pinpoint the gaps between the objective current situation of each target group's competence, and the ideal competences. By determining the gaps, you have a clear image of the areas and fields that have to be improved and empowered. In every different target group, competences and resources may vary, and of course this will lead to more personalised focus points.

Step 6. **Evaluation and prioritisation of attainable competences and training needs.**

After identifying the competences lacking, the next step is to carefully choose the ones that can improve after training activities. There might be gaps that cannot be covered through training, and other solutions might be necessary in this case. In each target group, you have to focus on its specific training needs and also its final desirable goal. For each case, there might occur different priorities and, it is very important to adjust training goals accordingly.

Step 7. **Conversion of training needs to learning outcomes.**

All the results from the training needs' analysis should be your base to define the learning outcome regarding skills, competences, resources, knowledge, abilities, information and expertise. This certain procedure will be the foundation on which to build the most effective learning programme.

Step 8**. Planning of the learning programme.**

At this point, all training needs have been identified, pinpointed, evaluated and transformed into educational programmes appropriately designed to meet them, and cover the existing gaps. The next step is the creation of the curriculum of the training, in which each content is based on a specific learning outcome.

Methods and Key Steps of Training Needs' Analysis in Cybersecurity in IoT Ecosystem

In order to collect the most important data and useful information, which results to an adequate training, there are certain methods and key steps to be followed.

1. **Desk research** consists of the thoroughly conducted research and study of documents that can provide useful data regarding a specific topic. These documents can contain studies, reports, databases, researches, anything that can clarify and give information that can be used. Needless to point that the selection of these documents, should be done with great care and responsibility, in order to avoid confusion or end up with false data.
2. **Surveys** are one of the most common tools, especially in the field of educational needs and gaps in knowledge. A survey includes the process of asking questions and receiving answers from the participants. Usually two types of surveys are conducted; questionnaires and interviews. Depending on resources, time availability, the number of people participating, either or both of them can be used. Questionnaires could entail closed or open-ended questions, or a combination of the two. Surveys can be useful, especially if there is not much time available, as they can be conducted on a very large number of people in a specific time, an they are better evaluated if combined with other methodological tools, as direct observation or specialized focus groups.

3. **Questionnaires** are set of questions directed to a specific sample of individuals, in order to collect data. The most important issue is that they must be designed with great detail and care especially in choosing the most appropriate words and structure when forming each question. They can be delivered by email, phone, or online, in the work setting or not. The more accurate the questions and the way of developing them, the more accurate the data will be.

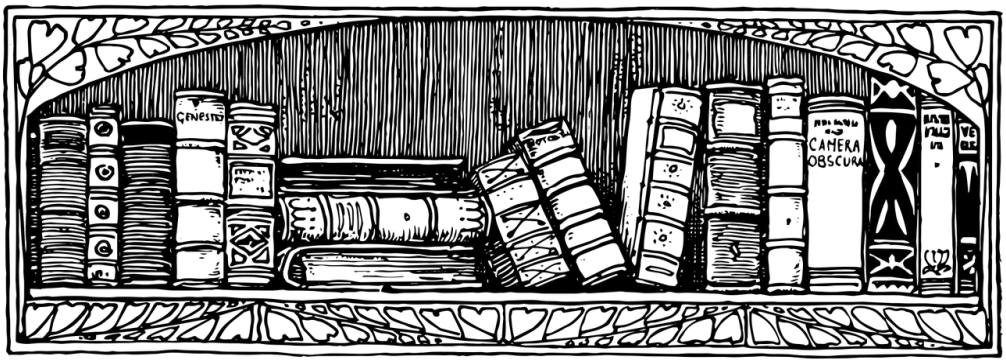
4. **Interviews** are a more coherent and thorough tool to collect information, as each interviewer has the chance to express and explain their thoughts in detail, and not just tick a box or give a short answer to a question. Interviews result to more detailed analysis and evaluations, especially if they are meticulously organised and prepared, focusing on the most crucial matters in question.
5. **Focus Groups** are a more targeted way to collect information, as it concerns a small group of people sharing common interests on given subjects, and offers them the chance to participate in a structured discussion on this specific subject. Brainstorming, creative thinking and ideas' exchange are strongly urged in focus groups, always aligned with the subject in question and focusing on the identification of needs. Focus groups requisite one individual to facilitate, and another one keeping notes throughout the session.
6. **Direct Observation** is extremely helpful as it collects data directly from specific participants that will be the ones receiving the training in the end. It can be structured, with the use of schedules, rating forms, checklists, or unstructured, using simply observation. The benefit of this tool is that provides realistic and accurate information in real time and conditions.

Module 2: Developing the Training Curriculum

Curriculum Design

The word curriculum derives from Latin and its first meaning was "action of running, course of action, race," from the verb **currere** which means "to run". (Mirriam Webster Dictionary online, retrieved 5 November 2020) Today the word's definition is " the content and specifications of a course or programme of study; or, in a wider sense, the totality of the specified learning opportunities available in one educational institution; or, in its very widest sense, the programme of learning applying to all pupils in the nation." It has been observed, with some irony, that the word is the Latin term for a track around which competitors' race for the entertainment of others. This metaphor is an interesting one in that it suggests a Darwinian view of formal education as a competition in which there are winners and losers. (Oxford Reference website)

The purpose of the curriculum design is to guarantee that learning outcomes are in total connection with the results from the training needs' analysis, and cover, in the most structured



way, the whole range of learning process. Contents should have an effective progression from one to the next, in order to achieve the optimum functionality of the training. The curriculum is extremely important as it plays a huge part in the effective implementation of the training itself. The curriculum most definitely should include:

1. The objective of the training
2. The contents of the learning programme
3. An effective and interesting structure
4. The general approach and methods of the training
5. Innovative learning tools
6. Contents in total alignment to the learning needs

7. Learning activities appropriate for each target group
8. Update and modern information
9. Specific and detailed methodology
10. Resources, equipment or facilities required
11. Adaptable form, suitable for additions and future adjusting
12. Effective ways to transfer knowledge and skills
13. Evaluation assessment

Specific goal	What is the exact purpose of the training and which are exactly the desirable outcomes?
Suitable contents	Which contents are fully aligned to the needs and will offer the best results in training
Training methods	Which is the most adequate way to deliver the training in order to achieve the best outcome?
Evaluation assessment	How can we detect if the training was successful and learners reached the end goal ?
Adaptation	How can we ensure that, if needed, the training can be adjusted to new needs and offer additional support?

It is obvious that the training curriculum for an end user will have adjusted content to the curriculum for a smart factory, as their needs regarding IoT Cybersecurity are probably different. And also the specific needs' analysis of a start-up might differ to that of a company manager, so the curricula will be created accordingly. In any case though, the methodology of the training should follow the same steps, and focus on the above-mentioned aspects

TARGET GROUPS	**All Users**	**Managers**	**Start-Ups**	**Smart Factories**
LEVEL	**Basic**	**Intermediate**	**Intermediate**	**Advanced**
OBJECTIVE OUTCOME	Inform on the issue of Cybersecurity and provide more practical skills and information to users.	Raise awareness and provide training to the responsible for the information security individuals, in order to get a	Raise awareness and provide training to the responsible for the information security individuals, in order to get a	Provide the tools, to already greatly skilled and informed on the subject organisations, so to design and achieve the implementation

TARGET GROUPS	All Users	Managers	Start-Ups	Smart Factories
LEVEL	**Basic**	**Intermediate**	**Intermediate**	**Advanced**
		deeper understanding.	deeper understanding.	of the appropriate measures.

Pedagogical principles of the Curriculum Design

The word pedagogy derives from the ancient Greek and literally means “leading a child towards knowledge and ethical behaviour”. It is the study of the methods and activities of teaching (Cambridge Dictionary Online) referring mainly to children’s education. The word andragogy is the one referring to the educational methods used for adults, but it is not as commonly used, when trying to define the principles of the educational process. The main issue in pedagogy has always been the interrelations between teacher and students, and the methods used to achieve the transfer of knowledge and reach the desirable outcome.

Throughout history pedagogical studies, ways and methods have been created, formed, re-evaluated and change, giving their space to new modern approaches of the educational and pedagogical process. The way teachers interact with students, the methods they use, the environment they create and the kinds of bonds they form, alongside the general ethics of each era, have gone through numerous alterations, to reach today.

Competence based learning is the most effective pedagogical method, as it is focused on the existing skills of learners and targets their personalized learning outcomes. It focuses on specific skills and aims on gradually developing them, depending on the learner’s pace of progress. The learning process follows the learners’ needs and not the other way round. Instead of providing general information and abstract pieces of knowledge, competence-based learning is at the same time extremely coherent and specific but also flexible, as it is adjusted to the students’ level of skills and the personalised learning outcome.

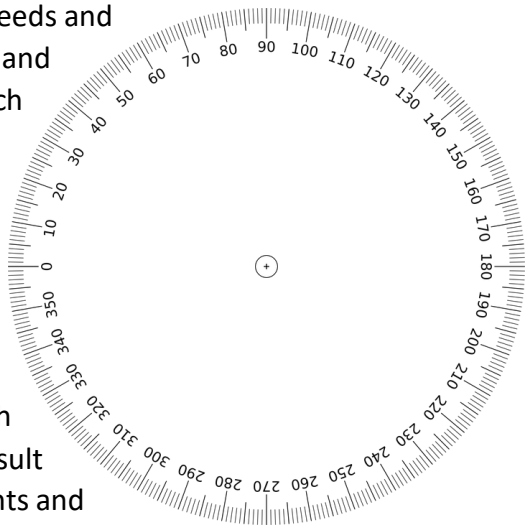
Though the centre of the pedagogical approach stays intact, the level of competences of each target group will define the desirable outcome, the learning tools, the velocity of the training and the end result. About IoT Cybersecurity the training is focused on four different target groups: end users, managers, start-ups and smart factories. The way the curriculum is designed and organized should cover the needs of all the above-mentioned groups and progressively provide knowledge that can be useful from an individual user wanting to secure their online activities to a smart factory, needing a high level of cybersecurity and also sustainability. It is extremely important that the curriculum contains comprehensible information and learning tools, adequate to each group of learners, and progressively offer gradually more complex and in-depth

knowledge on the subject. The curriculum design in IoT Cybersecurity should identify the existing needs in this area, and conseptualise the most effective learning tools, in accordance to current competences and resources of future learners. The issue of IoT Cybersecurity is grave and practically involves everyone since they use a computer. The complexity of information should be in analogy to the learner and their individual needs.

Learner-Tailored and Learning-Centred Pedagogy

In recent times the focus in education has shifted from the teacher to the student, forming what is known as learning-centred or student-centred pedagogy. Whereas in the past, the teacher was the point of reference and had an extreme concrete and severe role in the educational process, nowadays the learner is the considered the more important element of the equation. The learning process is defined by the learners' skills, needs and current level of competence, and not on an abstract idea of what they should already know.

The learning training is created according to the learners' needs and individualised competences, therefore it is flexible and adjustable and not rigid. The learner-tailored approach focuses on the identification of specific needs and then the formation of the most adequate learning methods. Learning new skills can always be challenging, so the more student-centred the approach, the more possibilities for a successful outcome.



For a learner-tailored training, we need to take under consideration the current level of competence of each learning group, the existing skills and resources, the end result we want to achieve, the priorities regarding learning contents and find the more functional learning tools and methods for every one of them.

Obviously, not all learners have exactly the same level of competence, even if parts of the same target group, and that is something that has to be taken under consideration. The training programme should be designed and organised in a way that will assist all learners, and progressively become more complex. Regarding different target groups, it is clear, that each time the focus should be the learning group, and the training should be tailored to the group's needs.

A coherent Learning Sequence

Learning sequence is the specific order that learning modules are organised, followed one another in order to be taught consecutively, as that will lead to a better understanding from the learners' point of view. Learning sequence is like a puzzle, where all the pieces should find their exact right space, and combined create the greater picture, in this case the learning outcome. It is easily understandable the reason that the learning sequence is important, as it slowly progresses from easier and more fundamental to more complex and difficult subjects. You cannot build a house starting from the balconies or the roof; you have to create a concrete foundation and then slowly progressing your way up.

In order to design the best learning sequence, you have to take under consideration the learning needs and make sure that the end result is served by the training modules. Learners should easily comprehend each unit, and detect the need that created this particular learning module. The more precise a module is, the easier for the learners will be to grasp the meaning of it, progress to the next step, and later on put it in practice. It is crucial to realise the specific desirable outcomes for each target group, and create a realistic and adequate learning sequence, always keeping your eyes on the end goal. A successful and coherent learning sequence:

1. Follows the more logical and smooth transition from one unit to the next so the learners have no gaps, or they don't suddenly face something totally complex for their level of competence.
2. All units, one after the other, create the most adequate way for the end goal. Each unit opens up the road a bit more than the previous one, in order to get at the desirable outcome.
3. Every unit uses the information and knowledge provided by the previous units, so learners can easily understand the links, and also ensure they have understood everything up to that point.
4. The more organised the learning sequence, the more prepared the whole training will be. Knowing which unit follows is extremely helpful for a better preparation and can gain loads of valuable time.

5. Trainers understand and can detect the time needed to complete each unit, which is extremely helpful for a future planning of a training programme. Obviously, that depends on the level of students' competence too, but it is a very useful tool for trainers.6
6. Having a very specific learning sequence makes it much easier to understand what actually worked, as a learning tool, and what not as much, so the evaluation process becomes clearer and more precise. Learning sequence helps the trainer become more adjustable if needed, and change specific units that may have proved not as functional.

Learning Outcomes and Training Curriculum

The learning outcomes are explained in terms of skills, knowledge and competence, and are based on the needs' analysis results. The training curriculum which is the third part of this interlinking chain, provides the description of the learning outcomes that have to be achieved by the participants after the completion of the training, the units and lessons that trainers will teach, the assignments and projects, videos, presentations, and also the tests, assessments, and other methods used to evaluate student learning.

The **Learning Programme** provides the ways and methods that form the training, and are created specifically for the identified needs that have to be covered, and also the existing resources and competences. The learning programme is of course a part of the curriculum and it includes:

1. The training modules linked to the desirable Learning Outcomes.
2. The units contained in each module
3. The time required to complete each unit and finally module.
4. Clear levels of Learning Outcomes from Basic to Intermediate to Advanced.

The Curriculum also provides the Teaching Methods which are, especially in adult education trainer-centred**,** or learner centred and focus on the successful deliverance of the training for the learners' benefit. It has to be made clear yet again, that the training and its level of complexity depend on each target group's required learning outcomes, and have to be adjusted accordingly. The same applies for the teaching methods as well, which have to suit to each target group's needs, skills and general characteristics. The most characteristic teaching tools include:

1. Team exercises
2. Brainstorming
3. Discussions and ideas exchange
4. Individual assessments and presentations
5. Use of digital technology (especially microlearning**)**

Especially after the event of the pandemic, e-learning and online training sessions are advised, whereas in more normal times, face to face teaching was a key aspect of the educational process, as the teacher could perform his role as a mentor and coach.

The Curriculum must also incorporate the assessment criteria which are extremely important in order to clarify between trainers and trainees what exactly is expected from them by the end of the training process. In order for a functionable evaluation, it is significant to:

1. Determine the aspects that will be evaluated
2. Define the ways and abilities needed for achieving the learning outcome
3. Describe clearly the different levels of learning outcomes depending on different target groups.
4. Keep in mind the different starting points of the participants, regarding resources, skills, equipment, knowledge
5. Never forget the very first step of individualised needs' analysis, and keep expectations at a realistic level.
6. Try not to overload your criteria, in case participants feel disappointed, or think they might have failed- especially regarding individual users.

The Curriculum must also include:

Resources required, in terms on the trainer's professional expertise, qualification, level of skills and knowledge.

Essential equipment**,** which especially, in the IoT Cybersecurity issue is very crucial.

Microlearning as a learning method

In the case of Cybersecurity in the IoT Ecosystem, the innovative method of **Microlearning** is the main key aspect of the training. Microlearning is the perfect educational tool for people needing to expand their knowledge on a specific matter, while dealing with an intense and hectic every-day life, and numerous professional responsibilities.

As a method, it is strongly linked to learning in the digital and technological advanced era we live in, where mobile devices are connected and interrelated, creating the IoT Ecosystem.

It has been chosen as a methodology within the IoT-nuggets project, as it fits perfectly into the objectives pursued in the project.

The micro-learning emerges from micro-content, from small fragments of digital information. It is usually, as in this case, a specific theme, limited in its dimensions, which is consumed quickly and often limited by the device for display (screen size, bandwidth, navigation, user attention span,).

It is therefore based on the use of small units of learning content and flexible technologies that allow people to access them more easily at specific everyday times and conditions (e.g., during rest time or while traveling).

It is based on brief interactions of the apprentice with a learning topic broken down into very small pieces of content. Learning processes called "microlearning" can cover a period of a few seconds (e.g., in mobile learning) up to 15 minutes (e.g., learning objects sent as e-mail messages). In our case the elements are designed for a duration of 3 minutes.

Template for the Training Curriculum

Title	
Introduction	
Short description	
Total duration	
Target group	
Objective of the training	
Learning outcomes	•
Thematic units and the use of specific learning nuggets	

Current level of skills and competence	
Assessment methods	

Units guidelines	
Full name	
Unit summary	
Structure of the unit	
Learning outcomes of each unit on Cybersecurity in IoT	

Knowledge of specific tools and methods to secure the IoT Ecosystem	
Skills	
Competences	
Microlearning implementation in each training unit	
Resources needed in order to achieve the optimum training	
Assignments	

Module 3: Delivery of Training

A successful delivery of training

The success of the training, obviously is the most desirable outcome, and the reason the training takes place. Success though, cannot be measured in absolute value, as the Learning Outcomes for each different target group vary. Keeping that always in mind, we also understand that there are some key factors leading to a successful training, no matter the target group or its current level of competence.

1. It might sound simple and easily achieved, but the training should be understandable and comprehensible, especially if the participants do not acquire high skills regarding the training's learning subject. In a learner-centred training, the current level of competence should be fully taken under consideration and become the base on which the training will be built on.
2. The training should be aligned to the specific needs of the target group, and set specific goals, suitable and realistic for each group of participants.
3. The training should be interesting and in cases, even fun, and stimulating for the participants, as adults tend to get easily bored, and probably have been through numerous trainings in their professional life.
4. Microlearning should be a huge part of the training, as it provides knowledge and information, and can be implemented in the participants' every-day life. The possibility to watch a three-minute video, wherever you are, and any time you want, that provides all the learning information needed is astounding.
5. The training should by principle contain in a logical order exercises leading to learning outcomes, that start from a basic and simpler level to an intermediate and an expert one, always adjusted to the participants' level.
6. A learner-centred training should urge the participants to express questions, and discuss the real effectiveness of the program.
7. Exercises must be strongly linked to the exact existing needs, so learners can quickly see in practice the benefits of the training, and be encouraged to learn more.
8. Creativity and innovation in training exercises is especially nowadays a prerequisite.
9. As in every educational process, there needs to be an evaluation system, for both the trainers and the trainees, not in terms of school grades, but in terms of realistic effectiveness of the training.
10. The more incorporated in everyday life the training, the better and faster results for the participants.
11. Successful training is the one, ensuring that the participants have fully gained the required knowledge, that can put in practice everything they learned, improved their performance and most of all, have the tools to use it in the future too.

How can a nugget become a learning tool?

Imagine if you had the choice to read a whole manual or watch a three-minute video with instructions on how to operate a device for instance, what would you choose? The majority of people wouldn't even consider to go through even a few pages. The power of image in our days is immense, and our brains are so used to absorb information through visual stimulations. Especially on a complex issue, as cybersecurity, the use of small videos as learning tools is a genius idea.

The data provided in the duration of such a video is much more effective than having to read and understand the same written information. In terms of training on Cybersecurity in IoT, trainees will watch three minute videos, providing information on how to secure your devices from hacking attacks, and then they will be able to discuss the content of the video with their trainers, exchange ideas, discuss on the impact of the video and ask questions.

The training is designed so that trainees can watch these videos whenever they want, in the device of their choice. Videos are designed for viewing on computers but phones too, so access to the learning information becomes totally accessible and within your hands' reach. Consequently, the training gets implemented in your daily life, as you can watch a video on your way to work, or when at home resting, or even if you face a similar problem with your personal home devices. The key to microlearning technique is that though significantly informative, videos are much more interesting and intriguing for the trainee, and are pact with useful knowledge in an entertaining and up to date way.

Training in Practice – Techniques and Tools

In a constantly changing and demanding professional world, the skills required to be able to follow these challenging developments, get more and more diverse. At the same time there is a need for higher technological abilities, and also an empowerment of creativity and soft skills, as

communication, time management, problem solving or conflict resolution. These skills apply not only to trainees, as employees, but also trainers too. In a student-centred learning process, trainers should be very perceptive of their trainees needs, personalities, responsibilities, even lifestyle, as all these factors affect the trainees' learning process. No matter what the subject of the training is, by principle trainers must attain specific skills, that have proved through time and experience, extremely crucial, in order to lead successful trainings. Needless to say, that each training is different, as different is the subject, the trainer and trainees, but there are still some core cross-cutting practices and techniques.

1. Be very specific about the objective of the training, and even though it might sound basic, explain as clear as possible the subject of the training.

2. Be very observant and listen to the trainees, even if your role is to talk and explain. Listening to your students is crucial for establishing their general level of competence, and will gradually reveal to you the most suitable for them teaching technique.
3. Make the training interesting, by maybe sharing personal stories linked to the subject of the training, or your own experiences from the time you had to go through a training. The more open and honest a trainer is, the more trust the trainees will feel, which is crucial l for a successful learning process.
4. Be informed on current trends, music, movies, or tv-shows, as all these elements can become a subject of conversation and bonding with your students, or even become references-especially in digital and technological related trainings.
5. Treat your students with respect, as they are adults with already formed personalities and sometimes too many professional or personal responsibilities.
6. Adjust your training's level of complexity and pace depending on the current level of the participants' competence.
7. Create and promote an environment of creativity and team spirit, through bonding exercises, discussions, and trust your sense of humour. Humour can be such an amazing addition to any kind of training.

8. Discover the technique that works better for each target group, and try to apply it as often as possible, enriching it and developing it throughout the training's lifetime.
9. Repeat often the more complex contents and make sure that they are comprehensible to everyone.

Delivery of Training on Cybersecurity in IoT Ecosystem – Indicative Examples

In our days, modern learners do not resemble at all past learners, and have extremely different requirements in terms of the training process. The human brain is now used to analyse and process so many information in seconds, and technology has changed the way we read, communicate and watch movies or plays. Modern people find it difficult to concentrate in very long plays in theatre, as their brains are used to the extreme velocity that scenes change in the movies and their attention span is getting less and less. Consequently, the more modern and advanced learning techniques should be intriguing and totally up to date, in order to catch the learners' attention, make them actively participate and finally understand and learn. The majority of employees, especially nowadays are not actually working in their office, so learning techniques are adjusted not only to this fact, but also the increasing number of devices we all use, and the limited time individuals can spare for a training, and in general. People need to learn new information, in the minimum time, with the greatest results.

Microlearning is exactly the technique targeting students interested in accessing very specific pieces of information, on a very precise subject, in order to gain specific skills. It consists of the use of small units of learning content and flexible technologies that offer people the possibility to access them at specific everyday times and conditions, while travelling, when at home resting, when they break from work, or whenever they have a few minutes to watch a video on their devices. As a practice is totally in tune with our digitalised environment, and perfect for trainings associated especially with technological issues, such as

Cyber security. The microlearning consists of micro-content, which means small pieces of digital information, consumed quickly, so the learner has the chance to learn in a limited amount of time, a small piece of knowledge. Obviously, all the small pieces, are part of a whole concrete subject, but breaking it down in fragments makes it easier for the learner to grasp. From a few seconds to 15 minutes, the content provides concentrated and easily accessible knowledge. In this specific training, of Cybersecurity in the IoT Ecosystem, the length of each fragment of digital information is 3 minutes.

In any case, the term microlearning describes a phenomenon of knowledge acquisition in an IT context, describing how people acquire knowledge by learning in small steps and consuming information in small pieces that form a broader and deeper connected knowledge (Schafer & Kranzlmuller, 2007).

Indicative examples

1. Teaser videos, in order to provoke curiosity on the subject.
2. Videos containing movies scenes concerning the subject of the training- especially nowadays when cyberattacks, or hacking is such a popular theme in numerous movies.
3. Animated videos.
4. Videos summarizing in the given amount of time and in a fun way, the contents of the curriculum already taught.

Module 4: Learner's Assessment

Assessment

The main goal of any training program is to offer to learners all the skills and tools to transform theoretical knowledge into practice. Which means if by the end of the training, the participant learners are able to put in practice what they have learned in theory, and if they are able to transform the educational training into skills and competence. The success of each training is countable by its participants' ability to utilize the skills they were taught, in their everyday life and workplace. In adult education things can become a bit more complex, as the assessment cannot contain just a simple grade, but needs to be more detailed and holistic. Training groups are usually formed by adults with various cultural backgrounds, different genders, and many already established personalities, and that needs to be taken under consideration.

Assessment methods are all the tools, techniques and strategies used to collect as much information as possible, proving if the participant learners have reached the desirable learning outcome, or to what extent they did, where they found difficulties and what methods worked better for them. In order for a learning assessment to be accurate, it has to contain many different techniques and tools, and evaluate each training content separately and in detail. The more tools used the easier it becomes to describe in accuracy the training and its results, otherwise there is a great chance of missing significant information, that would be useful in the future. The most precise and valid results will come by the combination of assessment methods throughout the lifetime of the training.

Methods and Tools of Assessment

Your tools of assessment should be aligned with the desirable learning outcome of each group. Having established from the beginning the expected level of competence trainees should reach, will be your guideline for the choice of assessment methods. Different groups have different desirable learning outcomes, so the level of difficulty or complexity of the assessment methods may vary. There are though certain assessment tools, that adjusted can be used during any training.

1. Tests. The most common assessment tool of all, tests are the first assessment tool that comes in mind, and obviously something that most people are used to since their school days. Tests could be daily, weekly, or every two weeks, depending on the structure of the training, and should contain questions or tasks that will allow you to check the learners'

progress on specific subjects. Tests could be performed in classroom, or online, depending on the training.

2. Presentations. Ask your trainees to work in groups or on their own, giving them a specific subject to analyse, do research, collect the data, and then present it. The more intriguing and interesting the subject, the more engaged trainees will become, so focus on their interests, their overall personalities and age, in order to assign them with a suitable presentation. Each time the trainees not presenting should ask questions, keep notes, and actively participate in the presentation.
3. Projects. Set from the beginning of the training one project for each participant that needs to be complete by the end of the training process. Throughout the training check with your trainees, in case they need assistance, and give them feedback on their so far progress. Projects can prove if learners have fully comprehended the training contents, if they are able to combine various information and put in practice the newly gained skills.
4. Final assessment. By the end of the training, a final assessment can prove the level of knowledge, and compared to the level of competence before the actual training, can give a clear image of the participants' progress. The final assessment should contain as many learning subjects as possible and various degrees of complexity, according to the dynamic of your trainees.
5. Games and exercises. You can incorporate games and role-playing exercises in your training, as a fun way to assess the level of progress and understanding of the training. Give your trainees specific conditions, like in theatre, and urge them to interact in groups trying to find the solution.
6. Tests created by trainees. On a weekly basis, each participant can create a test for the rest of the group. This way you can check their level of knowledge, proved not only by their answers, but questions too. Each trainee can choose the style of questions, the complexity and the time needed to complete the test.
7. Quick rounds. Like in quiz shows, establish a weekly speed round of questions, trying to make it fun and competitive, focused on the things you taught during the week. It is an entertaining way to assess progress, without losing the lightness of a game. Everybody loves a good quiz night, so bring that fun in the classroom.

Self-Evaluation

"Self -assessment" refers to the involvement of students in identifying standards and/or criteria to apply to their work and making judgements about the extent to which they have met these criteria and standards" (Boud, 1995). It is an extremely helpful process especially in adult education, but also a tricky one, as it can be easily influenced by external factors.

The first and most important step towards an accurate self-evaluation is that trainers and trainees should have set a very clear learning outcome and specific goals in the beginning of the training. Trainers must make very obvious what the desirable learning outcome should be, so when trainees are called to evaluate themselves, they know exactly what their target was, and realise if or to what extent have reached it. There are certain factors that can influence trainees' self-evaluation process, the most significant of them being:

1. Each individual's character and personality. Not all people have the skills to evaluate themselves accurately, as often they either overestimate or underestimate their progress, due to their overall psychological attributes, or their current general life conditions, or personal issues.
2. Comparing their own progress to other participants' progress, or others' achievements. Comparisons are mostly harmful not only for the self-evaluation process, but for life in general, and usually can block self-development and personal growth. Same rule applies here, as only with the thought that someone has done more progress than you, you will most probably underestimate your effort, and rate yourself lower than you should.
3. The feedback, official or unofficial we get from people surrounding us. No matter if it is the trainer's feedback, or a colleague's or just a friend's, people get affected and their own judgment gets blurrier. Obviously, living in a society we cannot avoid criticism sometimes, but trainees should learn to differentiate objective feedback, to useless criticism.
4. Cultural and social background is yet another factor that can influence the self -evaluation process, as all the things we learned growing up and all the experiences we gained, cannot easily be dismissed, on the contrary usually stay with us forever and can influence our perception of our self.
5. The content of the training itself and its level of complexity, trainees' experience in similar trainings or not, the time of the self-evaluation, the methodological tool used, are also significant factors influencing the objectiveness of the evaluation.

The Theory of Learner-Centred Evaluation

Evaluation as a term was strongly connected to the notion of a teacher putting a grade to a student, making the process not only stressful but also alienating. The theory of learner-centred evaluation turns the table, and puts the trainee in the centre, giving him not only the opportunity to evaluate himself, but also the skills and tools to do so. The main goal of the learner-centred evaluation is to implement the evaluation in the training itself, and make it a crucial part of it. Consequently, not only trainees gain the skills to evaluate their own progress, but also, trainers get a clear idea on which teaching techniques and learning contents were actually functional, which learning methods were not as helpful, so they are able to adjust them in the future. Thus,

an ongoing process is created, where feedback is used for future training planning, and future developments of the learning contents. In adult education, self -evaluation shows the extent to which a trainee has transformed the learning material into skills and competence, and also the actual utilisation of these skills in practice.

The importance of self-evaluation in adult education, is that every individual becomes the direct source of information about themselves, breaking the old fashioned rule that only the teacher or the trainer can evaluate someone's progress and just put a grade on it. The self-evaluation process makes participants more responsible for themselves, enhances critical thinking and also, if done with honesty, leads to personal growth, self-knowledge and consciousness. Adult education is not obligatory, so the self-evaluation automatically becomes a learning tool, and is focused not strictly on the level of knowledge but also on the impact of the training, the ideas and thoughts of the participants, their actual concerns and possible criticism.

Methods and Tools for Learner's Self-Assessment

Due to the fact that we grew up and were educated in societies, that more often than not, used the traditional methods of evaluation, by which the teacher is the only one responsible for giving information on the student's progress, by marking them with a grade, self-evaluation becomes a tricky and challenging process. We are not used in the critical thinking that is required for a self-evaluation, and also the perception of our own progress gets easily distorted by external factors, comparisons or falsely established ideas about ourselves.

Learner's self – assessment, as a process, is very anthropocentric, and can also be extremely individualised, which means that carries and brings all the characteristics, limitations, strengths, attributes and weaknesses of human nature. The assessment starts the moment a learner gets involved in the training, in the first meeting with the trainer and learning goals are established. It is in that first meeting, and of course throughout the training, that the trainee should feel an equal partner

in the learning process, and not a student waiting to be scolded by the instructor. Trainers should discuss with the trainees about their learning goals, help them realise their level of skills, encourage them and make them an active member of the program itself. Trainers should form an ongoing and trusting relationship with their trainees and guide them towards self-assessment throughout the training. The main outcome of the self-evaluation process is that it provides credible information for future training plans, and engages the trainee in a deeper level.

There are three crucial steps in order to achieve the trainees' engagement:

1. Setting clear learning outcomes and expectations. If a trainee knows exactly the desirable outcome, feels more secure to evaluate and judge himself, as he has a clear outline of the training and a specific target to aim to.
2. Self-evaluation exercises. Trainees are urged to use the self-evaluation tools for every project they have to complete, minor or major, from a presentation to an essay, a report or a public speech. They keep notes throughout the planning of their task, comparing their actual performances in progress to the expectations they had in the beginning.
3. Final review. Trainees analyse the feedback from their self-assessment in order to revise their whole training. Knowing that their self-assessments will be used and taken under consideration by the end of the training is substantial and urges trainees to seriously work on their self-assessments, having the knowledge that all the results will be used for a future possible improvement of the course. This way, they get to become a significant part of the educational cycle themselves.

The trainers' role has many responsibilities, one of them all being the constant effort to keep trainees engaged and interested and also never forgetting that learners are in the centre of the educational process. Assessments can be performed during the lifetime of the training in various ways such as tests, reflective questions and discussions, trainees' interviews, weekly evaluation tests, formal written assessments and checklists. What is of great significance is the way trainers can guide trainees to reliable, honest and effective self-assessments. Even though each training is different, and each trainer has a

different personality, there are some key practices that if followed can substantially help trainees with their self-assessment process.

1. Especially when dealing with adults, it is mandatory to keep trainees involved in the assessment process from the beginning, and establish a relationship based on equality and a common target.
2. Honesty. Being honest with your trainees about the desirable learning outcome but also their current level of skills can only have positive results. Adults know more or less their weakness or gaps in knowledge on specific matters, so by being honest with them you make them feel that they are treated as an equal partner in the learning process. Of course, trainees should realise that being honest about their current skills is crucial, and nothing to be embarrassed about, as if there were not any gaps in knowledge the training wouldn't have a reason of existence.
3. Focusing on strengths. Everybody, no matter what their age is, needs encouragement and positive feedback, in order to feel more motivated to continue the training and take it seriously. Praise your trainees when they succeed, highlight their strengths, don't focus on their possible poor results in a test, on the contrary make them understand the progress they are making and let them know how proud for themselves they must be.
4. Acknowledging diversity in personalities. Needless to say that in a group of trainees you will come across not only different skills 'levels, but also different personalities and characters, from various social and cultural backgrounds. As a trainer you should be inclusive of diversity, try to understand each trainee more as an individual person and not just a student. Creating an environment of acceptance and trust will lead to excellent results not only for the trainees' self-esteem, but their self-evaluation and the whole training too.
5. Use trainees' feedback as a learning tool shortly after they have turned it in. This way you succeed in creating a strong link between feedback and learning material, and trainees understand that their own evaluations become a tool in the educational process.
6. Provide time. Give your trainees time to reflect on their evaluation, help them if needed, give them time to get familiar with the evaluation process, and most of all make it clear that evaluation in their case does not equal just a grade.

Learner's Assessment in Cybersecurity in IoT Ecosystem

Using videos as an assessment tool

In order to make the process of self-evaluation interesting and engaging, ask your **trainees** to film small videos with their reactions to the learning material throughout the lifetime of the training. From the first time they get in touch with the subject of Cybersecurity in IoT Ecosystem until the day they finish the course, and even some months later. Following the concept of microlearning, they will use videos as a self-assessment method. By the end of the course, they will have a digital manifestation of their own progress and thoughts, that will allow them to actually watch the progress made. In order to help them in the beginning, you can give them a structure of the video, by giving them questions to be answered in the two or three minutes of the recording.

1. What is your first reaction when you hear the term Cybersecurity?
2. How did you feel during the training?
3. Which part of today's training was the most comprehensible and which part made your life really hard?
4. How do you think you will cope with the training?
5. What are your expectations from the training?
6. How much time you spend on trying to understand the content of the training?
7. Find a fictional character, from a book or movie, or animation films that can better describe yourself in the training process each time.

You can ask your trainees to share their videos and especially by the end of the course watch them in sequence, like a movie, and then write a report on their own self-evaluation vlogs.

Since **managers** face day to day issues in their work environment, and they are called to resolve numerous setbacks, they could implement their self-assessment, in a creative way, in their every day schedule, by filming daily vlogs with their progress, or struggles regarding Cybersecurity issues. If their colleagues consent, they could also participate in these short vlogs, stating if their managers' training was also helpful for them, if hindrances are more efficiently resolved, and also if they would like to participate in similar trainings. The combination of their personal honest reactions to the training, with their colleagues' views can lead to a more complete evaluation and lead to future improvements of trainings. In order to help them in the beginning you can propose the following questions to be answered as a starting point for their videos:

1. What was exactly the problem I faced today?

2. Did I already know how to solve it or used information provided by the training on Cybersecurity?
3. Was there a specific learning nugget that came in my mind when trying to find a solution for the problem on cybersecurity?
4. How long did it take to solve the occurring matter?
5. Did I solve it alone or asked for some extra help from colleagues participating in the same training?
6. How did I feel before and after resolving that problematic situation?

By the end of the training all managers can create their own short movies, by editing the videos and share with each other their progress, thoughts and challenges they faced.

Start-Ups could create a platform for their employees to upload their self-assessment videos, and also find other start-up enterprises that participate in similar trainings and create mini online competitions between them, regarding the training on cybersecurity. Employees could participate on their own or as teams on online quizzes and tests competing other employees or other teams, and check their progress throughout the training. The creation of such a platform for start-ups will aid the whole evaluation of trainees, and consequently the training itself and can become a valuable tool. In order to assist employs in the beginning you can propose the following questions as a basis for their own videos:

1. How often do I come up with an issue regarding cybersecurity not only in my professional but personal life too?
2. How did I feel before the training regarding cyberattacks, and do I feel more capable now to deal with such issues?
3. How did learning nuggets change my understanding on cybersecurity?

Smart Factories could also create similar platforms for their employees and connect to other factories on an even larger scale. Most probably smart factories face more complex issues regarding cybersecurity, so the vulnerability of information is of great importance. Self - assessment videos should be focused not only on the progress during the training, but also urge employees to expand on their own ideas of the training's sustainability.

Module 5: Evaluation of the Training

Evaluation-Aims and Objectives

It is interesting how through years, the meaning of the word evaluation has been shifted from a strict and judgmental term, to a more wholesome interpretation, obviously following the global changes in our way of thinking, the progress made and the need for a student-centred educational system. Evaluating a programme should be a process of honesty and reflection, aiming to future improvements and developments.

In general, "an evaluation is the systematic and objective assessment of an ongoing or completed project, program or policy, its design, implementation and results. The aim is to determine the relevance and fulfilment of objectives, development efficiency, effectiveness, impact and sustainability". (Glossary of Key Terms in Evaluation and Results Based Management)

Through the evaluation process we gain information on the functionality of a program, the impact it created, the more substantial and effective training contents, its strengths and flaws, in order to reflect on it, analyse the data, and enhance future training planning. The core of the evaluation process is the future improvement of trainings, skills and performances of companies or individuals.

Common Learning Evaluation Methods

Through the years of theoretical analysis of the evaluation process, there are some iconic and still functional evaluation methods, recognized globally. The most important of them being:

1. **Kirkpatrick's Model of Learning Evaluation**

Kirkpatrick's model of learning evaluation has been used for more than 50 years. The model encourages us to evaluate learning on four levels:

Reaction – Did they enjoy the training?

Learning – Did they pass the assessment?

Behaviour – Do they work better?

Results – Did business metrics improve?

The important thing is to measure at all four levels so you can see exactly how each stage of your learning design was effective. Design your learning program by starting with a business problem. Then identify the actions needed to solve that problem and the learning needed to support those actions. Once that's complete, design the program needed for that learning to happen. Your evaluation metrics should follow that same chain so that if you don't meet the business goal, you'll know where it went wrong. (4 Learning Evaluations Models You Can Use, Downes Andrew 20 January 2016, eLearning Industry website)

2. **Kaufman's Model Of Learning Evaluation**

Several models build on or react to Kirkpatrick's. Kaufman's model of learning evaluation is one of those. He makes two significant changes from Kirkpatrick:

Kaufman splits Kirkpatrick's level 1 into "input" and "process". Input is the learning materials and resources available to learners. Process relates to the actual delivery of the learning experience.

Kaufman adds a fifth level above organizational benefits to look at the benefits to society as a whole or to a business' clients. (4 Learning Evaluations Models You Can Use, Downes Andrew 20 January 2016, eLearning Industry website)

3. **Anderson's Value Of Learning Model**

If a learning program led to an increase in factory production by 50%, you might think it was successful. But if the organization where the program took place already had surplus stock and not enough sales, the real story is that the learning program was poorly aligned to the organization's priorities.

Anderson's Value Of Learning model encourages us to focus evaluation on the alignment between the learning program's goals and the strategic goals of the organization. Only once the goals are aligned can we evaluate the success of the learning program in meeting those goals. (4 Learning Evaluations Models You Can Use, Downes Andrew 20 January 2016, eLearning Industry website,)

4. **Brinkerhoff's Success Case Method**

Sometimes learning programs are resounding successes, and other times they are total flops. Most of the time they are somewhere in the middle. However successful the program may be as a whole, there will always be a few learners who were successful and few others for whom the program didn't work.

Brinkerhoff's Success Case Method (SCM) involves identifying the most and least successful cases within your learning program and studying them in detail. By comparing the successes to the failures, you can learn what to change to ensure success in future endeavours. Based on what you learn, you can also write and publicize success stories to show how valuable your program has been. (4 Learning Evaluations Models You Can Use, Downes Andrew 20 January 2016, eLearning Industry website)

5. **CIRO model**

The CIRO model developed by Warr, Bird and Rackham focuses the evaluation process on context, input, reaction and output.

Context: collecting information about performance deficiencies and from this setting training objectives.

Input: analysing the effectiveness of the training design, planning, management, delivery and resourcing to achieve the desired objectives.

Reaction: analysing the reactions of learners to enable improvements to be made.

Outcome: evaluating what actually happened as a result of training measured at the learner, workplace, team or department and wider business level. (Warr, Bird and Rackham 1970, Evaluation of Management Training.)

A Systematic Perspective of Evaluation

As education is an ongoing and non-stop process, trainings are living organisms that have the opportunity to be improved through one and only path. And that is the effective and holistic approach to evaluation. It cannot be stressed enough, that the evaluation process is an equal and extremely vital part of the training itself.

Only through evaluation we gather reliable data on the quality of the training, the impact it had on trainees, the extent of its success regarding the utilisiation of skills and knowledge gained, and most of all what evaluation offers is a guarantee that future trainings will be even more suitable, even more effective and that future trainees will gain all the required skills and reach their desirable learning outcome. Evaluation has long stopped being a grade, and becomes a process in which all behavioural, intellectual, cultural, and social aspects are taken under consideration. And of course that is only logical, as the evaluation process follows the educational process in which the student, a human being, is the main focus and the centre of it.

They key actions for an effective evaluation process are:

1. Ensure that all results will be taken under consideration and turned into the base for a future training plan.
2. Be ready and prepared to alter the training program, by making improvements, based on the elements of the evaluation. The more clear the link between evaluation and learning process, the most accurate and effective the evaluation process is.
3. Highlight the best results, and the people that managed to achieve them, as their stories can be inspirational and lead to new trainings or institutional changes in the working environment.
4. Analyse your data focusing on the impact the training had, the expense of it, the number of participants and if the utilisation of skills improved the professional performance of trainees and the company's as a whole.

5. Agree on shared responsibilities, as the training on its own, cannot survive outside the professional setting for which it was designed. The results of the training must be measured in practice, which means that trainees must be able to use their skills for an sufficient period of time that allows evaluation. If the training gets alienated from the actual working place, then the evaluation is useless and will not be of help for future planning or improvement in the organisations themselves.
6. The sustainability of the program is vital, so your focus should be on using resources wisely, collect data in ways that will not disturb the operation of the company, but also provide reliable answers. No company wants to spend huge amounts of money on just an one off training, on the contrary you need to create the foundation for a sustainable and flexible training.
7. Engage stakeholders and work as a team creating a plan of action based on collected data, on future improvements and creative ways to implement the evaluation process in the professional environment.

Main Principles (Stages) of Evaluation.

Each evaluation process should be planned following these fundamental principles:

1. Clarification of the evaluation's purpose. It is easily understood the reason why this is the first and extremely crucial principle for conducting an evaluation. Not defining the reason of the evaluation renders all data and information useless, as they cannot be analysed, deciphered and give valid answers.

   Examples:

   Collect data on which parts of the training offered to trainees the most practical information on Cybersecurity in the IoT Ecosystem.

   Which parts of the training need alterations, as from the self-assessments it is demonstrated that trainees got confused and found them difficult to follow.

2. Set specific criteria for each different target group. Set criteria for a top performance, each time taking under consideration the limitations or strengths of each target group. Top performance will not be the same for an end user and an expert in a smart factory. Setting criteria for an excellent performance to each group, allows you to understand the extent to which learning outcomes were successful and could be put in practice.
3. Have clear and precise expectations. Define the desirable benefits of the evaluation and how you will use the information provided. Logically, one main expectation is that through evaluation you can ensure quality improvement. Through evaluation you may want to define if certain learning tools, contents and exercises worked or not, which target group found them useful or not and understand the ways to develop them.

4. Define the scale of the evaluation. You should know from the beginning of the process if you have the resources to cover just a number of trainees or every participant, and also if you can cover the whole training, or only some learning contents and also if you will analyse data from the whole institution after the training. The scale of the evaluation process should be in analogy to resources, time needed and participants' availability.
5. Choose the appropriate methodological tools. It is clear that if the evaluation is conducted to a vast number of people, quantitative tools such as questionnaires and surveys should be favoured, whereas if you are trying to define the impact of the training to a small group of employees interviews and observation will be more effective. If your resources allow it, the combination of quantitative and qualitive methods result to a more detailed and at the same time broader evaluation process.
6. Participants should be fully informed on the reason for the evaluation. An evaluation is not conducted by itself, which means that all participants must understand the purpose of it, the fact that their information will be analysed, used and then shared, and consent to that.
7. Revise and be prepared for changes. The evaluation's outcome might surprise you, as you can never be sure of the participants' answers and thoughts. The crucial issue is that a review of the results is mandatory and leads to improvements and changes. Make sure that you communicate the evaluation's results to the trainees and also make clear the unbreakable link between evaluation and practice. Be prepared to revise the results with honesty and use them in the more effective and beneficial way.

Implementing Evaluation

As every single process in which humans are involved, there are some key factors that can affect and influence the evaluation, so keep in mind some vital rules for a more successful implementation:

1. Find the right time, and possibly place too. As long as humans are participating, you need to take under consideration their overall condition in terms of stress related to work issues, tiredness, deadlines that need to be met, or anything else that can influence an individual and tamper the results. A survey on availability may be needed, in order to find the most convenient time for the majority. Give participants time to complete the evaluation, and try to do it on the right time.
2. Choose methodological tools wisely. Adjust or customise the tools you will use, in order to suit each different target group. From the language used, to the complexity and also the time required to complete it, each evaluation should perfectly fit the diverse target groups.
3. Do not overdo it with the number of questions. People, especially stressed adults, with not much time to spare, might get annoyed by an endless evaluation process with similar or overlapping questions, and even if they don't realise it, subconsciously their results will be affected.

4. Choose the most appropriate number of participants. A vast number of participants might provide a huge amount of information, but make sure that you have the resources to collect and analyse them. Also keep in mind that maybe a more careful and targeted selection of participants might prove more efficient in the end.
5. Make sure to check if the results of the evaluation are transformed into practice. Evaluating a training without ensuring that the results reflect reality is pointless. It is crucial to follow up the evaluation and critically review the utilisation of the results.
6. Communicate the results with each different target group, so participants are informed and also get their feedback on the evaluation's outcome.

7. Be open to discuss the evaluation's results, accept possible criticism and figure out if the evaluation gives the complete picture or some things were overlooked.
8. Ensure that the bond between the evaluation and changes made is strong and clear to everyone. The clearer you make that changes and improvements will happen due to the evaluation process, the more engaged people will be in the next evaluation, and the more certain they become that their opinions actually matter. The knowledge that changes can be made, and things can be developed has a great impact on each individual separately and consequently to whole companies too.

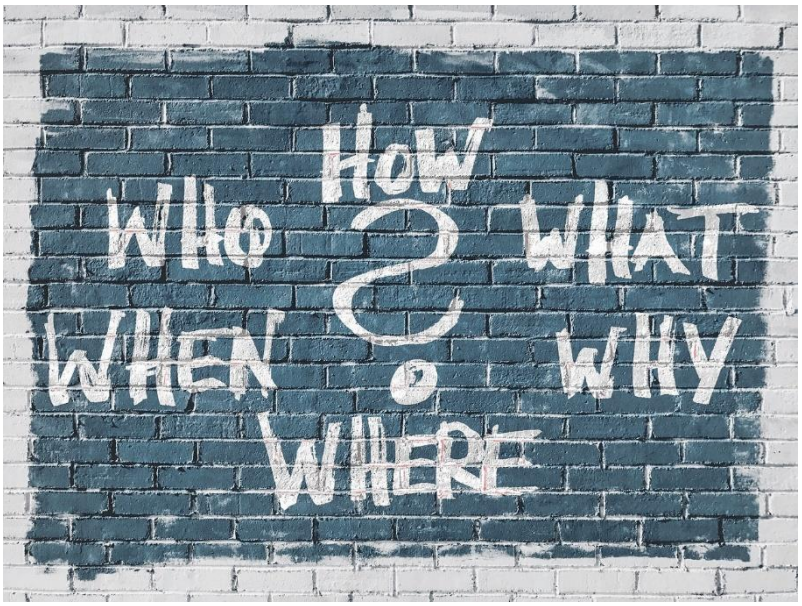
The Evaluation Plan

Each evaluation process goes through four different and distinctive stages: planning, implementation, completion and dissemination, and finally revising and reporting. In order to achieve the best outcome and have a very clear path to follow regarding this process you need an evaluation plan.

The evaluation plan is your structural guide on the purpose of the evaluation, the exact subject, the data you want to collect, and for whom you are conducting the evaluation. The plan contains all the key and significant questions that require answers, which leads you to the appropriate methodological tools you will need and also the kind and size of information you want to gather. Depending on the evaluating plan, and if it will be fully detailed and time consuming or not as much, you get to choose the more appropriate way for the evaluation, and also the resources required. In your plan you can define who is responsible for each task, share responsibilities and set a timeline. Your evaluation plan is your lighthouse and your anchor at the same time as:

1. It clarifies the sort of data you need to collect.
2. It sets a realistic and feasible timeline.
3. Defines the most suitable methodological tools.
4. Contributes to the development and empowerment of the training.

To create an efficient evaluation plan for the training in Cybersecurity in IoT Ecosystem you should keep in mind:



1. Define training objectives and end goals.

It is vital to set specific, clear goals of the educational training. Describe exactly what you want to achieve, and what tools you will use to do so. Identify the most significant training contents that you consider needing evaluation.

2. Form the most valuable evaluation questions.

The evaluation questions should be in a result of cooperation with the stakeholders and go far beyond a simple measurement of success. The main concern should be how through these questions you can get the clearer answers so you can form an improved training plan, and release the accurate effectiveness of the existing. Your questions should be formed now, in the present but, aim towards to the future.

3. Define your diverse stakeholders.

Defining your stakeholders is crucial for the evaluation plan and the whole planning process in total. Stakeholders are all people interested in the program, in this case end-users, managers, start-ups and smart factories. Engaging the stakeholders in the evaluation process results to credibility, to more accurate end results, and also provides a realistic view to the whole training itself. By involving stakeholders, you get to really understand their point of view, find out things that might surprise you, and lead you to more accurate and to the point questions of evaluation.

4. Choose the more adequate evaluation methods.

The methods you choose depend on the requirement of the evaluation, its purpose, and the type of questions you need to be answered. You should, obviously, take under consideration the stakeholders involved and adjust the complexity, length even style of your evaluation. Take under consideration each stakeholder's specific characteristics, availability, skills and purpose they participated in the training. Acknowledging all these factors, you should choose the methodological tools accordingly.

5. Revise and share the results with stakeholders.

Maybe the more crucial stage of the evaluation process. It is pointless to conduct an evaluation, if you don't communicate its results, and no further actions are taken. The more accurate and well conducted an evaluation is, the better it can be presented, taken under consideration and lead to practical changes.

Evaluation questionnaire of the training course

Course title:

Date:

Thank you for selecting and attending our training course. As a final task of the course, we kindly ask you, to fill-in this evaluation questionnaire. This way, you help us improve our training courses. Please fill-in the questionnaire and give it back to your trainer.

Personal info

Name: .....
Facebook: .....
Linkedin: .....
Skype: .....

Please answer the following questions using a scale of 1-4.

1. Totally disagree
2. Disagree
3. Agree
4. Totally agree

Preparation

	1	2	3	4
The information about the course in the website is sufficient and well presented				
The communication with the course organizer was timely and good				
I had the chance to communicate my specific learning needs and expectations				

Do you have additional comments regarding course preparation?

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Training course design

	1	2	3	4
Microlearning as a teaching technique is effective				

The training course has clear objectives and learning outcomes				
It includes a good mix of theoretical contents and practical exercises				
It is appropriate for a transnational and diverse audience				
It is innovative and in-line with EU educational priorities				
The training material supports the achievement of the learning outcomes				
The learning methodology is appropriate and follows the principles of adult learning				
My specific learning needs were taken into account				

Which course contents were most valuable to you?

.....
.....

Do you have additional comments regarding course design?

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.....
.....
.....

Training delivery

All the videos used during the training were accessible and comprehensible	1	2	3	4
The training room, facilities and resources were good				
There was good administrative support				
The course contents were covered satisfactorily				
The course delivery was flexible to accommodate participants' needs				

Do you have additional comments regarding the training course delivery?

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Trainer:

	1	2	3	4
… created and managed a positive learning atmosphere				
… encouraged participation, supported and built motivation in participants				
… used various learning methodologies and aligned them to learners' needs				
… facilitated learning and gave constructive feedback				
… linked theory with practice				
… established trust and respect as a trainer				

Do you have additional comments regarding the trainer?

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Evaluation and follow-up

	1	2	3	4
Trainer(s) monitored regularly the learners' progress and adjusted the training plan				
I got constructive feedback from the trainers				
I met my learning expectations				
I would like to follow-up contacts with other course participants				
I would like to network with other people interested in the topic of the course				

Do you have additional comments and suggestions to improve this course?

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Testimonial (optional)

Please provide an overall comment and/or recommendation of our course. Your quote may appear as a testimonial in our website.

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