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WP6 – Attracting people to ICT: innovative learning and teaching

DELIVERABLE 6.1 – Computer Science Education Consultations – Conclusions and Recommendations

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Table of Contents

1 Introduction to the deliverable and scope

The Grand Coalition for Digital Jobs has the ambition to cope with the negative effects on today digital economy and society, of the lack of skilled professionals for the ICT sector as well as the decreasing interest among youth for ICT studies and careers.

While mitigation actions, as e.g. training, re-training and mobility programmes, can be certainly successful in producing short and mid-term effects, longer term and structural changes are considered crucial to solve the problem at its roots. The Secretariat of the Grand Coalition has been therefore focusing on awareness raising actions aimed to change young people perception of the ICT sector, and worked towards the endorsement of structural changes in the Education sector aimed at equipping pupils with stronger digital competences.

On the latter, a stronger emphasis on computer science education, especially when integrated in the curriculum with innovative approaches, was regarded as a crucial element for both educating on digital competences and engaging youth to ICT studies and careers.

1.1 Description of the deliverable

This report was compiled as part of the activities of DIGITALJOBS Work Package 6: *Attracting people to ICT: innovative learning and teaching,* led by EUN. The main objective of WP6 was to boost the supply side for ICT jobs creation through more aligned educational schemes as well as structural changes inside educational systems. To achieve this goal, EUN has implemented the following actions:

- Organised regional and European roundtables linking education, training, industry and civil society representatives to identify and exchange best practice in teaching and learning about ICT in primary and secondary schools.
- Deployed teacher training, both online and face-to-face in order to encourage educators to take up innovative and best practices in teaching ICT and computer science, and to give young people a more comprehensive view of technology studies and careers.
- Identified relevant education materials and programmes, made available by the pledges of the Grand Coalition, and shared them with key education stakeholders.

This report builds its conclusions on these activities and on researches and consultations actions undertaken within the DIGITALJOBS project as well as other relevant programmes, which provided with broad understanding of the many approaches and initiatives, both at formal and non forma education, to teaching computer science in innovative ways across Europe.

In particular, since May 2014, three dedicated regional workshops have been organised, two questionnaire on computing in the curriculum have been distributed to Ministries of Education, ad hoc desk research has been carried out, high level policy consultations involving education policy makers and ICT sector major companies representatives have been integrated in major events, and finally a European closing workshop took place in Brussels on the 27th of January 2016.

Informed by the results of these consultations, special attention was dedicated by EUN to the integration of computing and coding into the formal curriculum as this has proven to be a practice with high potential to change the way the discipline is taught, moving from the use of ICT tools to the understanding of their functioning and their manipulation.

The ultimate aim of this report is not only to take stock of the situation of computer science education in the different countries, but also to consider and assess different approaches adopted by Ministries of Education and other stakeholders in order to foster teaching and learning of digital competences.

The intention is in fact to promote a variety of innovative initiatives and curricula reforms that may translate well in context other than the ones that have generated them.

1.1.1 Methodology

Given the diverse nature of the sources and stakeholders consulted, the approach used to prepare this report has followed different leads and approaches, including face-to-face roundtables, distribution of questionnaires and surveys, desk research and informal consultations. The process has also been constantly adapted in reason of the findings of the consultation iterations, leading to focus on specific aspects of computer science education as for instance computing and coding.

In order to gain a better understanding of the situation regarding computer science education across Europe, three regional face-to-face workshops were organised bringing together formal education, training providers, industry and other stakeholders' representatives. The roundtables were also expected to help identify and exchange best practice in teaching and learning ICT.

Ad hoc consultations have been carried out in 2014 and 2015 with the aim to investigate at country level how computer science, computing and coding are already, or plan to be, integrated in the formal education curriculum both at primary or at secondary school level. These questionnaires, addressed to all the Ministries of Education member of EUN served as a basis for the publication of two reports:

- 2014 - Computing our future: Computer programming and coding. Priorities, school curricula and initiatives across Europe
- 2015 - Computing our future: Computer programming and coding. Priorities, school curricula and initiatives across Europe

The results of the questionnaires provided not only a good insight on the integration of computing by the formal education sector, but also a better understanding of how initiatives undertaken by the civil society and the industry are supporting the spreading of digital competences and coding across all age groups.

Results from the policy workshops organised annually in conjunction with EMINENT - the Experts Meeting in Education Networking event organised by EUN - provided also useful information for the purpose of this report. During these sessions, experts in education, Ministries representatives and industry stakeholders, had the chance to discuss latest trends in education with a specific focus on digital competences and computing.

When necessary, desk research and bilateral consultations were also carried out with the aim of collecting more details on specific initiatives and programmes.

1.1.2 Definitions

Computer science as a discipline can be defined as the science that deals with the theory and methods of processing information in computers, the design of hardware and software and the use of computers.

In a narrower sense, it is generally intended as the study of **computing**, **programming** and **computation** in correspondence with computer systems. This field of study utilises theories on how computer works to design, test and analyse concepts.

Computer programming is the process of developing and implementing various sets of instructions to enable a computer to perform a certain task, solve problems, and provide human interactivity. These instructions (source codes which are written in a programming language) are considered computer programs and help the computer to operate smoothly.

In order to write a program to instruct a computer, tablet, smart phone or any other electronic device which can be programmed, each problem needs to be clearly thought through and broken down into something called *methods* (occasionally referred to as *functions*). A typical computer program will be constructed of lots of these methods, and each will contain commands and statements to perform the operations required.

Coding on a technical level is a type of computer programming that closely or exactly represents what happens at the lowest (machine) level. However, when most people talk about coding, they usually mean something at a higher, more human-readable level which could be anything in problem-oriented languages like Java, C++ or PHP.

Often **computer programming** (when referring to software) and **coding** are used interchangeably and refer to more or less the same activities of writing the instructions (recipe) for the computer to perform a specific task following a logic. However, based on the definitions above, coding can also be seen as **a specific subtask of software computer programming** which arranges the implementation of the algorithm in the target programming language.

2 Status at Regional and Country level

Among its objectives, the Secretariat of the Grand Coalition for Digital Jobs aims to boost the supply side for ICT jobs creation through more aligned educational schemes as well as structural changes inside education systems across Europe. In order to assess the actual situation at the national/regional level in relation to the teaching of computer science, the Secretariat planned to organise regional roundtables linking education, training, industry and wider stakeholders.

As part of the Secretariat activities in this context, at the beginning of the project EUN developed a concept document outlining the overall objectives and the format of these workshops. Additionally, a proposed draft agenda was prepared for the regional workshops. The agenda has been used as a basis for the organisation of the four workshops, although it has been largely adapted according to the specific needs and circumstances of each region.

Aiming to cover all countries in Europe, the regional meetings took place physically in one of the countries of the four clusters that were used to group similar or close countries, as shown in the following table.

Cluster	Member Countries
Mediterranean	Cyprus, Greece, Italy, Malta, Portugal, Spain
Eastern-Central	Austria, Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovakia, Slovenia
Nordic-Baltic	Denmark, Estonia, Finland, Latvia, Lithuania, Norway, Sweden
Western	Belgium, France, Germany, Ireland, Luxembourg, Netherlands, UK

Structure of the workshops: each event was led by an expert, and aimed to present relevant examples from the region, and discuss means of scaling up approaches to teaching and learning computer science and programming skills at both primary and lower secondary level.

Key topics: The discussions focused especially on innovative approaches to computer science teaching such as coding, robotics, online learning, non-formal learning, hackathons, games and mobile apps development.

In addition to the best practices and elements presented and collected during the face-to-face meetings, the next section compiles key data and information on the actual integration of computing in the different curricula across Europe. This data was collected through a structured questionnaire circulated annually to representatives of European Ministries of Education and focus specifically on the degree of integration of computing and coding into k12 formal education curricula across Europe.

2.1 The Mediterranean Region

The first regional workshop covering the Southern, “Mediterranean” Region was organised on 7 May 2014 in Greece and was hosted by the Microsoft Innovation Centre in Athens.

EUN and DIGITALEUROPE organised the regional Workshop on Computer Science Education in combination with the e-skills for Jobs 2014 Grand Event “Mobilising to Support Job Creation and Upskilling of the Workforce”. In this occasion, government and industry representatives, companies, teachers, Grand Coalition pledgers and other stakeholders presented and debated relevant examples, successful initiatives and best practices in teaching computer science and programming skills at primary and secondary level schools.

Here below some of the main initiatives presented during the roundtable are reported.

2.1.1 Ministries’ national plans and campaigns

Both in Portugal and in Greece, five-years national plan have been established in order to modernise education, introduce the use of ICT in the classroom and reinforce the introduction of computer science related skills and competences within the curriculum. These following case studies represent a good example of how national public authorities can intervene with a holistic approach to cope with the shortage of digital competences.

PORTUGAL

Vitor Figueiredo, Direção-Geral da Educação, Ministry of Education, Portugal, presented the situation in his country focusing on the national plan to digitalise and transform education.

ICT resources and educational technologies are managed through a multidisciplinary team of specialists from within the Ministry of Education. This is the ERTE – Resources and Educational Technologies Team. The general goals of ERTE are to:

- ➔ Propose ways of integrating effective use of ICT in curricula and teaching guidelines, at all levels of education and training
- ➔ Promotion research and disseminations studies on the education use of ICT in schools
- ➔ Design and development of new pedagogical approaches and teaching and learning resources

As part of this strategy, Private firms, schools and Ministries started to work together to establish the ecosystem for the teaching of ICT in schools. Efforts of a five-year plan are showing positive results.

Results

Employment in the ICT sector has been growing and number of graduates in ICT from public education has also increased. The five-year plan was framed under Digital agenda for Portugal and the Strategic Programme for entrepreneurship and innovation. These two initiatives are closely linked. A specific technological plan for education was launched in 2007 including the roll out of high speed broadband in 100% of lower and higher secondary schools. Specific ICT in curricula was added to lower secondary schools in 2014. This will include digital competences plus other skills including communication and learning languages. The new discipline of ICT will go beyond digital literacy to include for example the development of analytical skills.

GREECE

Pantelis Nikolaidis, Coordinator of the Women and Girls Go Digital Campaign, from the Ministry of Interior, introduced the five-year plan undertaken by the Ministry of Education in Greece, who is managing the ICT and education policy.

A five-year plan - The New School Digital school 2010-2015 - was created to increase ICT education in Greece. The long term goal was to set the basis for all classes to become digital and be empowered through the effective use of ICT in education by 2020.

The plan was articulated along four axis:

1. Provision of digital infrastructures and equipment: broadband internet connection, personal computers, tablets, interactive whiteboards, etc.

2. Promotion of digital educational content (e-books): books need to be available in digital format too; additional materials are made available, e.g. photos, animation, videos, games etc.; model teachings in video for all courses of examination as of 3rd grade of Lyceum (2 year of deployment); localised digital educational contents. New Curriculum for ICT: new curriculum for the 1st class of the Lyceum (probably there will be programming), with the ambitious objective of delivering better educational contents in les school hours.
3. Training of teachers on the use of ICT: in service training of 120 000 teachers (67% in total) in the educational utilization of ICT tools.
4. Use of ICT in Special Needs Education: improve the digital infrastructures of Educational Units (schools etc.).

In addition, horizontal support was offered, including the certification of knowledge in ICT (basic skills not computational thinking) in all students in 3rd grade.

2.1.2 Innovative teachers and educators

Disruptive changes can happen in the classroom under the lead of very innovative teachers. For instance, elements of computing can be effectively introduced already in primary education as a cross curricula approach to teach critical thinking and creativity in the lesson. This approach should not forget that collaboration and team work is a crucial aspect of the learning process for kids of any age.

Rui Lima, Teacher and Kodu Europe national ambassador, from Colégio Monte Flor, Portugal, introduced game development tools and other digital learning resources in his primary school classroom increasing the level of pupils' attention and dedication and being able to transmit notions and competences more quickly and effectively. His main observations are the following:

- ➔ Before introducing these elements in the lesson children were only consumers of digital tool (video games), now they are actively involved in digital creation processes.
- ➔ Teachers can have a facilitation role in the classroom and become learners themselves. Pupil's quote: "I can teach other students and my teachers how to code".
- ➔ Pupils are also creating teaching tutorials to transmit their knowledge to other pupils in the school. This contributes to bringing collaboration and peer learning beyond the classroom and age group of the learners.
- ➔ Students develop all kinds of games, have different approaches and while exchanging ideas and plans, develop team-work, communication, collaboration, creativity and social skills. They also can connect ICT with STEM more easily and understand the link between what they study and the reality they live in.
- ➔ Teachers' challenge: transform the classroom into an interactive environment. Pupils are encouraged to present when project based learning approaches are used in the classroom, as they are eager to share their projects results with their classmates.
- ➔ Teachers' challenge: the educators needs to introduce new tools, change the classroom format, use creativity and thinking out of the box, promote collaboration, and ultimately "be prepared to teach but also ready, and open, to learn".

Nikleia Eteokleous-Grigoriou, Ph.D, Lecturer in Educational Technology, Frederick University, Cyprus, is involved in teacher training and gave her perspective on the situation in her Country.

According to Ms Eteokleous-Grigoriou, whilst it is important in Cyprus to prepare the new generation to be ready for the job market, it is very hard to predict how professions in the future will look like and what skills will be necessary. For this reason, it is important to train people to be flexible and independent in their learning processes. Technology can play a crucial role in this process, but while in other public sectors, the digital innovation is being realised quickly, the education sector does not integrate new approaches and tools so quickly and effectively yet.

It is also to be considered that ICT is used by children in everyday life but not at school, and while there has been a change of the classroom structure, not all classes are equipped with technology. Quote from a student: "When going to school it's like being on airplane mode: switch off all technology".

- ➔ Challenges for Academia: it is crucial for both pre-service and in-service teachers to receive appropriate trainings and opportunities to understand the importance of using ICT in the classroom and to be ready to effectively use it together with innovative teaching approaches.

Kostas Doukas, Head Master of Doukas school, `School of the future`, Greece, shared his school experience in innovating the learning environment, infrastructures and practices.

Programming has been included in the Doukas school's curriculum since 1983. In 1995 the school started to be digitalised, with the integration of projectors and ultimately interactive whiteboards. Already in 1997, a one to one PC strategy was introduced.

The key challenge identified was to change the education model to ensure students remained motivated and did not drop out of school. 73,5% of students declared at the time that they felt obliged to study, while learning should instead be a pleasant and engaging experience, subjects should be taught creatively and the courses should be useful and adapted to today's job market.

To reach this ambitious objective, Doukas School has therefore:

- ➔ Tried to listen to students' needs, take into consideration parents views and share these with educators. Thus engaging the whole community around the school: teachers, families and pupils themselves.
- ➔ Focused on competences: values, knowledge and skills should be recognised, combined and blended in the lesson plans.
- ➔ Pursued personalised learning: matching of students' needs analysis and career management through goal settings.
- ➔ Used more extensively project based learning approaches. Moved from a teacher to a student and team centred approach through a collaborative environment.
- ➔ Integrated ICT teaching and learning into all courses.
- ➔ Raising educators' engagement by: involving them in the programme development, allowing them to co-author multimedia materials, organising experience-sharing opportunities, etc.

2.1.3 Role of industry

ICT is more and more interconnected with the educational process and is having already major impact on education in both formal and non-formal learning settings. Industry has played a major role in developing products and services that cater for the growth of ICT knowledge and skills across the full educational value chain starting at kindergarten up to University.

Danny Gooris, Senior Manager Oracle Academy EMEA, pointed out that the main challenge identified by the private sector, is that Europe is lagging behind in terms of number of computer programmers. While India trains 300,000 programmers a year and China 700,000, Europe educates only about 100,000 programmers.

To contribute mitigate this skills gap Oracle launched the Oracle Academy, which provides online training to help prepare students for life and work in our modern technology-driven global economy. There are different levels if uptake of the Oracle Academy courses across Europe, however the attendance from Southern European Countries citizens is increasing due to the fact that the training opportunities are now free of charges.

Fotis Draganidis, Education Lead, Microsoft Hellas, focused his intervention on the need to develop more strongly entrepreneurial competences and mind-sets among young people. This is why Microsoft is supporting youth to grow their start-ups. Since 2008 Microsoft organises programmes as the Imagine Cup, but offers also Bizpark, free software to start ups, incubator services, Start-up weekends and Startupbootcamp (an accelerator based in The Netherlands where Microsoft sends start-ups it finds for three months.

The Microsoft Innovation centres, disseminated across Europe, act as hubs for supporting start-ups and young entrepreneurs to develop business models and plans as well as to connect to "local heroes", creating a network of like-minded and complementary young entrepreneurs.

Presently the Microsoft Innovation centre in Athens is supporting 210+ start-ups. Some examples of such innovative business ideas are: *Care across*: online community to support cancer patients, *Kinect* games developers, *hexcraft*, *bugsens*, *ikiosk*, *itrack*, etc.

2.1.4 Main outcomes

The main conclusions and recommendations that emerged from this workshop can be summarised as follows:

- ➔ The use of ICT should be integrated into all courses by introducing new tools in the school and making sure the classroom set up is conducive to digital learning.
- ➔ ICT lessons should emphasise collaboration, team-work and problem solving. Subjects should cover: Information, knowledge, the safe use of the computer, software, devices and the internet, as well as critical analysis. Connect the learning process with the 'real world' is also fundamental.
- ➔ There is a need for more collaboration between Ministries of Education and initial teacher training institutes. This would provide opportunities to teachers during their training to: understand the importance of computer science education and technology enhanced learning , and to get trained on the effective use of technology.
- ➔ Parents tend to be conservative and protective towards their children education, and it is therefore important to involve families in the transformation reform, giving them all the relevant information and when possible ownership on the innovation process.
- ➔ It is important to raise educators' engagement in the reform process by: involving them in the programme development, allowing them to co-author multimedia materials, organising experience-sharing opportunities, etc.
- ➔ We can equip youngsters with the skills they would need into the ICT sector, but we should also prepare them for the unknown. As we cannot predict what skills will be needed in the future, we must focus on empowering youth giving them more independence, autonomy and the capacity to lead their long life learning process.
- ➔ We need to dedicated relevant efforts to support the establishment and development of the National Coalitions, as within those frameworks the private sector and civil society partners can more effectively contribute to the transformation process.

In the sections below, the results from the 2014 and 2015 consultations on the integration of computing and coding formal curriculum in the Mediterranean cluster are summarised per Country.

2.1.4.1 Cyprus

Cyprus **(Information extracted from the report *Computing our future*, 2014)**	
Curriculum location	As a specific subject In the general ICT/technology course
Rationale for integrating coding	Fostering logical thinking skills
	Fostering coding and programming skills
	Fostering problem-solving skills
	Fostering other key competences
Level of integration	National
Integration by level of education	Compulsory in: ✓ Lower secondary school level (general education) ✓ Upper secondary school level (general education) Offered in: ✓ Upper secondary school level (vocational education)

ICT skills priorities	✓ Developing students Digital Competence (including Media Literacy) ✓ Developing how to use ICT as a tool for learning ✓ Developing ICT user skills ✓ Developing how to use ICT for developing key competences ✓ Developing students computing programming skills including coding skills
Terminology used	Programming (emphasis on computational thinking/algorithmic thinking)

2.1.4.2 Greece

Greece **(Information extracted from the report *Computing our future*, 2014)**	
Curriculum location	As a specific subject In the general ICT/technology course
Rationale for integrating coding	Fostering logical thinking skills
	Fostering coding and programming skills
	Fostering problem-solving skills
	Fostering employability in the ICT sector
	Attracting more students in studying computer sciences as part of higher education programmes
Integration by level of education	Offered in Primary level, Upper secondary school level (general education), Upper secondary school level (vocational education). Compulsory in Lower secondary school level (general education) and in Upper secondary school level (general education).
ICT skills priorities	✓ Developing how to use ICT as a tool for learning ✓ Developing ICT user skills ✓ Developing students computing programming skills including coding skills
Terminology used	Programming

2.1.4.3 Italy

Italy **(Information extracted from the report *Computing our future*, 2014)**	
Curriculum location	In the general ICT/technology course In other subjects as cross curricular approach Depends on regional or school curricula
Rationale for integrating coding	Fostering logical thinking skills
	Fostering coding and programming skills
	Fostering problem-solving skills
	Fostering employability in the ICT sector

	Fostering other key competences
Level of integration	National and regional
Integration by level of education	Currently offered in: ✓ Primary level ✓ Lower secondary school level (general education) ✓ Upper secondary school level (vocational education)
ICT skills priorities	✓ Developing how to use ICT as a tool for learning ✓ Developing ICT user skills ✓ Developing how to use ICT for developing key competences ✓ Developing students computing programming skills including coding skills
Terminology used	n/a

2.1.4.4 Malta

Malta **(Information extracted from the report *Computing our future*, 2015)**	
Curriculum location	Integrated as a separate subject called Computer Science
Rationale for integrating coding	Attracting students into ICT
	Fostering coding skills
Level of integration	National (since 1997)
Integration by level of education	Offered in Upper Secondary (General)
ICT skills priorities	ICT user skills
Terminology used	Coding (general English term) Programming (commonly used for higher level syntax basic coding

2.1.4.5 Portugal

Portugal **(Information extracted from the report *Computing our future*, 2015)**	
Curriculum location	Depends on regional or school curricula
Rationale for integrating coding	Fostering logical thinking
	Fostering problem solving
	Fostering ICT Employability
	Fostering other key competences
Level of integration	National (Starting in 2012)
Integration by level of education	✓ Compulsory in Lower Secondary (General) ✓ Compulsory in Upper Secondary (Vocational)
ICT skills priorities	Digital Competence
	ICT as a tool for learning
	ICT to develop key competences
Terminology used	Computing Environment Exploitation (ENG)

2.1.4.6 Spain

Spain (Information extracted from the report *Computing our future*, 2015)	
Curriculum location	Depends on regional or school curricula In other subjects: Mathematics (depends on regional or school curricula)
Rationale for integrating coding	Fostering logical thinking
	Fostering problem solving
	Fostering coding skills
Level of integration	National Regional
Integration by level of education	Offered in: ✓ Primary level ✓ Lower Secondary (General) ✓ Upper Secondary (Vocational) ✓ Depends on regional or school curricula
ICT skills priorities	Digital Competence
	ICT as a tool for learning
	ICT to develop key competences
	ICT user skills
Terminology used	Programming, algorithmic and robotics (ENG)

2.2 The Nordic and Baltic Region

After the delivery of the first regional workshop in Greece in 2014, the second roundtable on innovative approaches to computer science, covering the Nordic-Baltic region (Denmark, Estonia, Finland, Latvia, Lithuania, Norway, Sweden) took place in Riga, Latvia. The workshop was organised as a collateral event to the eSkills for Jobs 2015 high-level conference on the 12th March 2015. Representatives from industry, Ministries of Education and teachers used the workshop as a platform for an exchange of best practices and a productive discussion on ways for upscaling initiatives on a regional level.

Here below some of the main initiatives presented during the roundtable are reported.

2.2.1 Cross-border development plans

Torben Aaberg, Head of Public Affairs, Baltic Development Forum (Denmark), gave an overview on the region. The Baltic Sea Region is in fact one of the global ICT hubs but how does the e-skills situation look like in the region? What are the key challenges and how are they addressed? How do employers and educators collaborate on demand and supply of e-skills? What can be done to bridge the gaps and bring stakeholders together?

	Denmark	Sweden	Finland	Estonia	Lithuania	Latvia	Germany	Poland	EU28
	score	score	score	score	score	score	score	score	score
DESI Human Capital Index	0.73	0.75	0.78	0.59	0.5	0.45	0.6	0.43	0.54
Internet Users individuals (aged 16-74)	92%	91%	90%	82%	69%	72%	82%	63%	75%
Basic Digital Skills individuals (aged 16-74)	76%	78%	79%	69%	59%	57%	69%	46%	59%
ICT Specialists employed individuals	4.1%	4.8%	4.7%	3.2%	1.7%	1.7%	3%	2%	2.8%
STEM Graduates Graduates in STEM per 1000 individuals (aged 20-29)	19	16	22	13	23	14	16	18	17

With the aim to answer these questions, the Baltic Development Forum together with Microsoft set up *Top of Digital Europe*, an independent, non-profit think tank that promotes the Baltic Sea Region as a leader in the ICT sector. The think tank main challenges are: identify key issues and solutions related to ICT as a growth driver and the digital economy, strengthen competitiveness through innovative cross-border actions, stimulate dynamic discussions on growth through ICT.

Among its programmes, Coding the Future has been identified as one of the keys for meeting future e-skill demands in the Nordic-Baltic ICT Hub, as teaching and learning how to programme can not only upskill young people but also make them more eager to pursue further studies and careers in the ICT sector.

According to Mr. Aaberg, computer science education need to take into account multiple elements though, including: the need to start at early ages (already at primary education), the need to develop 21st century competences together with technical skills and the need to give the right emphasis to cutting edge technology as e.g. cloud computing and app development.

2.2.2 Innovative teaching and learning

Edgars Bajaruns, teacher in Sigulda City Secondary School (Latvia), presented how he is integrating technology, programming, robotics, game design and multimedia design as cross curriculum learning activities.

Edgars teaches not only history, social studies and physics in Sigulda secondary school, but he also organises mechatronics study group and leads teacher education courses. The main duties of Edgars include lesson planning and teaching as well as organising and leading laboratory works in physics.

Edgars is working his fifth year in school and actively uses modern technologies in his work. Within the framework of the project "Gatavi Rītdienai!" (Ready for Tomorrow) he implemented the tablet class, developed study materials and a study course for teachers on introduction of and use of technologies in teaching. During lessons, Edgars' pupils create 3D models, projections, digital maps, infographics, video materials, etc.

Carl Myrland, is a teacher in Norway and an active member of the LKK Network, Lær Kidsa Koding! - LKK (Kids learn coding). LKK is a voluntary movement that works to ensure that children and young people are empowered to play an active and independent role in today digital society. LKK helps young people not only to be responsible users of technology but also creators of their own digital tools and materials.

The organisation aims to raise awareness in the public about the importance of ICT related skills and to help bridge the eSkills gap by encouraging more young people to take up ICT studies and careers.

An important part of LKK action is to ensure that all young people of school age have the opportunity to learn programming and become familiar with computer science as a subject, either in the classroom or in after school clubs and communities.

2.2.3 Industry support

Anita Zorgenfreija, field project manager for WW Education Industry, Microsoft Programming School leader, pointed out the important role ICT major companies have to play in transforming teaching and learning digital competences.

According to Ms. Zorgenfreija, it is in the interest of the companies, and their responsibility too, to enable everyone to become active and responsible digital citizens and not only digital consumers, empowering them to exploit technology potentials in their daily lives. As the education sector is not always capable to keep up with the technology transformation speed, industry can support the process and making the transition smoother and beneficial. Industry is also generally supportive of the integration of 21st century skills, i.e. communication, critical thinking, collaboration and creativity in the formal education sector, especially through project based learning and flipped classroom approaches.

To respond to the high demand for advanced digital skills education, Microsoft developed a new computer science curriculum which provides hands-on experience creating new software and applications, and develops the critical-thinking and computational skills for life and careers in the digital world. Microsoft has released this new computer science curriculum designed for young people who may not have expressed much interest in computer programming – and teachers who don't necessarily have any background in the field, either.

2.2.4 Main outcomes:

The main conclusions and recommendations that emerged from this workshop can be summarised as follows:

- ➔ As teachers are often not well disposed towards technology, it can be very beneficial to focus on grassroots and hands on initiatives and build on enthusiasm of those committed teachers.
- ➔ The new discipline of ICT goes beyond basic development of digital literacy and advances to the field of development of analytical skills of students through exploring appropriate computing environments.
- ➔ Computer science needs to be taught in innovative ways, starting possibly in primary education as young children are increasingly using internet (a variety of tools can be used to this end, as

e.g. *Scratch*, *Turtle point*, Windows *phone app studio*, robotics, *Lego Mindstorms*, *Bee-Bot*, etc.).

- ➔ It is important to promote the knowledge value chain. Successful models of collaborations between industry and education, along knowledge value chains, should be identified and benchmarked.
- ➔ Industry can play a crucial role in engaging pupils to the ICT sector, however some private companies find challenging to reach out to teachers and students and collaborate with education institutions.
- ➔ Tools, resources and initiative provided by industry for complementing, supporting computer science education, have proven to be highly engaging and successful. There should be a higher adoption of these in the classroom.
- ➔ It has been suggested that the Grand Coalition for Digital Jobs may make available a portal where all vendors offering ICT related education material could promote their solutions and training opportunities.

In the sections below, the results from the 2014 and 2015 consultations on the integration of computing and coding in the formal curriculum in the Nordic and Baltic region are summarised per Country.

2.2.4.1 Denmark

Denmark (Information extracted from the report *Computing our future*, 2015)	
Curriculum location	As a separate subject and in the general ICT/Technology course: depends on regional or school curricula. In other subjects as cross-curricular approach: Physics, Chemistry, Maths
Rationale for integrating coding	Fostering logical thinking
	Fostering problem-solving
	Fostering other key competences
Level of integration	National (since 2014)
Integration by level of education	**Offered in:** ✓ Upper secondary (general) ✓ Upper secondary (vocational) **Compulsory in:** ✓ Lower secondary (general)
ICT skills priorities	Digital Competence
	ICT as a tool for learning
	ICT user skills
	ICT to develop key competences
Terminology used	Programming (ENG) – Programmering (DK)

2.2.4.2 Estonia

Estonia (Information extracted from the report *Computing our future*, 2015)	
Curriculum location	As a separate subject and in the general ICT/Technology course: depends on regional or school curricula.

	In other subjects as cross-curricular approach: Maths, Technology, Informatics. Depends on regional or school curricula
Rationale for integrating coding	Fostering logical thinking
	Fostering problem-solving
	Attracting students into ICT
	Fostering other key competences
Level of integration	National and school level
Integration by level of education	**Offered in:** ✓ Primary ✓ Lower secondary (general) ✓ Lower secondary (vocational) ✓ Upper secondary (general) ✓ Upper secondary (vocational) ✓ Depends on regional or school curricula
ICT skills priorities	**Digital Competence**
	ICT as a tool for learning
	ICT user skills
	ICT to develop key competences
	Computing and coding skills
Terminology used	Programming (ENG) – programmeerimine (EST) Technology education (ENG) – tehnoloogiaharidus (EST) Technology literacy (ENG) – tehnoloogiline kirjaoskus (EST) Digital competence (ENG) – digipädevus (EST)

2.2.4.3 Finland

Finland (Information extracted from the report *Computing our future*, 2015)	
Curriculum location	Especially in Mathematics
Rationale for integrating coding	Fostering logical thinking
	Fostering problem-solving
	Fostering coding skills
Level of integration	National, regional and school level (since 2016)
Integration by level of education	Compulsory in: ✓ Primary ✓ Lower secondary (general)
ICT skills priorities	Digital Competence
	ICT as a tool for learning
	ICT to develop key competences
	Computing and coding skills
Terminology used	Programming (ENG) – Ohjelmointi (FI)

2.2.4.4 Latvia

No information was provided.

2.2.4.5 Lithuania

Lithuania (Information extracted from the report *Computing our future*, 2015)	
Curriculum location	**As a separate subject and in the general ICT/Technology course: depends on regional or school curricula.** **In other subjects as cross-curricular approach: Maths, Technology, Informatics. Depends on regional or school curricula**
Rationale for integrating coding	Fostering logical thinking
	Fostering coding skills
Level of integration	National and school level (since 1986)
Integration by level of education	Offered in: ✓ Lower secondary (general) ✓ Upper secondary (general)
ICT skills priorities	Digital Competence
	ICT as a tool for learning
	ICT user skills
	ICT to develop key competences
	Computing and coding skills
Terminology used	Programming Fundamentals, Programming (ENG) Programavimo pradmenys, Programavimas (LT)

2.2.4.6 Norway

Norway (Information extracted from the report *Computing our future*, 2014)	
Curriculum location	n/a
Rationale for integrating coding	n/a
Level of integration	n/a
Integration by level of education	n/a

ICT skills priorities	Developing students Digital Competence (including Media Literacy)
	Developing how to use ICT as a tool for learning
	Developing ICT user skills
	Developing how to use ICT to develop key competences
Terminology used	Programming Coding

2.2.4.7 Sweden

No information was provided.

2.3 The Central and Eastern Region

The third regional workshop was co-organised with DIGITALEUROPE and ECWT with the support of IVSZ, the Hungarian Association for the Digital Economy, in Kecskemét, Budapest (member of DIGITALEUROPE). The event took place in September 2015 as a collateral to the MENTA conference, organised by IVSZ that has kindly supported the workshop by providing content contributions and logistical support.

Representatives from industry, Ministries of Education and teachers discussed the main factors influencing the process of modernisation and digitalisation of the education sector and shared experiences on reforms aimed at introducing computing in the K12 formal education curriculum.

2.3.1 eSkills gap and the role of ICT in education

János Setényi, Expanzio Consulting Ltd., gave a comprehensive presentation of the study *E-skills gap and the impact of ICT-based educational projects.*

The research starts from the following assumption on the eSkills gap: the root causes of such gap lies on the structure and content of primary and secondary education. In fact, even expanding informatics on the tertiary level cannot help solve the problems and can even be counterproductive, increasing possibly drop-outs. The only way to solve the problem is to focus on primary and secondary education, including the vocational education and training system. But how?

According to Mr Setényi, ICT based education can potentially have a high impact on the issue as:

- ➔ it can contribute to an increased quality in teaching and learning;
- ➔ it strengthens the employability of students;
- ➔ it gives access to a broad variety of learning materials allowing also to development new user-generated teaching and learning contents;
- ➔ it leads to an increased focus on students' critical reflection with respect to the use of ICT in teaching and learning and in society in general;
- ➔ it can lead to the establishment of an online system of evaluation and data management (learning analytics) creating the possibility of evidence based policy-making interventions in education;
- ➔ it gives a major contribution to address digital divides;
- ➔ the use of new ICT-based instruments for cooperation and exchange of knowledge and experiences can be beneficial at all levels of educational.

However, Mr Setényi pointed out that when considering the introduction of ICT based teaching and learning we must consider that there is a non-linear and complex relationship between ICT and learning. In fact, the quality of use determines the positive impacts: good ICT infrastructure, skilled teachers, integration into the curriculum, quality of school leadership, clear definition of pedagogical goals.

Here below some of the main initiatives presented during the roundtable are reported.

2.3.2 Czech Education Strategy: developing computational thinking

The Czech Education Strategy was mentioned as an interesting case study during the debate, but since no representatives from the Ministry were attending the workshop, the below information has been collected via a bilateral consultation with government representatives.

Instead of referring to computer programming in the curriculum, the Czech Ministry of Education decided to refer, in its national Digital Education Strategy, to computational thinking on a general level, in line with the growing interest in the education sector for this concept.

Computational thinking can be defined as the ability to compare, to integrate, to find adequate strategies to problem solving and to validate them in practice. It is outlined as a new way of thinking that adopts computational methods to solve complex or vaguely defined problems; it can also heighten the ability to express one's thoughts and to record them in formal descriptions that serve as a universal means of communication (or to ultimately programme any machine).

Computational thinking is also about using essential universal terms that broaden contemporary technology conception: structures, algorithm, effectiveness, modelling, representation of information, information systems, and principles of operation of digital technology.

The integration and the development of computational thinking will help, according to the Ministry, to structure and formulate more valuable and upper-level educational objectives in the curriculum. This action aims not only to develop more IT professionals who can fill in the shortage on the labour market, but to shift from using specific forms of technology to the basic principles of computing itself, which synthesises different aspects of science, technology and mathematics.

The development of computational thinking empowers students to master different skills involved in determining the solution for a wide range of problems which is originated from the very nature of effective, i.e. usually automated, information processing. Computing should therefore develop into a fully-fledged subject in its own right, with deeper links to other subjects.

2.3.3 Poland curriculum: computer science and personalised learning

Another Country in the Region is taking big steps to reform the education curriculum for what concern computer science education, it is the case of Poland. Professor Maciej M. Syslo, member of the Council for Informatisation of Education at the Ministry of National Education, helped us understand how the reform is effecting the national curriculum.

The new computer science curriculum which is being adopted in Poland is modifying the IT traditional set of notions adding to it rigorous computer science itself, including programming and coding. It consolidates all the different elements related to ICT into a stand-alone and comprehensive subject called Informatics. Thus, according to the new curriculum, Informatics is a compulsory subject in primary schools (grades 1-6 grades), middle schools (grades 7-9), and high schools (grade 10). Likewise, Informatics is also an elective subject in high schools (grades 11-12) and high school students may graduate in Informatics, taking the final examination (Pl. matura) in the subject.[1]

The new curriculum's main objectives are the following:

- ➔ **Developing the ability to understand and classify problems** – algorithmic thinking, logical and abstract thinking and representation of information;
- ➔ **Making use of computers and other digital devices to programme and solve problems** - designing and programming algorithms; organising, searching and sharing information;
- ➔ **Using digital devices, and computer networks** – principles of functioning of computers, digital devices, and computer networks; carrying out calculations and executing programs;
- ➔ **Developing and fostering social competences** – communication and cooperation, more specifically in virtual environments; project-based learning; taking different roles in group projects;
- ➔ **Respecting law, digital security principles and regulations** – being respectful with the privacy of personal information, data security, intellectual property, netiquette and social norms, and in general with positive and negative impact of technology on culture, social life and security.

An innovative aspect of the new national curriculum is that it also allows teachers to include optional attainment targets to the subject syllabus, or to assign them to a specific group of students. These elective targets make possible for teachers to support personalised learning of talented students as well as students with a particular interest in specific areas of computer science and its applications (such as science, mathematics, arts).

The possibility to adapt the new curriculum to pupils needs and interests aims to encourage and motivate students to choose within a wide range of computer science related topics and areas in middle and high schools that may lead them towards a computer science specialisation in their professional career.

Summing up, the new curriculum identifies and empowers the value of computer science as the underlying academic discipline, and foresees students to use and to understand the basic concepts of

[1] Syslo, M. & Kwiatkowska, A.B. (2015): Introducing a New Computer Science Curriculum for All School Levels in Poland, presented at ISSEP 2015 in Ljubljana, published in LNinCS, Springer Verlag, 2015.

computer science, analysing and solving problems computationally and programming their solution. In spite of that, students are still expected to apply information technology, to be creatives and responsible users of technology in other school subjects, disciplines, and areas of computer applications.[2]

The Ministry of National Education has made it available for public discussion until end of October 2015 and is expected to formally adopt it in 2016.

2.3.4 Innovative tools for teaching and learning how to code

Namik Delilovic, teaching assistant at Graz University of Technology and Catrobat marketing responsible, presented a free tool developed to teach pupils how to code in a very easy and engaging way. This application is called Pocketcode and is a block-like programming language aimed for children and people with small or zero programming skills.

Pocket Code allows learners to create, edit, execute, share, and remix Catrobat programs in a visual programming environment and programming language. This software is inspired by the Scratch programming system developed by the Lifelong Kindergarten Group at the MIT Media Lab.

Catrobat (http://www.catrobat.org/ and http://developer.catrobat.org/) is an independent non-profit project creating free open source software (FOSS) under AGPL and CC-BY-SA licenses. The growing international Catrobat team is entirely composed of volunteers.

In addition to the tool promotion itself, Catrobat is also organising competitions and other awareness raising events with the result of building a community of likeminded educators as well as disseminating widely their solution to schools around Europe and beyond. Collaborations with Google and code.org have also contributed largely to the uptake of Pocketcode by a large audience of educators, young people and technology enthusiasts.

2.3.5 Main outcomes:

The main conclusions and recommendations that emerged from this workshop can be summarised as follows:

- ➔ ICT can (and should) have a disruptive impact on education. However, focusing only on equipment while designing a digital plan for a school can lead to: unused infrastructure, lack of crucial elements (training, content, network) to utilise existing infrastructure, fragmented and isolated developments, outdated technologies and missing interoperability. This situation can also have political consequences, discouraging further investments.
- ➔ To avoid the above mentioned situation, it is important to make an assessment of the already existing infrastructure, monitor typical and desired usage, analyse in detail what are the pedagogical needs of a school, give the necessary attention to the legal and financial framework to grant sustainability of the plan.
- ➔ To support change at a bigger scale, a national plan to bring about ICT based learning is necessary. Bottom up approach is beneficial but top down interventions are also essential to mainstreaming transformation in education. There is a need for program development at national policy level, where system wide decisions can be made.
- ➔ Curriculum for education to computer science related competences should undergo a paradigm shift towards coding, web design and mobile application. The most advance and complex elements (e.g. algorithms) should be integrated in already established subject as mathematics
- ➔ Learning materials: shortage of project practice and evaluation tools, shortage of appropriate software for youngsters Create a bank of project descriptions for teachers and students

In the sections below, the results from the 2014 and 2015 consultations on the integration of computing and coding in the formal curriculum in the Estern-central cluster are summarised per Country.

[2] More information can be found on the *Computing our future* report. Balanskat, A and Engelhardt, K. European Schoolnet (EUN Partnership AIBSL). 2015.

2.3.5.1 Austria

Austria **(Information extracted from the report *Computing our future*, 2015)**	
Curriculum location	Software development (as a separate subject) In the general ICT/Technology course In others subjects as cross-curricular approach
Rationale for integrating coding	Fostering logical thinking
	Fostering problem solving
	Attracting students into ICT
	Fostering coding skills
	Fostering ICT Employability
	Fostering other key competences
Level of integration	National
Integration by level of education	Offered in: ✓ Lower Secondary (General) ✓ Upper Secondary (General) ✓ Upper Secondary (Vocational) ✓ Depends on regional or school curricula
ICT skills priorities	Digital Competence
	ICT as a tool for learning
	ICT user sills
	ICT to develop key competences
	Computing and coding skills
Terminology used	Informationstechnologie (at Technical colleges)

2.3.5.2 Bulgaria

Bulgaria **(Information extracted from the report *Computing our future*, 2014)**	
Curriculum location	As a specific subject In the general ICT/Technology course
Rationale for integrating coding	Fostering logical thinking
	Fostering coding and programming skills
	Fostering problem-solving skills
	Attracting more students in studying computer science as part of higher education programmes.
Level of integration	National
Integration by level of education	Compulsory in: ✓ Upper Secondary school level (general education) Offered in: ✓ Upper Secondary school level (vocational education)
ICT skills priorities	Developing students Digital Competence (including Media Literacy)

	Developing ICT user sills
	Developing students computing programming skills including coding skills
Terminology used	Algorithmic problem solving and programming (in the subject informatics)

2.3.5.3 Czech Republic

Czech Republic **(Information extracted from the report *Computing our future*, 2015)**	
Curriculum location	As a separate subject: varies (e.g. Programming) Depends on regional or school curricula In the general ICT/Technology course: depends on regional or school curricula In other subjects as cross-curricular approach: depends on regional or school curricula
Rationale for integrating coding	Fostering logical thinking
	Fostering problem-solving skills
	Attracting students into ICT
	Fostering coding skills
	Fostering ICT employability
	Fostering other key competences
Level of integration	School level
Integration by level of education	Compulsory in: ✓ Upper Secondary (vocational) ✓ Offered: depends on regional or school curricula
ICT skills priorities	Digital Competence
	ICT as a tool for learning
	ICT to develop key competences
	Computing and coding skills
Terminology used	Computational thinking (ENG)

2.3.5.4 Hungary

Hungary **(Information extracted from the report *Computing our future*, 2015)**	
Curriculum location	As a separate subject: informatics In the general ICT/Technology course In other subjects as cross-curricular approach
Rationale for integrating coding	Fostering logical thinking
	Fostering problem-solving
Level of integration	National
Integration by level of education	Compulsory in: ✓ Upper Secondary (general)

	✓ Upper Secondary (vocational)
ICT skills priorities	Digital Competence
	ICT user skills
	ICT to develop key competences
Terminology used	In the Frame Curricula, subject ICT: Programming (ENG)-programozás (HU) In the National Core Curriculum: Algorithm design (ENG)-algoritmizálá (HU), data modelling (ENG)-adatmodellezés (HU)

2.3.5.5 Poland

Poland **(Information extracted from the report *Computing our future*, 2015)**	
Curriculum location	As a separate subject: informatics In the general ICT/Technology course
Rationale for integrating coding	Fostering logical thinking
	Fostering problem-solving
	Attracting students into ICT
	Fostering coding skills
	Fostering employability
	Fostering other key competences
Level of integration	National (since 1985)
Integration by level of education	Offered in: ✓ Lower secondary (general) ✓ Upper Secondary (general) ✓ Upper Secondary (vocational) ✓ Depends on regional or school curricula
ICT skills priorities	Digital Competence
	ICT as a tool for learning
	ICT user skills
	ICT to develop key competences
	Computing and coding skills
Terminology used	Programming (ENG)-programawanie (PL) (Computer) Programming (ENG)-programowanie komputerów (PL)

2.3.5.6 Romania

No information

2.3.5.7 Slovakia

Slovaquia **(Information extracted from the report *Computing our future*, 2015)**

Curriculum location	As a separate subject: programming/informatics (depends on regional or school curricula) In the general ICT/Technology course In other subjects as cross-curricular approach (vocational subjects)
Rationale for integrating coding	Fostering logical thinking
	Fostering problem-solving
Level of integration	National and school level (since 1990)
Integration by level of education	Compulsory in: ✓ Primary ✓ Lower secondary (general) ✓ Lower Secondary (vocational) ✓ Upper Secondary (general) ✓ Upper Secondary (vocational)
ICT skills priorities	Digital Competence
	ICT as a tool for learning
	ICT to develop key competences
Terminology used	Computer programming and coding (ENG) – počítačové programovanie a kódovanie (SK) Computer programming, object programming, coding, encryption, algorithmic thinking, algorithmic problem solving

2.4 The Western Region

The fourth regional workshop covering the Western region was initially foreseen to take place in the context of the Women in Computing conference in Brussels on the 9th and 10th of December 2015. However, due to potential overlapping with other initiatives organised within the eSkills for Jobs campaign on the same topic, the conference was postponed to April 2016, resulting on the impossibility to host the workshop in this occasion.

Therefore, after various unsuccessful attempts to find additional suitable occasions to host the fourth workshop, EUN decided to organise instead bilateral consultations with some key representatives to cover the policies and initiatives in the field of computer science education in the western European countries.

The most significant initiatives and case studies are briefly described in the section below.

2.4.1 The UK curriculum reform: Computer Science for every child

The Department for Education of the UK (England) provided in 2012 grant funding to Computing at School (CAS), a community of individuals committed to deliver high level computer science education to every child, to establish the Network of Teaching Excellence for Computer Science teachers.

This Network has built up relations between schools, universities and employers and CAS has harnessed pro bono support from organisations such as Microsoft and Google. The Network was funded in April 2013, and it aimed at building a network of 400 'Master Teachers' by March 2015. Instead of directly creating a large CPD programme, schools can commission these Master Teachers to provide training for their teachers.

BCS/CAS hope to expand the network even further in the future. Once fully established, the Network will be self-sustaining, as participating schools will charge for the services of their Master Teachers. The Network has made it possible for 260 Master teachers to be recruited, and over 7,000 teachers to receive training so far. In 2013, the Department for Education announced further funding for the CAS/BCS to run the Barefoot Computing programme. In order to help primary school teachers with little or no experience in teaching computing, CAS is creating resources to help them to deliver new curriculum. CAS is creating online resources to help primary school teachers with little or no experience in teaching computing to deliver the new curriculum.

These resources will prove that teachers can use their existing knowledge to teach computing, and how progression can be enhanced across other subjects such as literacy, maths and science by teaching computer science. The teachers will also be equipped with the basic computer science subject knowledge and confidence needed to begin teaching. To support this, 800 in-school workshops will be delivered by BCS to introduce primary schools to computing, showing them how to use the online resources and set up computing self-help groups.

Smaller projects that have managed to secure over £600,000 from partners including Microsoft, Arm, Google, Raspberry Pi and IBM amongst others are also receiving a further £500,000 by The Department for Education.

2.4.2 Learning computing in non-formal education settings

Learning and teaching computing can be a fun and engaging experience, especially if innovative techniques and interactive tools are used. For this reason, many coding clubs and spontaneous groups have been flourishing around Europe and beyond. The most advanced and widespread network of such informal learning hubs in Europe is certainly CoderDojo.

Coder Dojo is a concept ideated in 2011, when James Whelton organised the first after school computer club following requests from students in his school, eager to acquire skills in coding and software development. Later on, the entrepreneur Bill Liao expressed his wish to scale up the project, thus further developing the idea of after school computer classes. Since then, their project has gained popularity to a scale exceeding the geographical scope of Europe, reaching out to North America, Africa and Asia.

The CoderDojo Foundation was therefore established with the aim of mainstreaming the initiative. The Foundation is based in Dublin, Ireland, and it focuses on developing the wide community of Dojos and partners and on supporting the local clubs. It is an important factor for raising awareness about the initiative on a global scale.

The CoderDojo community is based on a wide network of Dojos: local, independent, volunteer-led programming clubs with no common curricula or study plans. This allows for a considerable flexibility as to use of study materials or skills covered by the training activities, which turns out in a wide variety of activities in the different clubs.

Despite the fact that there are no commonly agreed study plans, there are some activities and tools which have been recognised by many Dojos as useful and user friendly. Very often Dojos cover Scratch, an introduction to programming for young people and website development using HTML, CSS and PHP. Dojos also work with JavaScript, Python, Ruby and Node.js, work on game development, Minecraft mods and experiment with hardware and robotics such as Raspberry Pi, Arduino boards and Intel Galileos.

The CoderDojo movement also fosters the development of soft skills thanks to the communal features, where there is a focus on community, peer learning, youth mentoring and self- led learning. Setting a creative environment outside the formal educational system that contributes to teaching coding CoderDojo has proved to be a very successful initiative for young people, raising also their interest in the area of of ICT jobs. CoderDojo has established an open forum, called Kata - CoderDojo, where members from the community can share and exchange resources with each other.

The initiative encourages partnership and cooperation between different individuals and organisations, including private and public institutions.

2.4.3 France: Pasc@line, an industry led initiative

As in the other Regions explored so far, also in the Western one an important and sometime leading role in fostering computer science education is played by the Industry.

Pasc@line represents a wide network of companies working in or associated with the digital jobs sector. As a result, the activities promoted by the association are very closely linked to the employers' needs and requirements, thus contributing to enhancing the process of matching young people's skills to the jobs available in the market. This initiative allows young people to realise what it is expected from them, and which competences they are supposed to develop further.

The promotion and development of digital literacy among young people through concrete actions is one of the main aims of the association. One of the measures is a series of videos presenting different professions. Another important step occurred in 2012 is the introduction of ICT in high schools as an A-levels school subject in, with Pasc@line's support.

In addition to that, the association engages in actions aimed at establishing cooperation and long-lasting relationship between industry and educational and training institutions.

The strong network established through Pasc@line tries to build upon specific activities focused on awareness raising, career guidance, training and matching; as a consequence, it has produced recommendations for the enterprises and the digital sector training institutions, ensuring that ICT education and job matching are always close to the industry's needs.

Despite having being recognised as a strong network of industry stakeholders and educational institutions, the Pasc@line activities are only funded by the industry partners, so unfortunately they have not received any government budget allocations, and the cooperation with government institutions has been very limited. Nevertheless, this area could be further explored in order to achieve a successful policy dialogue which could enhance the scope and results of Pasc@line Association's work.

2.4.4 Main recommendations related to these initiatives:

Based on the bilateral discussions held by EUN with national representatives of the education sector and on the consultations carried out involving different stakeholders and including ICT industry players, some main recommendations were formulated together with specific references to the regional context.

- ➔ Computer science is a discipline and a school subject, not just a university level discipline. It is educationally important as well as economically relevant. Therefore, the necessary emphasis should be given to it within the K12 formal education curriculum.

- ICT as a subject is useful but dates quickly, computer science instead is about principles, ideas, techniques and theory. Computer science is about information and computation, algorithms, programs, computational processes => these are very beneficial in developing abstraction, modelling, design, computational thinking, programming.
- Every child should be educated in the foundations of digital technologies and principles of computing so that the can become informed citizens in a modern world. Furthermore, giving every child the opportunity to study computer science empower them to become part of the next wave of inventors and entrepreneurs.
- Curriculum reform is important, but innovative ICT teachers are in the vanguard on the movement for change. Furthermore, teachers' confidence is key to the successful implementation of any curriculum reform, especially when it entails the introduction of new elements and subjects as it is often the case for computing and coding. Empowering teachers providing them with extensive training and continuous support on the use of ICT and computer science innovative teaching practices is paramount.

In the sections below, the results from the 2014 and 2015 consultations on the integration of computing and coding in the formal curriculum in the Western region are summarised per Country.

2.4.4.1 Belgium

Belgium **(Information extracted from the report *Computing our future*, 2015)**	
Curriculum location (Belgium Flanders)	Not decided yet
Rationale for integrating coding (Belgium Flanders)	Attracting students into ICT
	Fostering employability
	Fostering other key competences
Level of integration (Belgium Flanders)	Regional
Integration by level of education (Belgium Flanders)	Offered in: ✓ Primary ✓ Lower secondary (general) ✓ Lower secondary (vocational)
ICT skills priorities (Belgium Flanders)	Digital Competence
	ICT as a tool for learning
	ICT to develop key competences
Terminology used (Belgium Flanders)	Computational thinking and programming (ENG) Computationeel denken en programmeren (Flanders)

2.4.4.2 France

France **(Information extracted from the report *Computing our future*, 2015)**	
Curriculum location	In the general ICT/Technology course In other subjects as cross-curricular approach (Mathematics, technology)
Rationale for integrating coding	Attracting students into ICT

	Fostering employability
	Fostering other key competences
Level of integration	National (since 2016)
Integration by level of education	Offered in: ✓ Primary Compulsory in: ✓ Lower Secondary (general) ✓ Upper Secondary (general)
ICT skills priorities	Digital Competence
	ICT as a tool for learning
	ICT user skills
	ICT to develop key competences
	Computing and coding skills
Terminology used	Coding (ENG)-Codage (FR)

2.4.4.3 Germany

No information

2.4.4.4 Ireland

Ireland **(Information extracted from the report *Computing our future*, 2015)**	
Curriculum location	As a separate subject (coding) In other subjects as cross-curricular approach (depends on regional or school curricula-e.g. Scratch in primary)
Rationale for integrating coding	Fostering logical thinking
	Fostering problem-solving
	Attracting students into ICT
	Fostering coding skills
	Fostering other key competences
Level of integration	National and school level (since 2014)
Integration by level of education	Offered in: ✓ Lower Secondary (general) ✓ Depends on regional or school curricula
ICT skills priorities	Digital Competence
	ICT as a tool for learning
	ICT to develop key competences
	Computing and coding skills
Terminology used	Coding (ENG)

2.4.4.5 Luxembourg

No information

2.4.4.6 Netherlands

Netherlands **(Information extracted from the report *Computing our future*, 2014)**	
Curriculum location	Not clear yet
Rationale for integrating coding	Other
Level of integration	School level
Integration by level of education	**Offered in:** ✓ Primary ✓ Lower secondary (general) ✓ Lower secondary (vocational) ✓ Upper secondary (general) ✓ Upper secondary (vocational)
ICT skills priorities	Developing Digital Competence
	Developing ICT as a tool for learning
Terminology used	✓ Media literacy: the skills and knowledge needed to use media and ICT in a successful way ✓ Digital literacy: being able to use a computer and the computer skills: the skills needed to use a computer programme ✓ Coding: building a computer program

2.4.4.7 UK (England)

United Kingdom **(Information extracted from the report *Computing our future*, 2015)**	
Curriculum location	As a separate subject: computing In the general ICT/Technology course and in other subjects as cross-curricular approach: depends on regional or school curricula
Rationale for integrating coding	Fostering logical thinking
	Fostering problem-solving
	Attracting students into ICT
	Fostering coding skills
	Fostering employability
Level of integration	National (since 2014)
Integration by level of education	Offered and compulsory in: ✓ Primary ✓ Lower secondary (general) ✓ Upper secondary (general)
ICT skills priorities	Digital Competence
	ICT user skills
	Computing and coding skills
Terminology used	**Not indicated**

3 Final Workshop on Computer Science Education

On the 27 January, 2016 a ***Final Workshop on Computer Science Education*** was organised at the Future Classroom Lab, in Brussels, bringing together representatives of key think tanks in the digital competences domain, as well as national and European policy makers.

During the event, the main findings and outputs of the above mentioned consultations and research works were presented, in order to achieve a deeper understanding of what reforms, solutions and initiatives are being adopted in Europe to improve and further disseminate Computer Science education at both primary and secondary school levels. The ultimate aim of the event was to discuss together with key stakeholders the findings collected so far and reflect on where to focus our actions in order to make sure our commitment reaches the best outcome and impact.

What is being done by the education sector to make computer science education more effective and widespread? How can we support and contribute to this process? What are the action priorities in making young people more proficient on computing skills? These and other key questions informed the discussion that took place on the day.

The starting point for the dialogue were the key findings extrapolated from previous consultations on computer science education, which can be summarised as follow:

The government perspective

- ➔ It is a priority to equip students with ICT skills & competences
- ➔ There is an interest to innovate and transform teaching practices
- ➔ There have been investments in ICT equipment for schools

However

- o There are several other priorities on the Ministries' agenda to be considered
- o There is a need for evidence based studies in order to justify and support curriculum reforms
- o Teachers need to be (re)trained to keep up with the change in curriculum / pedagogical approaches

The civil society perspective

- ➔ Civil society has been more and more active in the promotion of ICT skills and especially programming and coding skills
- ➔ Computer science education is considered a means to foster not only young people employability but also entrepreneurship and active digital citizenship

However

- o There is a lack of coordination among the initiatives and a high degree of overlapping / duplication at local, regional and European level
- o The majority of these initiatives are run by volunteers and there is a lack of sustainable funding
- o The attention for coding and computer science has raised exponentially in the last years giving a lot of traction to civil society initiatives, a decrease of the public opinion attention towards the topic may lead to a decline of the support such activities receive

The industry perspective

- ➔ Industry created a variety of highly innovative and engaging digital tools for educating to coding, programming, game and app design, and other digital skills
- ➔ The main motivating factor for industry is to contribute to the upskill of future ICT professionals and to an increase interest in ICT careers among youngster.

- ➔ Having a more digital savvy society could also boost economy and create new business opportunities, keeping European digital economy vibrant and thriving

However

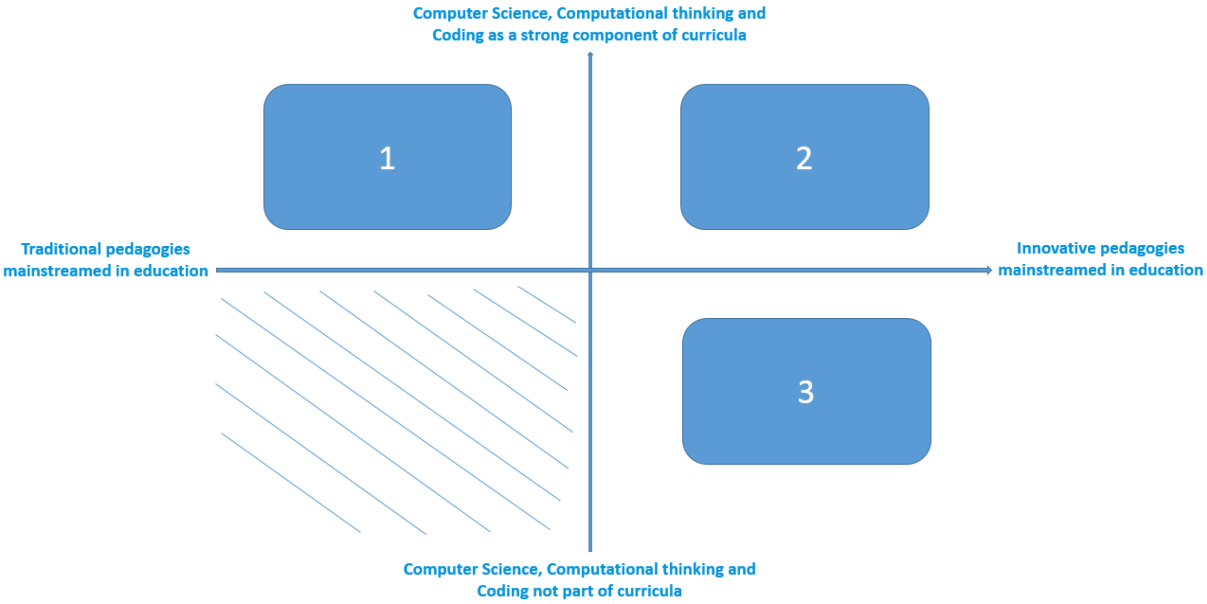
- Companies need clear recognition of their efforts and would like their investments to generate the desired impact on society. In order to get this recognition, companies often partner up with public authorities and civil society organisations
- It is sometime difficult to join forces with other companies which may be direct competitors, even if we can notice several programmes where natural competitors are working together to achieve a better impact with their initiatives

Given the key role that they can play in promoting computer science education, it was deemed necessary during the workshop to keep in consideration the different role played by these three actor categories and make sure the relations among them are fruitful and well structured.

During the final workshop a scenarios building exercise was carried out to try to forecast the challenges and opportunities that Europe might face in the future of education. Participants were asked to reflect on specific future scenarios that could take place in 2030. In order to do so, two macro variables were considered, namely:

- ➔ The integration of computer science, computational thinking and coding as a strong component of K12 curricula
- ➔ The innovation and transformation of pedagogies and teaching approaches in the school (process that need to be mainstreamed and formally recognised)

The macro variables were declined in their extremes. For the first variable, we assumed that Computer Science, computational thinking and coding would be a strong component of school curricula in 2030, while in its opposite declination Computer science, computational thinking and coding would not be part of curricula in 2030. For the second variable, the two opposite proposition would be that innovative pedagogies would be mainstreamed in formal education or that traditional pedagogies would be mainstreamed. The overlapping of the two macro variable created a matrix, as shown in the figure below. Out of the four scenarios generated with this matrix, we considered only three. We excluded the combination of traditional pedagogies and lack of reference to CS in curricula, as we believe that option to be the least likely to happen in the future and at the same time the least desirable.



The matrix gave therefore way to three scenarios that were discussed by participants:

1. In 2030, traditional pedagogies are mainstreamed in formal education and Computer Science, computational thinking and coding are a strong component of curricula;

2. In 2030, Innovative pedagogies are mainstreamed in formal education and Computer Science, computational thinking and coding are a strong component of curricula;
3. In 2030, Innovative pedagogies are mainstreamed in formal education and Computer Science, computational thinking and coding are not part of curricula.

Participants were asked to reflect on the impact of each scenario on the learners (their motivation, their employability perspectives, their possible decision to take up CS in higher education); on teachers (their readiness to teach or training needs, the type of support they need, the recruitment practices, the impact on their work and work/life balance); on society (possibilities for third parties to contribute to activities foreseen under this scenario, support that school need, role of industry). For each scenario and focus, positive and negative aspects were elicited.

The analysis and the comparison of the three scenarios confirmed that the scenario 2, where computer science is a strong component of curricula, and where teachers are using innovative pedagogies and teaching approaches in the school, is the most desirable. However interesting elements and concerns were raised during the discussion:

- In service teacher training is a critical element in this scenario as the majority of teachers need to be re-trained to effectively use new teaching approaches. This effort may be considerable for the government, teacher training institutions and teachers themselves.
- Initial training education would also play a crucial role in this reform process and university need to be fully on board to equip teachers with the necessary skills and competences. The provision of computer science specific knowledge need also to be carefully considered.
- The different paces in learning and the innovative approaches in teaching may allow talented students to excel, while leaving the others legging behind. Giving more independence to students in guiding their learning processes may lead to a widening gap between more and less talented pupils.
- Innovative approaches to education may lead to bridging the gap between formal and non-formal learning. For this to happen effectively though, pupils' families need to be involved in the process and allowed to take some ownership on their children education.
- The highly innovative learning environment children would be exposed to could generate a gap between their and their predecessors' generations possibly leading, at a very extreme end, to intergenerational social clash.

Nevertheless, the positive sides of such a scenario overcome considerably the critical points as participants describe them as follow:

➔ Teachers are more satisfied in their job and feel they are playing a more relevant role in their students' education and life.

➔ Teachers are empowered to make better use of technology in the classroom, they can also count on the support and cooperation of the students who have increased responsibility on the appropriate use of technology

➔ Students are more motivated and engaged in the lesson. They are possible achieving better results and are empowered to consider more study and career paths, having a broader set of skills and feeling less predisposed (or unfit) for specific subjects

➔ Students acquire more independence, autonomy and critical thinking, thus being empowered to take the lead not only of their learning process but also of their lives

➔ Society benefit from considerably higher standards of digital literacy and digital competence. The digital skills gap is also impacted, as more students would most likely pursue careers in the ICT sector.

➔ Society cohesion may benefit from the fact that families, parents, peers and friends are engaged in the children learning process, which is no longer confined within the school.

➔ In development countries may have the opportunity to uptake this approach and benefit from the increased social and economic competitiveness this may generate

- ➔ Collaboration between public and private sector as well as civil society may be improved by the fact that the integration of formal and non-formal education is widely encouraged

4 Conclusions & Recommendations

Digital competences and skills are one of the main conditions for the success of the digital transformation in Europe, its growth, and the wellbeing of citizens and society as stated in the Digital Single Market Strategy launched by Vice President Andrus Ansip on May 2015.

The **challenge for the Education sector** is to upskill the future workforce, but more importantly to empower young people with the competences to master and create their own digital technologies, and thrive in a digital society. Teaching and learning how to code, in formal and non-formal education settings, can play a significant role in this process.

Based on the consultations carried out within and beyond the DIGITALJOBS project, we can state that computer science education, and especially computing and coding, is currently high in the agenda not only of policy makers in the education sector, but also of industry key players, civil society organisations and training providers.

The rationale for integrating computing in school curricula is twofold: to equip all students with skills that are increasingly perceived as important in today's digital society, such as problem-solving and logical thinking skills, and to respond to the lack of IT-skilled labour force in Europe.

Referring specifically to the integration of computing in the formal education national curricula, we can highlight the following main findings and conclusions:

- ➔ Among policy makers, the **development of students' digital competence** as well as the **use of ICT as a tool for learning** is high on the agenda. Developing ICT user skills and using ICT for developing key competences is also highly regarded.
- ➔ A higher profile for **coding in the curriculum**. A number of countries already integrate coding in the curriculum at national, regional or local level: Austria, Bulgaria, the Czech Republic, Denmark, Estonia, France, Hungary, Ireland, Israel, Lithuania, Malta, Spain, Poland, Portugal, Slovakia and the UK (England). Finland and Belgium Flanders have plans to integrate it in the curriculum. Finland has defined coding in the core curricula for 2016.
- ➔ Integrating coding in the curriculum is seen as an effective way to **foster 21st century skills**. The majority of countries consulted aim to develop students' **logical thinking** skills and **problem-solving** skills, thus addressing 21st century skills. Attracting more students to computer science related studies and foster their employability is also considered a rationale.
- ➔ Computing and coding is **mainly integrated at secondary** level, **but also increasingly in primary education**. Coding is integrated or will be integrated by about half of the countries consulted at upper secondary school level in general education. In comparison with the data collected in 2014, more countries, namely Estonia, France, Israel, Spain, Slovakia, UK (England) integrate or will integrate (Belgium Flanders, Finland, Poland, Portugal) coding at primary level.
- ➔ In about one third of countries consulted **coding is already compulsory**, but at different levels of education. E.g. in Bulgaria, Czech Republic, Denmark, Portugal, Slovakia, Spain, UK it is compulsory for specific levels of education and mainly integrated as part of a computer course. In Denmark to know about simple programming is a compulsory part of the Physics, Chemistry and Maths curriculum.
- ➔ **Increasingly coding or computing is also integrated in other subjects**, mostly mathematics, in a cross-curricular approach, e.g. in Denmark, Estonia, Finland, Slovakia, Spain and France. Finland will be the first country to introduce coding in a purely cross-curricular approach.
- ➔ **Assessment of coding skills** is mostly part of students' general assessment. Most countries consulted (e.g. Austria, Bulgaria, Czech Republic, Denmark, France, Hungary, Ireland, Israel, Lithuania, Malta, Poland, Portugal, Slovakia and Spain) assess coding competences as part of the general assessment of students (during ICT-related exams or project work). If it is integrated as a cross-curricular approach, coding is assessed as part of the subject skills (Portugal, France or Finland in the future).
- ➔ There is a variety of **support for teachers (formal and informal)** provided mainly by universities, but also companies and non-profit organisations. In most countries, a variety of

bottom-up initiatives exists to support teachers and students, e.g. summer schools and programming courses, competitions and coding clubs.

- ➔ **Working with key stakeholders is the common scenario** (e.g. Austria, Belgium Flanders, Bulgaria, France, Estonia, Israel, Ireland, Lithuania, Poland, Portugal, Slovakia, Spain, UK have ongoing collaborations with a variety of key stakeholders in the field through mechanisms such as industry partnerships, sector organisations, teacher and subject associations, computer society clubs, IT/media literacy foundations, and through activities to raise awareness.
- ➔ Evaluation of coding initiatives is still rare among countries, which is reflected by a lack of evidence-based studies on these approaches. Only a **few countries are currently running pilot exercises** to assess whether the introduction of computing in the formal curriculum is actually achieving the expected impact.

Even though computer science will be high on the education sector agenda, and coding will remain most likely an important component of the subject, there are several questions that need to be tackled from a pedagogical perspective, i.e.:

- ➔ How to design effectively the learning processes and outcomes involving coding? Which concrete activities (and programming languages) are most appropriate for different students, according to their age, interests and capacities;
- ➔ What are the particular merits (and limits) of adopting a cross-curricular approach to teaching coding or computer science?
- ➔ How to refine assessment, in particular where computing is integrated in a cross-curricular approach in other subjects.

Some interesting developments are already taking place in this regard. For instance, the concept of computational thinking has recently gained importance when integrating coding into the curriculum. It describes a take on computer science education that puts computer science techniques in the forefront to enhance 21st skills like problem-solving and logical thinking skills that matter even beyond the digital world. This new focus also suggests a conscious shift in some countries away from a focus on students' ICT user skills in traditional ICT subjects, towards an approach as part of computer science subjects that focuses on teaching underlying computer and design principles and puts students in a role where they create their own programs.

Based on the findings above, it will be important to support teachers in the implementation of the new curriculum requirements and in providing students with the best approaches to learning computing, to consider new assessment approaches and to develop more awareness activities on the importance of coding in all schools in Europe, as well as promoting and scaling up any other initiative aiming at supporting coding activities in schools. The European Commission itself might review the support given to this important area by considering and/or strengthening actions such as:

- ➔ Promoting and scaling up initiatives from industry and NGOs and any other stakeholder active in teaching coding and supporting coding activities, thus promoting interconnections between public, private and civil society actors (e.g. CoderDojo);
- ➔ Supporting teachers and students in computing and coding based activities, as part of both formal and informal education. This could result in more training opportunities as well as in exchange frameworks where practices, resources and learning materials could be co-developed, validated and shared;
- ➔ Offering a dialogue platform on computer science education to policy makers (on the basis e.g. of the European Coding Initiative) and developing a major awareness programme on computing (on the basis e.g. of the Europe Code Week);
- ➔ Supporting the gathering of evidence in this area by monitoring and analysing research studies and evaluations in the field, encouraging pilot testing of educational approached and teaching and learning practices.
- ➔ Endorsing the integration of computer science in the school already from primary education level. Stressing at the same time the importance to consider the cross-curricular approach to coding as a powerful mean to both train and interest pupils in computer science and technology related topics and careers.

- ➔ Encouraging a European exchange between countries that already integrated or reformed computer science in the curriculum and those that still intend to do so. Discussions should not only address the question why coding is a useful skill but also provide answers to more specific questions on how computing should be thought.

All these proposed actions should ultimately aim to support the momentum gained by computing and coding in the last years, making sure that all the stakeholders involved in the process are equipped with the best resources, networks and contexts to operate a radical and long lasting change in the way young people are provided with computer science related competences. Thus introducing widely in the curriculum computer science as a subject that enable a person to become an active and responsible digital citizen and a creator of technology, rather than merely a user or consumer of digital software and devices.