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SENDING ONLINE TRAINING CONCEPT – COMPETENCY-BASED, ADAPTIVE LEARNING IN DATA SCIENCE FOR ICT PROFESSIONALS

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Overview

The European Union has noted over many years the existence of rapidly changing skills and persistent skills mismatches in the EU labour market. In the ICT sector, gaps have been regularly reported between the skills required and the skills actually attained by graduates of European Higher Education Institutes. The focus therefore has been to adopt a more proactive learning policy that can develop and test mechanisms that will help ICT graduates and workers to acquire the key relevant skills that will make them employable and adaptable to future market trends. In addition, such mechanisms will be designed to enhance worker mobility and flexibility.

The key steps proposed need to centre on engagement with employers to clarify their needs and with Higher Education Institutes to assess the nature of the skills, attributes and competences with which they are seeking to equip graduates. Further issues identified in this process include; the development of flexible modules of learning to address identified gaps, piloting of learning modules in several countries, and the evaluation of the impact of such learning modules from the point of view of ICT employers and workers. Making available learning modules in an OLE (together with systems such as a learning badge and an e-portfolio which will allow potential workers to record their relevant non-academic achievements in a structured way) would facilitate the dissemination and exploitation of such outputs in a sustainable and dynamic way.

A result of this endeavour is the SENDING project (KA2: Cooperation for innovation and the exchange of good practices – Sector Skills Alliances) which started in early 2018 with aims to address the skills' gap of Data Scientists and Internet of Things engineers that had been identified in the ICT and other sectors (e.g. banking and energy) in which Data Science and Internet of Things have broad applications.

To achieve this goal, SENDING is developing two learning outcome-oriented modular VET programmes using innovative teaching and training delivery methodologies for the two identified occupational profiles (data scientists and IoT engineers). Each VET program is being provided to employed ICT professionals into three phases that include: (a) 100 hours of on-line asynchronous training, (b) 20 hours of face-to-face training and (c) 4 months of

work-based learning. A certification mechanism has been designed and will be used for the certification of the skills provided to trainees of the two vocational programs, while further recommendations will be outlined for validation, certification & accreditation of provided VET programs. Furthermore, SENDING has defined a reference model for the vocational skills, e-competences and qualifications of the targeted occupational profiles that are compliant with the European eCompetence Framework (eCF) and the ESCO IT occupations, ensuring transparency, comparability and transferability between European countries. Finally, a set of exploitation tools will be developed, giving guides to stakeholders and especially companies and VET providers, on how they can exploit project's results.

In this paper, we will focus specifically on the development of the SENDING online training concept – how the project team was able to identify what kind of approach would fit this specific purpose of training, what the key design principles were and how technology solutions will be used to implement the concept in practice.

Skill gaps identified among ICT professionals

Competitiveness, innovation and job creation in European industry are increasingly being driven by the use of new Information and Communication Technologies (ICTs) and the availability of high skilled and qualified workers in line with rapidly evolving market trends. ICT is an economic sector that is rapidly changing, has a strong momentum and an important contribution to the growth of almost every economy. According to EC, during 2010, the ICT contribution to Europe's growth represents 5% of GDP and ICTs drive 20% of Europe's overall productivity growth. Furthermore, despite the uncertainty seen on global labour markets during and after the economic crisis, the employment of ICT specialists has been largely unaffected, as at European level the employment growth rate for ICT specialists has remained on an upwards path averaging 3% growth per annum since 2006, i.e. it was more than eight times higher than the average growth rate of total employment over the same period (Eurostat, 2019).

As ICT is a general-purpose technology, changes and disruptions in the economy can have significant influence on the future skill demands for ICT professionals. Data Science (DS) and Internet of Things (IoT) have been recognized as the technologies among the key drivers of change with regards to the skills required by ICT professionals (Skills Panorama, 2016). Furthermore, Big Data and Data Science in general have the potential to directly contribute €206 billion to the EU economy by 2020. However, one of the main barriers to achieving this potential is the forecast skills gap associated with Big Data given that, according to estimations, there will be a 160% increase in demand for Data Scientists from 2013 to 2020 for 346.000 new jobs (European Commission, 2019).

This forecast, together with the rapid and continuous evolution of Data Science and IoT technologies and their broad application at other industry's sectors than ICT sector (e.g. banking, energy, assurance) make the skills required by related occupational profiles (e.g. Data Scientists, Internet of Things Engineers) increasingly sophisticated, and the need to be

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constantly updated is now imperative. In the aforementioned landscape, the specific needs and challenges that the SENDING project intends to address can be outlined as follows:

- Challenge 1: Addressing the skills' gap of Data Scientists and IoT engineers, by developing curricula for the provision of learning outcome-oriented modular VET programmes using innovative teaching and training delivery methodologies.
- Challenge 2: Providing the Data Scientists and IoT engineers skills and competences, that are transferable and recognized among European countries according to European established frameworks and standards.
- Challenge 3: Contributing to the increased demand of industry sectors other than ICT sector (e.g. banking, energy, logistics) for high-qualified Data Scientists and IoT Engineers occupied with e-skills and competences that meet their expectations.
- Challenge 4: Making the trainings provided more relevant to the actual needs of labour market, by focusing on learning outcome-oriented programs that include strong work-based learning components and combine knowledge and skills with personal and sociocultural competences.

Education and Training 2020 (ET 2020) strategic framework (European Commission, 2018) is the main framework established by EC for the European cooperation in the fields of education and training. It is a forum for exchanges of best practices, mutual learning, gathering and dissemination of information and evidence of what works, as well as advice and support for policy reforms. SENDING contributes to achieving the objectives set by ET 2020 by the following means:

1. Eliminating skills deficits in the ICT workforce, and further development of skills, through the design, delivery and assessment of VET programs that include effective learner tracking systems and feedback loops and are more relevant to the ICT labour market.
2. Improving the quality and efficiency of vocational education and training, through the design of learning-outcome oriented VET curricula, as the trend is moving away from learning objectives set for teachers, to designing curricula based on learning outcomes, defined as a set of knowledge, skills and competences.

Furthermore, SENDING contributes to the Bruges Communiqué on enhanced European Cooperation in VET (European Commission, 2010) for the period 2011-2020 which reinforces the main VET development directions established within the Copenhagen Process. Its contributions lie in (a) delivering VET programs that include high quality courses which provide the right skills for specific jobs and give to learners more opportunities for transnational mobility and (b) increasing the cooperation between the major players responsible for ICT professionals' enhancement, namely employers, professional associations, VET providers, higher education institutes, research centres, and SMEs, across Europe.

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ICT skill gaps in the European context

The skills gap in the ICT sector and especially that of Data Scientists and IoT engineers is a European wide problem which can potentially affect the ICT sector and other sectors at which ICTs are widely used, together with the European economy growth, innovation, competitiveness and sustainability. Furthermore, enterprises and organizations need to know the core areas of expertise required for each role and maintain appropriate levels of competences; they must be able to recruit and train suitable and high qualified employees in a European and global competitive and continuously changing technological environment. Handling this problem in an efficiently and effectively manner at European level, ensuring the transferability, transparency and applicability of the proposed solutions, requires the transnational cooperation between all the relevant stakeholders: higher education institutes, VET providers, associations representing IT companies, associations representing IT scientists, enterprises and accreditation organizations.

The fact that the stakeholders and beneficiaries of the project originate from four EU countries (Greece, Bulgaria, Cyprus, Ireland) that are characterized by diverse socioeconomic characteristics, VET systems and institutional environments is intended to result in project outcomes of broader European relevance and applicability. Furthermore, the European cooperation among main stakeholders will enable the definition of a skills' certification mechanism according to European standards, thus increasing the recognition of qualifications at European and national level within a sector, facilitating cross-border certification and building mutual trust.

Furthermore, EU labour-market mobility is particularly important in the ICT sector (and other economy's sectors) both from enterprises' point of view within the sector and the countries that either have or are seeking to have a developed ICT sector. Significant numbers of jobs in the EU ICT sector are filled from outside the EU. In Ireland, for example, over 25% of foreign nationals employed in the information and communication sector in 2012, and 30% of those in professional, scientific and technical activities came from outside the EU. SENDING will contribute to the increased professionals' mobility in the economic sectors at which Data Science and Internet of Things have broad applications (e.g. ICT, banking, assurance, energy) due to its European approach and relevance.

Finally, as the main outcomes of the project will be implemented according to European standards and policies, (e.g. the common reference scheme of competences, skills, knowledge and proficiency levels for Data Scientists and IoT engineers, that will be designed taking into account the eCF and ESCO), they will benefit the whole European ICT sector and additionally the VET system.

The profound changes in technology in recent years have touched all aspects of human life. These of course are also related to profound changes in society in general and the structured world of work in particular. There is a general acceptance that traditional schooling, the

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"front-end loading" approach for preparation for the world of work, is no longer appropriate. This is so for a number of reasons including:

- Rapid changes in the world of work.
- The changing nature of goals for education and training.
- The realization that most people will have a number of occupations and job changes during the period of their working life.

Emphasis has altered form a concentration on instrumental conceptions of vocational education as a preparation for work during the years of formal schooling towards a concept of lifelong learning that is work related. The old dichotomies between general and vocational education, between liberal education and specific job training, are dying away. There is a growing realization that – as well as highly specific job-related technical skills, the demands of the workplace make it imperative that social and interpersonal knowledge, skills and competencies be incorporated in any program of learning both for and in the world of work.

Traditional companies often saw training as being all that was required – enough to learn to do the job. This stratified and minimalist approach fits badly with the realities of rapidly changing external environments where all employees have to work together in anticipating change and challenge.

In this context employees are no longer seen as merely selling their labour. They are also seen as producers who have the capacity and, some would say, obligation to learn. Many companies increasingly see on-job learning as essential to growth and enhanced competitiveness. This is because new skills are continually being acquired by staff. New ways of using old skills are also being learned. The learning organization produces employees who are: adaptable, flexible, innovative, pro-active, responsible and highly motivated through critical thinking.

Methodology

The main principles of the strategy adopted by the consortium to address the needs identified are:

1. Design of modular learning-outcome oriented curricula. This is critical in order to ensure that the knowledge, skills and competences provided to trainees are in line with the needs of labour market.
2. Participatory design with the involvement of companies in the development of curricula and training material. This is also a critical aspect to ensure that the vocational curricula and the training content meet the needs of labour market.
3. Developing a training framework that incorporates a strong work-based learning component. Work based learning will be a major component of vocational trainings to provide opportunities to apply knowledge in practical real-life workplace situations, and embedding transnational learning experience.

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4. Structuring the training framework in a modular format to ensure that it can be adapted with minimum effort to the training needs of interested companies after the end of the project.
5. Developing a training framework that includes effective learner tracking systems and feedback loops. This is critical in order to be able to track the progress of the trainees during the implementation of vocational trainings and after their completion and evaluate their impact.

Expected outcomes

The expected outcomes of the project are:

- A report of the desired learning outcomes of the vocational trainings in terms of knowledge, skills and competences for the occupational profiles of Data Scientists and Internet of Things engineers.
- A common reference scheme of competences, skills, knowledge, and proficiency levels of Data Scientists and IoT engineers.
- Two modular learning outcome oriented vocational curricula, one targeting Data Scientists and another targeting IoT engineers. Its curricula will include at least five educational modules. In the case of Data Science vocational trainings an indicative list of educational modules is the following: (a) Python for Data Science, (b) Statistics for Data Science, (c) Storing and retrieving data, (d) applied machine learning and (e) Data Visualization. In the case of Internet of Things vocational trainings an indicative list of educational modules is the following: (a) smart cities and homes, (b) wearables, (c) location tracking, (d) security and (e) communication technologies.
- Training material for the implementation of the two VET programs. This training material will cover 200 hours of on-line asynchronous training (100 hours of Data Science and 100 hours for Internet of Things) and 20 hours of face to face training (soft and transversal skills).
- A training methodology (online, face to face and work based learning) for the delivery of the VET programs to the learners.
- A methodology for the assessment of the learners during the delivery of the VET programs.
- A mechanism for the certification of the skills and competences provided to the beneficiaries.
- Three workshops organized at Greece, Cyprus and Bulgaria to promote project's activities and services to stakeholders and main target groups.
- Exploitation toolkits for higher education institutes, VET providers and companies.
- One final conference organized at Greece, to present to all stakeholders the main outcomes of the project, its sustainability plan, and how its outcomes can be further exploited by higher education institutes, VET providers and companies.

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Development of SENDING adaptive training concept

During the first year of the project, the main focus has been in reviewing existing research on e-skills, e-competences and qualifications required by Data Scientists and IoT engineers. Based on this an analysis has been carried out about the specific demands of learners, and the curriculum to meet these demands has been established. The next steps of the project focused on outlining the pedagogical concept for training and identifying technological enablers to implement the concept in practice.

Pedagogical design principles

It's become evident that most learners participating the training would be employed full time when taking the training. Secondly, there's a lot of variety and diversity in the skills background and competences of participants. These issues set some specific demands for how the training should be delivered, particularly with regard to efficiency and effectivity of the training. When outlining the concept for training, three key design principles were considered critical:

1. Competence-basis – the training should appreciate and value the existing competences of participants.
2. Adaptivity – there should be mechanisms that shape the training content based on individual need and existing competences. This
3. Continuous assessment – to keep track of learning progress and to ensure learners are motivated in each stage of the training, assessment against learners' competences should be continuous and results of assessment should be fed back to learners. Self-assessment is considered essential as well.

The SENDING training concept applies principles from competency-based learning, where the focus of learning is in concrete skills rather than abstract learning (Gervais, 2016). "Adaptive learning" (Ravindra, 2017) has gained popularity in corporate learning over the recent years. It refers to learning systems that adapt to learner-specific needs using automation and artificial intelligence (AI). Adaptation can make learning for workplace learners more targeted and can provide a better learning environment since learners perceive and process information in very different ways (Verdú et al., 2008).

In the context of SENDING training adaptation is made possible by using assessment before each learning module. The learning environment then recommends topics to be studied based on how the learner performed in the assessment. It is, however, yet to explore how much intelligence can be built into the system to make this process as precise, efficient and automated as possible.

To help understand the idea of SENDING training concept, a workflow chart was created defining the steps of course completion in the course platform (Figure 1.)

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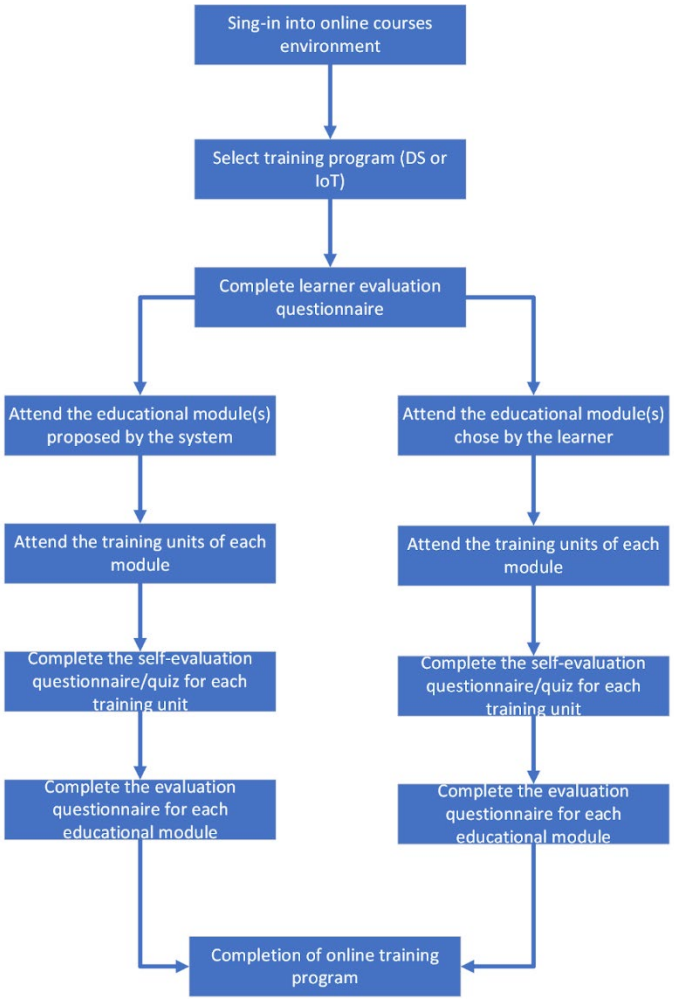

Figure 1. SENDING course completion workflow

Implementation and identification of technological enablers

Once the concept was outlined, it was time to look at the issue from the functional and technical perspective to understand what concrete mechanisms are needed to implement the concept in practice. This phase included expert interviews and a review of online sources covering most popular learning management systems and their applicability to demands identified by the project team. Using these sources an initial list of features was compiled including brief description of each feature in an easy-to-understand, practical manner. This list was shared with project partners and interest groups in the form of survey to allow them to assess the validity/applicability of each feature for the project purpose. A summary of survey results with total average weights assigned per each feature/functionality was compiled. The SENDING training concept will be implemented later in 2019 according to the concept definitions and the functional and technical specifications mentioned earlier.

Conclusions

The findings related to training concept development put strong emphasis on features that allow a flexible, modular and personalized learning experience for course participants. Noting the high volume of participants and plans to extend the training to larger audiences

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(particularly in companies) after the project much weight was put on user management, how easy and effortless it is and how course progress could be followed efficiently. Content development features are among the most valued features as well.

Thanks to the emergence of advanced learning data collection mechanisms and artificial intelligence (AI) there are new possibilities to develop online learning systems that enable more personalized and demand-driven provision of training. This will be highly important in workplace learning environments where time-efficiency and return on training investment are always considered critical.

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