ICT-INOV
MODERNIZING ICT EDUCATION FOR HARVESTING INNOVATION

D1.1 Analysis of current practices on fostering innovation in ICT education

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Executive summary

This report details the state of use of innovation techniques in information and communication technology (ICT) studies use of innovation in 7 different countries, 3 of which are in Asia while the rest are located within the European Union. The Asian countries are Vietnam, Nepal, Pakistan, and Malaysia. The European countries are Portugal, Greece, Italy, and Estonia. The analysis demonstrates that the importance of ICT education for the continued growth and economic prosperity is recognized in all countries in which review took pace, with every country taking steps to fund programs designed to improve ICT training.

The importance of integrating training programs with industrial practices and making sure that the skills learned are viable for future employees is also universally recognized, as is the usefulness of student-centred learning methodologies for building skills for the future. The importance of student-based learning, problem-based learning or other approaches that encourage student engagement is widely acknowledged, specific groups that focus at facilitating gamification in learning are established only in Portugal, Malaysia, and Italy. This highlights an area that could be leveraged to increase student engagement with ICT. The review showed that many governments have introduced state curricula which could best be described as aspirational. However, the deployment of the curricula inside the classroom may vary dramatically based on the teacher's preferences and the available resources.

An area of concern highlighted in several countries is the existence of a digital divide created between those who have access to computer technology and those who do not. Issues with internet connectivity and the lack of skills among teachers and populace in general are highlighted as concerns.

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The ICT–INOV project aims to address these two primary concerns, namely fostering innovation and bringing education to the digital age. This will be achieved by creating a digital environment which fosters the use of design thinking to encourage innovation. The environment will ensure that design thinking and gamification are integrated into the curriculum and can be observed clearly. It will address concerns about the digital divide by providing both hardware and training for the partner universities.

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1. Overview of the state of the art on innovation

The use of information communication technology has become ubiquitous. It has become essential to the modern running of industries all round the world. The ICT sector is inherently innovative. It is considered as one of the innovation sectors that drives economic growth. For every job that opens in innovation-related sectors another 5 open in other sectors of the economy. In addition, the rapid growth of technology and the evolution of network speeds has led to both a constantly increasing supply of ever more sophisticated software tools as well as demand as the public increasingly moves activity on the internet, including trade, communication with government agencies, banking, education, and more. This has led to an increased need to train skilled workers in the techniques needed. The traditional methods of teaching based on lecturing and teacher centred learning methodologies are insufficient to train people for addressing the modern complexities of ICT. A new methodology centred around student engagement and involvement in design practices will increase the ability of students to innovate when they enter the workforce.

This report is an example of a bright spot analysis, it looks at the ICT training practices in seven countries, 3 based in Asia and 4 based in Europe, to identify the best practices in ICT teaching. These best practices will then be adapted into the design of a service that aims to encourage innovation in ICT.

In summary, all the countries surveyed have governmental policies designed to encourage the teaching and learning of ICT. The policies differ in the time in which ICT education was started. However, in all of them there is recognition of its importance in tertiary and postgraduate education. All universities considered in surveyed countries offer at least 1 course dedicated to

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ICT training at the undergraduate level. Reviews in Vietnam, Malaysia, Pakistan, and Italy highlighted the importance and growth of the ICT market in these countries. They also brought focus on the fact that the programs designed to teach ICT were not producing enough skilled scientists to meet industry needs. This observation is particularly important as Asian countries are developing at a fast rate, which in some cases, such as Malaysia, exceeds 6% yearly. This high growth rate drives demand for ICT specialists in today's knowledge economy. In most countries curricula are directly or indirectly influenced by industry. Universities located in Asia focus on the training of professionals to meet industry needs. Malaysia for example has established an industrial advisory panel aimed to influence the design of courses in universities in relation to the needs of the world of work. In Nepal and Vietnam, the government has introduced public-private partnerships to ensure the quality of ICT education. Portugal has adopted cooperation efforts with local industries to ensure curricula quality whereas, in contrast. In contrast, in Greece there is less direct industry influence on curricula because of the time necessary to devise and certify courses once new learning needs are identified, which is partly overcome through the individual deployment of MOOCs by students for building specialized or emerging skills demanded by industry and not yet addressed by formal programs.

The need for innovative and engaging methodologies of teaching is identified in all 7 countries. In Asian countries these techniques are mostly mandated from government bodies in a top-down approach through governmental bodies. In contrast, most efforts towards student engagement in European countries is based on grassroots efforts of teachers to introduce the materials. It is worth noting that most universities use a combination of case studies, simulations, project-based work, and problem-based learning as the basis of their formal ICT educational curricula.

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In relation to design thinking, universities in Greece, Italy, and Estonia do deploy the method, even though still to a limited degree. Institutions in Pakistan, Nepal, and Vietnam do not use the method or use it very sparingly. The reviews have demonstrated a complete lack of related projects or initiatives. This highlights the importance of building the capacity of organizations towards deploying emerging designs for building student innovation skills.

The primary problem with formal curricula is that it is unclear whether emerging learning design is applied in the classroom or if it is largely theoretical with teachers not investing enough time for building foundational and skills, such as problem-solving. It is also unclear how many countries still rely on high stakes testing and summative assessment that does not accurately reflect the skills necessary to be successful in an industrial environment. In many cases the deployment of emerging learning methodologies is up to individual teachers. This results in sporadic adoption of student-centered learning.

Both Malaysia and Italy innovate through the introduction of teacherless schools for coding. In these schools the focus is on solving actual coding problems through project-based learning that helps prepare students for addressing real-world challenges.

In terms of the deployment of gamification, Malaysia has introduced a special task force on gamification which focuses on finalizing a guidebook for teachers. The task force requires universities to report the micro-credentials that are based on gamified learning every 2 years. This approach is an exception in Asian universities; in the other 3 countries, there is no evidence of direct support towards universities by government sources for deploying gamification elements. universities do not have any direct support towards gamification elements in learning. Portugal, Greece, Italy, and Estonia, in contrast, all listed several gimmicky projects and sources based on gamification used in ICT education. In particular, the review has highlighted 6 different

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projects in Portugal that focus on the deployment of games, interaction, and learning technologies research targeting postgraduate programs.

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2. Practices for fostering innovation in ICT higher education

This section presents an analysis of current practices on promoting innovation in ICT education in countries in which the ICT-INOV project has partners, namely Greece, Portugal, Estonia, Italy, Malaysia, Pakistan, Vietnam, and Nepal.

2.1 Greece

2.1.1 Organization of curricula in ICT education

The Greek educational system follows the International Standard Classification of Education (ISCED), which has 8 different educational levels. Higher education is structured according to the Bologna principles and targets students who have successfully completed secondary education or who have a legally equivalent qualification.
Level 6 involves Bachelor's programs or equivalent called Ptychio. Level 7 corresponds to Master's programs or equivalent and Level ISCED 8 to PhD programs or equivalent.

The emergence of university departments in informatics in Greece took place in 1980 with the establishment of the Department of Computer Engineering and Informatics of the Polytechnic School of the University of Patras and then, in 1984, with the Department of Computer Science of the Faculty of Sciences of the University of Crete. Subsequently, the popularity of ICT as a higher education major and a career choice, lead to the introduction of related departments were at all universities in Greece. The Greek Ministry of Education is emphasizing the support of departments that can lead to employment, including ICT departments such as Computer Science and Engineering. Most of these university departments also offer postgraduate programs leading to the acquisition of a Master's of Science or PhD degree.

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Different university departments in Greece on topics such as Computer Science, Informatics, Computer Engineering and more may offer similar curricula but be part of different faculties. The programs may also vary in duration. All the following exist: 4-year science programs, 4-year economics and 5-year polytechnics. Some have a more interdisciplinary character. For example, departments of Computer Engineering and Informatics focus on the intersection of Informatics and Electrical Engineering. Departments of Informatics and Telecommunications or Informatics and Telecommunications Engineering focus on the intersection of Informatics and Telecommunications. Some Economics departments, such as Applied Informatics, focus on Information Systems as well as the development and implementation of ICT products to meet business needs applying a more hybrid curriculum which combines ICT and Economics.

In the context of higher education programs in Greece, Information and Communications Technology (ICT) is a term that expands the concept of Information Technology (IT) and covers a wide range of disciplines that are constantly being expanded and specialized resulting in great diversity and fluidity among university departments addressing this field. Despite the significant differences observed in the name and organization of the various departments studies in Computer Science can be categorized in the areas of Computer Science, Computer Engineering, Telecommunications, and Information Systems.

According to Greek law, the graduates of Informatics university departments may engage in activities such as study, design, analysis, implementation, installation, supervision, operation, evaluation, implementation expertise, and certification in the scientific fields of computer hardware and software, information technology, communications systems and networks, telecommunications services and internet applications, graphics, signal processing, image processing, and speech processing systems and applications.

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Furthermore, graduates of 4 or 5-year study departments in Telecommunications Science and Technology and Informatics and Telecommunications may additionally work in the field of Telecommunication Systems and Networks. Informatics departments' graduates also have the opportunity to work professionally in scientific research in public or private institutions. They may teach in secondary or tertiary educational institutions. And they may work in the provision of computer services, computer networks, and technical support in the public and the private sector.

2.1.2 Learning methodologies used in ICT education

The digital era calls for the modernization of educational offerings through the integration of ICT in learning. Following is an analysis of learning methodologies that are used in ICT education in Greece.

A common approach is problem and project-based learning, which involves educational activities in which students are challenged to solve a problem or project, often open-ended and non-trivial, using knowledge from diverse subjects in the curriculum thus simulating how knowledge is used in the real world. The methodology is highly applicable in Engineering education, in which students develop problem-solving skills for addressing business and societal challenges. Problem- and project-based learning are deployed widely at all levels of their education, from the 1st to the final year of studies, in courses that range from mathematics to software engineering, programming, operating systems, energy, electronics, and more. Students engage in problem and project-based learning in mandatory projects that are required for course completion.

Furthermore, active learning is widely deployed. The method involves actively engaging students with course material through discussions, problem solving, case studies, role plays, and other methods. Active learning approaches place a greater degree of responsibility on the learner than

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passive approaches, such as lectures. However, instructor guidance is still crucial in the active learning classroom as the educator guides and facilitates learning. Active learning activities may range in length from a couple of minutes to whole class sessions or may span multiple class sessions.

Gamification is slowly emerging in higher education practices. The method involves the use of gaming elements in contexts other than entertainment. These include learning, training, crisis management, research, and more. Gamification elements may include rewards, recognition, a sense of mission, clear goals, a sense of affiliation, feedback, and more. In learning, well designed gamification may lead to the achievement of educational goals when gaming elements are integrated into practices in a manner that promotes the learning process.

Design thinking is one of the new methodologies for promoting innovation. The method is currently deployed to a very small degree despite its benefits for building innovative mindsets. Design thinking allows the introduction of solutions to complex problems and the more accurate address of user needs through a process that enables the identification of real, as opposed to perceived, needs. Design thinking involves a process of empathy for understanding the experiences and feeling of users when exposed to a particular solution, problem-statement definition using user input and designer perspective, brainstorming, and prototyping of potential solutions in a manner that allows their use by affected individuals and the generation of feedback.

2.1.3 Methods for aligning developed skills to industry needs

There is a lot of discussion on the alignment of skills developed in higher education with industry needs. Skills are aligned through the continuous evolution of curricula, in which new courses are added as technology evolves. Educational programs in Informatics, Information Technologies, and

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related fields integrate emerging trends, such as programming languages, network applications, and more. Furthermore, educational programs may shift focus when it becomes apparent that industry demands different competencies. For example, the Department of Computer Engineering, Telecommunications, and Networks of the University of Thessaly shifted focus to become a Department of Electrical and Computer Engineering a few years ago. The new focus of the department allowed the development of skills in a broader area of study helping meet industry needs and attracting a broader range of prospective students seeking a wider focus on their studies to become more competitive in the job market.

However, formal educational programs typically evolve slower than industry trends. The reason for this is the lengthy processes required for identifying a gap in industry needs, analysing existing curricula and identifying areas of improvement, designing new courses, and hiring qualified personnel. This process may take years and will always fall behind the rapid evolution of technology, especially ICT. One solution to this challenge is complementing formal curricula with informal courses or offerings delivered, for example, through MOOCs. MOOCs are typically shorter in duration and highly flexible, allowing organizers to develop them over a course of months instead of years. MOOCs can be deployed for addressing large groups of students. Perhaps more interestingly, they can be deployed for building specialized skills that industry needs not yet integrated into formal courses.

The combination of formal and informal educational offerings can lead to the development of skill sets that are closer to industry and societal needs through flexible learning design. Such offerings often integrate emerging learning methodologies, including problem-based and active learning, and exploit ICT for on-line delivery that meets the schedules of busy professionals and students alike.

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2.2 Portugal

2.2.1 Organization of curricula in ICT education

The Portuguese educational system follows the International Standard Classification of Education (ISCED) with 8 different educational levels. Regarding Higher Education, it is structured according to the Bologna principles and targets students who have successfully completed Secondary Education or who have a legally equivalent qualification. Level ISCED 6 corresponds to Bachelor's programs or equivalent called Licenciatura. Level ISCED 7 includes Master's programs or equivalent called Mestrados. Finally, Level ISCED 8 comprises PhD programs (or equivalent) called Doutoramentos. Moreover, the Portuguese educational system includes a range of Higher Professional Technical Courses (CTeSP), which are a different type of offer of higher education courses, generally with a duration of 4 academic semesters (120 ECTS). Its conclusion confers a Superior Professional Technician Diploma, with level 5 qualification in the National Qualifications Framework.

Almost all higher education institutions in Portugal offer ICT-related courses. The courses are divided into 3 different main categories. The 1st is related to the use of ICT in educational environments. The 2nd is associated with the use of ICT for communication purposes. The 3rd is focused on software development and programming. Examples of related programs are Bachelor's programs in Information Technology, Information Technology and Systems, Information Technology and Communication, Information Technology in Education and Training, post-graduation courses on Digital Educational Resources and ICT, specialization courses on Digital Technology and Education, and Master's in Pedagogical Use of ICT. The courses are either 2 or 3 years long.

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A comparison of the study plans of different educational programs in terms of the frequency of appearance of diverse subjects in the corresponding curricula showed that in most cases there is a requirement of attending an internship in the last semester of studies. At the same time, most educational programs require students to develop a project and consequently provide classes to help the participants develop their work and support their research.

Two areas appear more frequently in courses, namely programming and software and web development. The former is related to subjects regarding fundamental theories of programming, algorithms, object-oriented programming, data structures, database systems, Linux operating system, hardware fundamentals, computer architecture, operating systems, software engineering, programming languages, and computer-comprehensive technologies.

Web development courses address the following topics, namely production of interactive and informative on-line content, business and content for the web, communication on the web, introduction to web technologies, web development and technologies for apps, mobile applications, web marketing, and internet protocols. Commonly, subjects related to project management and business were also offered. They include management principles and methodologies, entrepreneurship, business intelligence, trade processes and document management, product development, and spreadsheets.

Courses focused on ICT in education address to subjects such as: academic management and teaching organizations, intergenerational education, on-line learning assessment, digital educational resources, virtual learning communities, innovative educational projects, communication and information technologies, and pedagogical integration. As expected, courses are also offered in mathematics applied to ICT and statistics.

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Courses in specialized knowledge are also offered. Examples include tools to support the decision-making process, SIG applications, geographic information systems, telematics, integration technologies, productivity tools, collaborative environment development, and acquisition and treatment of vectorial and static images.

Regarding subjects related to humanities and languages, 3 out of the 9 analyzed programs offers technical English. One institution offers Portuguese linguistics. At least 1 other course in the in the broader thematic area of languages is offered in almost every program, including organizational communication, techniques of oral and written communication, presentation creation, word processing and human-computer interaction.

In rare cases courses related to law are offered, such as communication and informatics law and fundamental communicational law, as well as cognitive psychology.

2.2.2 Learning methodologies used in ICT education

In today's constantly evolving world the rapid development of ICT contributes to the deepening of the phenomenon of globalization. This leads to new social and economic demands. It further leads to higher competitiveness in the job market. As a result, young professionals need to be better prepared with more practical skills to enter the work force.

To address emerging needs for advanced and specialized skills new methodologies need to be implemented in higher education for increasing the dissemination of knowledge, promoting students' motivation, and consequently better achieving higher performance and better educational results linked to learning goals.

In Portugal, new methodologies are gradually integrated into educational programs. Problem-based learning, for example, is a methodology that has a positive impact on students' motivation

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and performance. Students are exposed to diverse educational scenarios that empower them to brainstorm and to synthesize solutions, producing and accessing knowledge in their own way. The problem-based learning methodology develops knowledge going beyond conventional teaching-learning models. It is accompanied by less theoretical learning. It provides students with basic knowledge to research, understand, and critically interpret literature on a given subject. Problem-based learning involves an interdisciplinary view of knowledge, building professional and personal skills.

Problem-based learning helps introduce links between pedagogical and professional practices. The key concept of problem-based learning is the exposure of students to professional problems. Students are challenged to address scenarios inspired by real-life situations that underline the connection of the object of study and concrete professional issues.

Portuguese students entering Engineering higher education usually demonstrate common learning difficulties related to mathematics, particularly on topics such as calculations, related to adequate levels of required prerequisite knowledge, assimilation, manipulation, and authoring scientific articles on new concepts. New teaching and learning methods supported by technology complement classroom activities and can contribute to the alleviation of these difficulties, helping students not only to develop new knowledge and skills but also to apply them in practice.

Problem-solving activities aim to change students' traditional passive attitudes to learning into active. Project tasks can be translated into problems or research scenarios. They are increasingly applied in engineering courses. The implementation of project-based approaches, when well designed, integrates diverse knowledge in a multidisciplinary environment and promotes teamwork. Problem-based learning, sometimes integrated with project-based approaches,

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frequently deploys tasks such as mathematical modeling and physical process simulation, which can contribute to reinforcing mathematical learning especially in Engineering programs.

The use of problem-based learning in Engineering promotes the gradual acquisition of advanced knowledge since it allows understanding scientific and technological content, including knowledge on environmental and social issues, developing project management skills, building communication capacity and teamwork, self-assessment, and peer review.

Thus, the problem-based learning model is more efficient in building understanding on diverse learning concepts in Engineering than purely theoretical approaches.

2.2.3 Methods for aligning developed skills to industry needs

As a result of engaging in an environment that is constantly evolving, many companies and public services are faced with the need to invest more intensively in advanced digital technologies, such as mobile communications, cloud computing, analysis of large volumes of data and intelligent devices.

The information society is becoming a reality for European citizens and businesses faster than ever, transforming the European way of life and work. Information society's importance lies in creating even more new jobs, new opportunities, new products, and new services that lead to economic growth and competitiveness. On the other hand, due to its substantial growth, information society's influence is significant in modern economies and cannot be ignored when defining employment policy.

The skills developed in ICT courses are aligned to industry needs. This is particularly the case in advanced ICT courses in areas such as algorithms, object-oriented programming, data structures,

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database systems, operating systems, hardware fundaments, computer architecture, software engineering, programming languages and computer comprehensive technologies, production of interactive and informative on-line content, business content for the web, web-based communications, web technologies, web application development, mobile applications, web marketing, and internet protocols. ICT is more than ever becoming an essential skill in industry. Technical competences and facility in implementing daily digital tasks are highly valued in professionals.

A wide range of highly demanded competencies, beyond technical foundations, are developed through ICT curricula. They are valuable in the contemporary professional world. For instance, foreign language competences are developed through technical English courses, communication ability is developed through organizational communication, oral and written communication techniques, presentation preparation, and human-computer interaction. These competences further positively affect the ability of professionals to engage in teamwork, client support, and interactive activities.

On the other hand, there is a need in industry for information management, problem resolution, product innovation, planning, and organizational competences. These are developed through business and management subjects, such as management principles and methodologies, entrepreneurship, business intelligence, trade processes, document management, and product development.

In today's world that has faced the outcomes of a pandemic society values learning capacity and high literacy levels as fundamental competences necessary for addressing unpredictable situations and unexpected crises. ICT courses are to a certain degree aligned to these needs,

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which are further addressed through educational offerings that focus on the use of ICT in education, such as academic management and teaching process organization, intergenerational educational activities, on-line learning assessment, digital educational resources, virtual learning communities, innovative educational ICT projects, and pedagogical integration.

Portuguese researchers (Girão, n.d.) argue that one of the most effective ways for putting new ICT to work is through technology transfer, namely processes that convert scientific research outcomes into practical results. In this context, agreements between industry and universities have a fundamental role for fostering collaboration.

Finally, it is crucial to highlight the M-NEST-I and the M-NEST-RIS projects that intend to implement the operational conditions which allow universities and students, namely individual users, to explore, experiment, and qualify autonomously and intuitively to work with ICT in diverse innovation and production scenarios, particularly in technically demanding industrial sectors with high added value. Each university in Portugal has in place projects for supporting the training of students, teachers, researchers, and industrial technicians. Some universities further implement cooperation projects with local industries. For example, the University of Minho runs several partnership projects with Bosch® and other institutions. These partnerships apply guidelines developed by European project consortia, and specifically the Estratégia de Investigação e Inovação para a Especialização Inteligente - RIS3 (Research and Innovation Strategy for Intelligent Specialization) funded by the Horizon 2020 program and Portugal 2020 Programa Operacional Competitividade e Internacionalização" (COMPETE 2020)

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2.3 Estonia

Estonia is a relatively small country with a population of approximately 1.3 million. 2020 statistics showed that 31,561 individuals were employed in the ICT sector. This corresponds to approximately 2.5% of the population. The first computer, a Soviet-made Ural1, arrived in Estonia in 1959 and was installed in Tartu University. Four years later, the Computing Centre of Tartu University was built. It became a home for a brand new Ural4 computer. Programming and other Computer Science courses were taught mainly in the applied mathematics study program. The Institute of Cybernetics of the Academy of Science was established in Tallinn in 1960 (Kutser, 2010).

The birth of computing in Estonian secondary schools can be dated in 1965, when the old Ural1 was moved from Tartu University to Nõo Secondary School, a specialized boarding school for mathematically gifted pupils, located 16km from Tartu. In 1985, the plenum of the Soviet Union Communist Party announced computing (programming) as "the second literacy for Soviet citizens" and an ambitious school informatics program was launched (Afinogenov, 2013). The leading computer scientist of the Soviet Union, academician Ershov authored the first computing textbook for upper-secondary schools that was translated to many local languages in the Soviet republics. The mass production of locally designed school computers, branded as Juku, began in Estonia in 1988 (Kanger, 2016). About the same time, the computing centers of Institute of Cybernetics and Tartu University received the first Soviet-made supercomputers, but the race was lost and even before the collapse of Soviet Union in 1991, the computing education in Estonia turned towards Western paradigm, technologies, and educational models.

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2.3.1 Organization of curricula in ICT education

Education in Estonia follows the 0 – 8 level system recommended by OECD. Level 0 refers to early childhood education, Levels 1 and 2 to basic education, Levels 3 and 4 to high school education, Level 6 to university education, Level 7 to Master's and Level 8 to PhD. ICT education is a priority throughout the entire Estonian educational system. 50% of schools teach digital skills as an independent subject in level 2. Praxis, in addition the Proge Tiger program founded in 2012, brought coding and robotics into approximately 98% of kindergarten classrooms. This shows a desire of the Estonian government to encourage the development of ICT-skilled individuals. All universities offer ICT courses at the undergraduate, Master's, and PhD offerings equivalent to levels 6 to 8.

There are 6 public universities in Estonia. The 3 largest ones, namely University of Tartu, Tallinn University of Technology (TalTech) and Tallinn University, offer ICT study programs on Bachelor, Master and PhD levels. Tallinn University of Technology is the leading institution in the Computer Science domain with the largest number of students. A broad range of study programs are offered. For example, Tallinn University of Technology offers Bachelor's programs in Hardware Development and Programming, Informatics, IT Systems Administration, IT Systems Development, Cyber Security Engineering, and Business Information Technology. It further offers Master's level programs in Computer and Systems Engineering, e-Governance Technologies and Services, Communicative Electronics, Computer Science, Cyber Security, Business Information Technology, Software Engineering, Medical Technology and Physics, and Digital Health. Finally, it offers a PhD program in Information and Communication Technologies. The University of Tartu offers Bachelor's programs in Computer Technology, Informatics, and Software Engineering. It offers Master's programs in Computer Technology, Computer Technology and Robotics,

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Informatics, Teacher for Mathematics and Informatics, IT for Non-Informatics, Educational Technologies, and Data Science. It offers a PhD program in Computer Science. Tallinn University offers a Bachelor's program in Informatics. It offers Master's programs in Educational Technologies, IT Management, Human-Computer Interaction, Interaction Design, Digital Learning Games, and Teacher of Informatics. It offers a PhD program in Information Society Technologies. Many of these programs are delivered in Estonian, however there is also a good selection of programs in English. According to the Law of Higher Education, the study programs that are delivered in Estonian must be free of charge to all students. Universities are allowed to collect fees only in study programs delivered in English.

There is only one private university in Estonia, namely the Estonian Business School, which does not offer any study programs on ICT. The private applied higher education institution Mainor (Mainor, 2021) offers in Estonian and Russian 3-year applied higher education programs in Robotics Software Engineering and Web Technologies. It also offers Computer Game Design in English.

In total, the annual intake to all ICT study programs is close to 1,400 new students in the Bachelor's, Master's and PhD levels. Admission requirements to Bachelor's study programs are based on the final scores achieved in national exams in the mother tongue, foreign language, and mathematics. Each university defines their own threshold for the mathematics exam score, which is the most important admission requirement. Some universities, such as Tallinn University, further organize an admission test of their own. Usually, approximately 50 - 70% of candidates are admitted to Bachelor's study programs in ICT.

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Only less than 1,000 complete their studies. A study conducted by CENTAR showed that the main problem is the dropout of ICT students in the 3rd and final year of studies. The majority of dropouts have collected most of the needed credits, except the final thesis, as they have switched to full-time jobs after internships (Centar, 2015).

The ICT forecast report estimated the need for increasing the 50% output of tertiary ICT study programs (OSKA, 2016). As the universities struggle with reduced annual funding, the numbers of ICT students per faculty member have been increasing every year. This forced Tallinn University to reduce the intake of ICT BA students in 2022 by 50%, instead of increasing.

Scholarships are offered to international and domestic students in all 3 of the big universities listed above. Scholarships are awarded for both degree and short courses. Degree scholarships are awarded for fields including ICT and are available at all levels. In addition, 2 short courses eligible for scholarship are in the area of ICT at Tallinn University and cybersecurity Tallinn University of Technology. The offering of scholarships is a common method for attracting skilled students.

2.3.2 Learning methodologies used in ICT education

While there have been some efforts to include different teaching methodologies, such as project-based learning, problem-based learning, flipped classroom and gamification, the most common methodology in Bachelor's studies remains the traditional classroom. In this model it is common for the focus to be on the transmission of information from the instructor to the student via lectures. In many cases this has been combined with the use of high stakes testing and a very hierarchical educational format. For higher levels of study Master's programs have transitioned

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to a blended learning model. In person learning takes place on Fridays, Saturdays, and Sundays, while the rest of time is dedicated to asynchronous on-line learning activities. PhD students are hired as junior researchers and are supposed to stay full-time on-campus, contributing to research projects and teaching.

Fully on-line educational programs in ICT have been introduced in Estonia over the last 10 years. Tartu University delivers only online the Educational Technology Master's program, while Tallinn University has a joint online Interaction Design Master's program in collaboration with Cyprus University of Technology.

2.3.3 Methods for aligning developed skills to industry needs

The ICT industry has been growing in Estonia more than doubling in the past ten years from 15,855 in 2010 to 31,561 in 2020, generating annual exports of 1.5b Euros. During the last decade, 2010 to 2020, the ICT sector has been the main driver of economic growth in the country attributing 30% of added value growth on all sectors. Estonia is a startup nation, as the number of annually founded ICT-startups per 100,000 population is the highest in the world (Startup Estonia, 2021). Estonia has given birth to seven 'unicorns' in the ICT sector, namely companies with net worth over 1b Euros, such as Skype®, Playtech®, Bolt®, Wise®, Pipedrive®, Zego®, and ID.me®. This makes Estonia a country with the largest number of unicorns in Europe. Estonia is ranked first in Europe on the Digital Public Services indicator of the Digital Economy and Society Index DESI.

Estonian universities collaborate closely with industry in this dynamic start-up digital technologies environment. This academia and industry collaboration fosters research and development, facilitates sharing of know-how and ideas between the 2 sectors, helps develop educational

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offerings that are in-line with industry needs, and ensures that young talent engages in highly creative processes that drive growth.

2.4 Italy

2.4.1 Organization of curricula in ICT education

For years, Italy has shown a significant growth differential over the major world economies accompanied by a progressive decrease in competitiveness, more losses of world market shares, and a lower attractiveness of foreign investments. Whereas the widespread introduction of information and communication technologies (ICT) positively impacted the regional economy, manifesting in 50% of the increase in labor productivity in Europe between 1995 and 2000, in the same period, Italy invested in ICT much less as compared to the European average (65%) and that of the US (40%).

The effectiveness of ICT as a development engine for country growth and competitiveness depends on the context in which digital technology is used, such as skills development, organization, law framework or infrastructure.

Italy was one of the first European countries to have addressed the accessibility of new technologies by weaker groups, particularly disadvantaged or disabled individuals. This objective was implemented following the strategy for Europe's transformation into the world's most dynamic and competitive economy by 2010 established by the European Council meeting in Lisbon in March 2000.

As part of the more general objective of digitalization of public administration, the Ministry of Education, University, Research (MIUR) and the Ministry for Public Administration (PA) and Innovation signed a Memorandum of Understanding on 30 October 2008 for the implementation

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of digital innovation planning in both schools and universities. The memorandum focused on 5 areas including networked schools with access to the internet, the development of digital content for teaching, the adoption of innovative teaching methods, the strengthening of school and family ties via the web for simplifying relationships, the development of a national school register and the implementation of on-line services and WiFi for universities in the context of the Digital University initiative.

The digitalization process in higher education is still ongoing. In education, the first reform was implemented with the Law of 13 July 2015, n.107, aiming to renovate the school system's national education and training practices. This reform is known as The Good School (La Buona Scuola).

This reform's most important tool is the National Digital School Plan (PNSD), launched by the MIUR at the end of 2015. It is a multi-year program providing and organizing resources from different funds, European and other, as allocated by Law 107/2015.

This plan is divided into 35 Actions grouped into 5 fundamental areas: tools, skills, content, training and support. The implemented measures concerned both school administrative and infrastructural aspects, such as internet accessibility in schools, the development of digital teaching environments and staff training. As a result, new school roles have been identified, such as Digital Animator, who is in charge of promoting and organizing learning activities for the development of student digital skills.

Using the funds available in the context of La Buona Scuola, Italian school innovation has been promoted through several initiatives and actions that helped purchase equipment, implement internet access points, digital learning environments, platforms and digital administration services, and promote research on teaching methodologies.

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However, the situation of Italian higher education is quite different. There is no equivalent planning document for the digitalization of the higher education system. This lack of common intervention at the national level has resulted in an ongoing process driven mostly by individual initiatives from specific universities.

A first milestone was achieved in 2018 by a working group that involved 250 experts from 140 private and public universities, research centers, and public bodies belonging to the CRUI-MIUR, and specifically the Conference of the Rectors of the Italian Universities of the Ministry of Education, University, and Research. The group developed a document outlining the primary objectives of the future National Plan for the Digital University. The work was carried out through the organization of a round table on 8 thematic areas aimed at placing digital technologies at the center of higher education for lifelong learning as an essential tool for individual and country growth in a rapidly evolving technological and business environment. The result was a manifesto representing a starting point for profound change in Italian higher education. The manifesto constitutes the National Plan for the Digital University by setting clear and achievable objectives, such as innovation in teaching, greater inclusiveness in degree paths to bridge the related gap in Europe, enhanced flexibility, and addressing labor market needs.

2.4.2 Learning methodologies used in ICT education

The contemporary learner in Italian universities expects to be exposed to a set of learning tools suitable for a specific use, constituting their personal learning environment, promoting personalized educational offers. Technology can be used to enrich student experiences by combining traditional methods, including lectures supported by digital tools such as computers, video projectors, cameras, interactive whiteboards, and more as well as by integrating other

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digital instruments such as cloud computing and virtualization ensuring a more integrated and functional approach that fosters the relationship between teachers and learners.

Italian universities have transitioned from using video lessons delivered in synchronous and asynchronous mode to social learning, delivered through forums, chats, instant messaging systems, and apps for slide and file-sharing.

Digital technologies widely used in higher education teaching and learning processes include learning management systems (LMS), MOOCs, learning analytics, e-learning, open badge, personal learning through artificial intelligence (AI), and cognitive computing.

Learning management systems are specific technological platforms for distributing on-line courses, managing student registrations and tracking student activities, often usable via cloud computing. Some well-known tools used in higher education in Italy include Moodle®, Docebo®, Sap Litmos®, TalentLsm®, LearnUpon®, Mindflash®, eFront®, and TopHat®. Learning management systems have emerged as strategic tools during the Covid-19 emergency. For example, Università di Bergamo has moved lessons into synchronous on-line mode using the MSTeams® platform, accessible via the web and a mobile app. Università di Teramo has moved its training offers into e-learning modality through UniTE Mobile®, a platform developed by the university. The application may be deployed on smartphones and tablets, which allow anywhere and anytime access to educational content, interaction between students and teachers, career monitoring, and attendance control.

MOOCs drive innovative organizational models supporting digital learning in Italian universities. Examples of very successful MOOCs include modules on quantum mechanics and cultural heritage offered by Università degli Studi La Sapienza; managing fashion and luxury companies, financing and investing in infrastructures, international organizational behavior, and leadership delivery by

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Università Bocconi di Milano; human rights on global and local protection and addressing bullying offered by the University di Padova; engineering, communications, law, psychology, economics, literature, and others offered by the distance learning institution Uninettunoistance.

Finally, the interest in MOOCs as learning tools is underscored by a MUIR Talent Italy call to create MOOCs with established quality criteria through crowdsourcing, offering prizes for the best 4 MOOCs.

Learning analytics provides opportunities for learning personalization. Università di Parma carried out a 3-year pilot project in computer science. A study focused on establishing the usefulness of learning analytics to inform strategic choices regarding the enhancement of guidance actions for students, the possible redesign of study plans, the planning and preparation of courses, and the design of teacher training seminars from actual student activity data contextualized by thematic area of study. Another example of using learning analytics is during the start-up and monitoring phases of the Master's in Leadership and Management in Education of Roma Tre University. Data collected through qualitative and quantitative tools allowed the design of individualized interventions. The resulting training activities included both content reviews and knowledge assessment tests. The trainees had the opportunity to verify the adequacy of their knowledge through self-assessment activities that provided feedback. Learning analytics was further strategically used in the monitoring and assessment phases of the program. It allowed customization of the course curriculum and learning environment to meet individual learner needs and learning styles.

Open Badges are digital certificates composed of a graphic part and a part containing meta-data, which indicate the acquired competencies, the method used to assess them, the institution that issued the certificate and the identity of the person that obtained it. This innovative system was

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developed by Cineca®, one of the largest computing centers in Italy in collaboration with a consortium of universities. The Cineca Education department launched the Bestr® platform in July 2015, which delivers Open Badges. The primary users of Bestr® are the universities, such as Università Bicocca di Milano, the first Italian university to test the Open Badges system with specific content, the State University of Turin, that provides badges certifying specific skills, and in particular digital competencies, the University of Macerata, that develops and certifies continuing learning for teachers with education degrees, and the University of Genoa, that used the system to certify participation in international conferences.

Artificial intelligence (AI) and cognitive computing provide innovative methods for further enriching student experiences. An example of the deployment of artificial intelligence and data analytics is a 3-year agreement signed between the Conference of Rectors of Italian Universities (CRUI) and IBM® to enable universities to create new cognitive applications for educational, analytical, and research purposes. To support this process, artificial intelligence and data analytics are made available through the IBM® public cloud for developing research projects and creating prototypes and solutions that support researchers and teachers. This allows students to interact digitally with their university and reach peers in a direct and personalized way. Furthermore, the collaboration between CRUI and IBM supports Italian universities in designing and developing training courses on artificial intelligence and data analytics to align professional careers to labor market needs.

2.4.3 Methods for aligning developed skills to industry needs

The higher education sector offered 320-degree programs (CdS) involving 10,260 courses in academic year 2018 - 2019. However, despite national initiatives, such as the collaboration

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between CRUI® and IBM® and the setting of the Bestr® platform that aim at gap between higher education curricula and labor market needs, and the continuous growth of the number of students enrolled in related programs, the gap between graduates' skills and market needs is very high. Training courses that integrate ICT skills and sector skills are almost absent. Based on the estimates of the Digital Skills Observatory for year 2019 there is a shortage of approximately 15,000 graduates in the ICT sector. Furthermore, the need to encourage and support women who decide to undertake their training in the engineering and ICT industries is crucial for ensuring the Italian social system's harmonious and participatory development.

Some institutional initiatives seeking to create training courses that integrate ICT with sector skills exist. For the business-economics sector, some ICT departments have created study programs (CdS) in which ICT and business-economic culture are integrated in the same learning path. Furthermore, 3-year degree courses in the business-economics sector with strong ICT and AI links have recently been announced or are being launched.

In recent years, numerous training initiatives have been developed at universities alongside traditional curricula aiming at strengthening academia – industry collaboration. These initiatives, often grouped under the label of Academy, are designed as learning organizations in which both students and teachers are encouraged to create real communities of practice capable of enhancing skills and attitudes by transforming them into resources for cultural growth.

The priorities for ICT higher education in Italy are the following:

The higher education sector aims to establish links between the secondary and tertiary educational sectors, namely promoting greater collaboration between schools and universities based on joint initiatives favoring growth as well as knowledge and experience exchange in a more direct and structured way. It further aims to update teaching methods by reinforcing educational

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initiatives for promoting lifelong learning through active collaboration among different education and business actors. One of the emerging strategies is the definition of a Digital Portfolio, or in other words educational programs that include horizontal and vertical specialist paths, and its integration into existing training courses. The Digital Portfolio provides guidelines that help educational institutions to define and implement training courses that can be used flexibly in on-line and blended learning offerings. The higher education sector further develops links between universities and the ICT industry by enhancing professional study courses that exploit academia and industry synergies. This activity aims at supporting higher education institutions to design training courses with strong orientation towards industrial research and innovation, to train highly qualified professionals capable of fostering and supporting innovation in ICT, and to promote academia and industry partnerships aimed at creating innovative training courses contextualized in specific business scenarios.

And finally, reinforcing current training offers with the objective of revising and strengthening fundamental and transversal ICT skills needed for the digital transformation of the higher education sector. This activity helps design specialized training courses aligned to the ICT needs demanded in careers affected by the digital transformation.

2.5 Malaysia

In Malaysia, the significant role of ICT in promoting digital education is reflected in the national policy on ICT in education. Malaysia has taken various initiatives to facilitate integration of ICT in education, as outlined in its ICT Master Plan. To revolutionize education and learning, the National IT Council (NITC) was formed under the Sixth Malaysia Plan for the period 1990 – 1995 to ensure the integration of ICT into Malaysia society (Ministry-of-Higher-Education, Tenth

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Malaysia Plan: 2010–2015, 2010). To further the agenda, the Eighth Malaysia Plan, established in the period 2001 – 2005, and the Ninth Malaysia Plan, established in the period 2006 – 2010, continue to reform the education and training system through lifelong learning via multiple ICT-related media, the establishment of community colleges, open universities, and distance education (Ministry-of-Higher-Education, Tenth Malaysia Plan: 2010–2015, 2010). Nevertheless, studies in the Malaysian educational context have shown that the policy implementation resulted in varying degrees of success (Zainal & Zainuddin, 2020).

2.4.1 Organization of curricula in ICT education

ICT education curricula, just like the curricula of other types of education, are mostly developed by respective institutions that offer the courses. However, the curricula development at the institutions of higher learning in Malaysia is governed by the Malaysia Qualifications Agency (MQA), Ministry of Higher Education of Malaysia. For example, the content of the ICT programs to be offered at universities must follow the standards defined in the Program Standards: Computing, developed by the MQA. Before a new program can be offered, the Code of Practice for Program Accreditation (COPPA) needs to be strictly adhered to where a set of criteria for program accreditation by MQA are outlined. Several documents must be prepared describing program development and delivery, assessment of student learning, educational resources, program management, program monitoring and review, and more. Layers of evaluation are performed by the MQA to ensure the fitness of new programs. Evaluation leads to provisional accreditation and later full accreditation. Only MQA accredited programs can be offered to ensure graduates are recognized and marketable. MQA audits programs from time to time to ensure continuous and consistent adherence to standards. Some universities are granted self-

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accreditation status by MQA, which confirms that the universities have a robust internal quality assurance system. Self-accreditation by MQA empowers the senate of the universities to accredit their own programs on the Malaysian Qualifications Framework (MQF) and relevant standards as well as policies of MQA and the Ministry of Higher Education.

2.4.2 Learning methodologies used in ICT education

While MQA provides guidelines on the content of ICT education methods of delivery of the content are left open and are flexible if they are appropriate. Various learning methodologies are used in the teaching and delivery of ICT at the institutions of higher learning in Malaysia. These may range from traditional classroom lectures to fully on-line learning. Depending on the content and the learning objectives of the courses physical activities in labs are also executed, such as for programming courses. Additionally, lecturers may use active learning, problem-based learning as well as flipped classroom methodologies.

In line with the advances of ICT and the fact that the current generation is more apt technically, traditional face-to-face classroom learning has gradually evolved into blended learning. Blended learning combines on-line digital media with face-to-face classroom methods. Classes are collaborative, with students using mobile devices such as mobile phones, iPads, and notebooks as learning devices (Jamaludin, 2018). Most teaching and learning contents are made available on-line for students to access and learn at their own time. Some assessments are also conducted on-line. More engaging content, such as video and animated presentations are increasingly used by instructors. Most tertiary level institutions use web 2.0 in their blended learning to provide access to lectures, organize group discussions, delivering on-line presentations and performing other educated related activities (Razali, 2016).

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Yunus, Nordin, Salehi, Embi & Salehi (2013) mention that one of the popular tools that is commonly adapted in the teaching of reading and writing is the use of blogs. The research done by Yunus, Nordin, Salehi, Embi & Salehi (2013) shows positive findings in terms of student interest in presenting ideas and responding to their classmates' ideas by commenting on the blog. This type of feedback can be more effective than self-editing as more than one person is able to provide a response.

The Malaysian Education Blueprint 2013-2025, under Shift 7, has incorporated ICT in education. Similarly, globalized on-line learning has been incorporated for higher education under Shift 9 (Jamaludin, 2018). According to the guidelines of the Malaysian Education Blueprint infrastructure in schools, such as internet bandwidth, needs to be upgraded and made accessible 24/7. The blueprint recommends that devices such as tablets and interactive whiteboards or smartboards be introduced in classrooms. A green studio is recommended if recording of the teaching activities is needed. This allows students to watch lecture videos any time and at any place. Lecturers are becoming educators, facilitators, instructors, coaches, and e-moderators rather than one-dimensional teachers. Students, too, need to change from being recipients to creators of knowledge.

The COVID-19 pandemic amplifies the importance of digital technology for ensuring continuity in economic activity. The use of internet and technological advancements contributes to the rapid growth of data, which is the future commodity. Nevertheless, countries risk creating a digital divide if the response to digitalization is not well managed. Embracing digitalization and seizing opportunities arising from this trend is crucial for ensuring continuous wellbeing, relevance of activities and competitiveness. MyDIGITAL (Prime-Minister-Department, 2021) is designed to complement national development policies such as the Twelfth Malaysia Plan (RMKe-12) and

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Wawasan Kemakmuran Bersama 2030 (WKB 2030). The digital economy has been identified as a key economic growth area (KEGA) in realizing WKB 2030, to make Malaysia a country which is developing sustainably with fair economic distribution as well as equitable and inclusive growth. MyDIGITAL aspires to enable the public to embrace digitalization to improve quality of life and standards of living. The future Malaysia envisioned by MyDIGITAL will see the public enjoy improved digital literacy, more high-paying jobs, improved social wellbeing, and environmental sustainability.

2.4.3 Methods for aligning developed skills to industry needs

The Malaysia Digital Economy Blueprint is designed to enable Malaysia to benefit from the digital economy. This Blueprint is aligned with the Wawasan Kemakmuran Bersama 2030 (WKB 2030), the 2030 Agenda for Sustainable Development and Twelfth Plan to ensure structured and coordinated efforts towards a common goal. The Malaysia Digital Economy Blueprint introduces a vision for Malaysia to be a regional leader in digital economy and achieve inclusive, responsible, and sustainable socioeconomic development. It has 3 strategic objectives, 6 thrusts, and 22 strategies. Among the 6 thrusts, thrust 4 on building agile and competent digital talent focuses on the development of ICT talent and aligning it with industry needs. It aims to ensure that digitalization is successfully embedded and adopted within talent development at various levels of education and in the upskilling and reskilling of the existing workforce. According to the blueprint, the result of activities will be that current and future workforces will be well-equipped with digital skills to thrive in the evolving digital economy. Gig workers will be given opportunities to upskill and reskill. They will be provided with adequate support in the effort to have fit-for-

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purpose talent. Under thrust 4, innovation in knowledge is considered crucial for developing curricula that effectively integrate ICT with industrial and economic needs.

To ensure alignment with industry needs, Industry Advisory Panels (IAP) are being established at most higher education institutions. The IAP will convene regularly to review the content of programs and to advise on their relevance with respect to the needs of industry. Panelists are experienced practitioners in respective fields. In addition, part of the program requirements is for students to undergo industrial training at selected companies in the course of their studies. The duration ranges between 3 and 6 months after which students return to the universities to resume studies. This provides great opportunities for students to better understand the expectations of industry and vice versa.

More recently, public-private collaboration was also initiated through the Malaysia Board of Technologies (MBOT) to ensure the graduates are equipped with skills needed by the industry. The objective is to strengthen the role of MBOT in establishing the performance standards of industry players in their partnership with higher education institutions. This initiative aims to align curriculum design of universities and skills demanded by industry. It further leverages existing partnerships between government, academia, and industry through the MBOT and its Technology Expert Panels (TEP). This initiative also provides opportunities for participating industry players to assess future workforce capabilities and increase students' agility in becoming quality and competent workforce.

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2.6 Pakistan

2.5.1 Organization of curricula in ICT education

The Federal Ministry of Education and Professional Training has established initiatives that ensure national cohesion on education policies and reforms. This also includes ICT education, in which programs foster international cooperation and coordination on educational matters.

The ministry formulates national policy on the development and improvement of ICT, including related infrastructure. To achieve this, the Ministry of Education and Professional Training collects, analyzes, and disseminates information on key education indicators in collaboration with the Ministry of Information Technology and Telecommunication.

The aim of national policies on ICT education design is to promote the deployment of ICT in broad sectors of the economy. In addition, national policies introduce guidelines for the standardization of software used in educational contexts as well as within the government. To support higher education ICT curricula, Information Science and Technology Departments across Pakistan maintain foundational IT infrastructure and systems. Educational activities are further supported by IT system solutions and standardization, not only in the educational sector but throughout government services.

Each higher education institute offers degree programs at the Bachelor's, Master's, and PhD levels. Bachelor degree programs have a duration of 4 years, while Master's program have a duration of 2 years. The minimum duration of a PhD program is 3 years. The courses in the undergraduate computing degree programs are divided into strands. These strands include general education, university electives, math and science foundations, computing fundamentals,

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domain fundamentals in Computer Science, Information Technology or Software Engineering, and supporting domain electives in the same fields. Similarly, the courses in postgraduate degree programs at the Master's and PhD level are divided into program core courses, specialization courses, electives and a thesis or dissertation based on the degree program.

In addition, the Higher Education Commission (HEC) of Pakistan has been appointed by the government to oversee the development, review, and revision of curricula from the Bachelor's level and onwards related to all the degrees, certificates, and diplomas awarded by the higher education institutions in Pakistan (Higher Education Commission of Pakistan, Curriculum Revision, 2021). The HEC has established committees to address curricula revisions in different fields. Each committee includes senior faculty members and researchers from public and private sector universities, R&D organizations, councils, industry, and civil society nominated by their organizations. Furthermore, the HEC communicates and collaborates with higher education institutions at the national level on curricula revision every 3 years as per the decision of the 44th Vice-Chancellors Committee meeting. The National Curriculum Revision Committee for Computing Programs (NCRCC) is responsible for the curricula of Computer Science, Software Engineering, and Information Technology. The committee is also responsible for ensuring that curricula meet international standards and that curricula are similar across higher education institutions at the national level. The committee has revised the curricula of educational programs at the Bachelor's, Master's, and PhD levels in 2017. The HEC, Pakistan has separately published a policy on PhD degree programs in 2021. To address curricula changes, the NCRCC took into consideration the latest recommendations of the Association of Computing Machinery (ACM) for Computer Science (2013) and Software Engineering (2014) and the current market requirements for curricula revisions.

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The NCRCC has prepared a list of program learning outcomes (PLOs) for computing program students to ensure that students enrolled in any of the computing degree programs have attained foreseen educational objectives. These outcomes have been derived from the Graduate Attributes by Seoul Accord (Seoul Accord General Meeting, 2021) and they include academic education, knowledge for solving computing problems, problem analysis, design and development of solutions, modern tool usage, individual and teamwork, communications, computing professionalism and society, ethics, and lifelong learning.

2.5.2 Learning methodologies used in ICT education

Traditional tutoring methods are most common in higher education. However, in schools and colleges active learning practices are also popular. Several higher educational institutions use active learning methodologies, such as project-based learning, game-based learning, and problem-based learning among others.

Due to COVID-19 restrictions the Pakistani educational sector has moved to on-line and hybrid learning models in place of on campus face-to-face teaching in the last two years. For this, the government has launched several projects and programs to support ICT-enabled blended learning. For instance, Blended Learning System is a project for that promotes the implementation of blended learning in 200 classrooms. This system will start being implemented in the 2022 – 2023 academic year. To support the initiative, universities are in the process of purchasing equipment. In addition, project Smartboard System is already in process in 75 female institutions in collaboration with JAZZ (a telecom company) and Smart Learn Pakistan. This system will be extended to more intuitions in the near future. A handful of studies have already been

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conducted that highlight the benefits of teaching innovation in higher education (Khan et. al 2017, Huda et. al, 2016).

At the higher education level, no formal methodologies that have been introduced or recommended by the HEC of Pakistan that each higher education institution needs to use. Therefore, typically higher education institutions recommend that faculty members incorporate all necessary learning methodologies in their classroom teaching based on the vision and mission statement of the organization to support students, improve their learning experience, and prepare them for a better tomorrow.

2.5.3 Methods for aligning developed skills to industry needs

In Pakistan is a huge gap in the alignment of skills built in higher education and demanded by industry. There is a high demand for modern technology in the ICT job market. There is an urgent need to redesign the core educational system to close the skills mismatch gap. Higher education institutions often have in their organograms an Industry Liaison Office and an Industry Advisory Board. The role of these boards is to bridge the gap between the graduates' skills and industry demands. Board members are carefully selected from the industry based on their standing, experience, and expertise. They hold biannual meetings with the participation of faculty to discuss how the gap between academia and industry can be bridged. The board suggests changes in existing course focus, introduction of new courses based on new technologies, such as devOps and MLOps, offering of internship programs for graduates and introduction of weekend programs for hands-on courses on skills required in industry. These activities contribute to the alleviation of skills gaps and the development of a competent young workforce.

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The degree programs offered by higher education institutions in Pakistan follow the recommendations of the NCRCC, which, as discussed above, is comprised by individuals from the R&D sector and industry among others to ensure that students are offered courses that can help them in the future. As a part of the degree programs, students can optionally take an elective course of internship during the summer break where they are expected to spend a certain time amount of time, typically 2 months, in an organization of their interest. This allows them to have industry exposure and prepare themselves for the future. Additionally, each student in the final year takes a final year project course. This course runs in both semesters of the final year. Students work in groups. The department typically organizes 2 presentations each semester for the students to present their updates and receive feedback for improvement. Lastly, as a part of a final presentation at the end of the second semester of the 4th year, external individuals are invited for the evaluation of the projects; they may be senior faculty members from other institutions within the region or experts from the industry. This provides an opportunity for students to get feedback from the industry and for the industry to look at the of and prospective candidates that they may wish to recruit for their organization.

2.7 Vietnam

2.6.1 Organization of curricula in ICT education

The Vietnamese Qualifications Framework, issued by the government in 2016, introduces eight educational levels. Levels 1 through 3 are elementary, levels 4 and 5 are intermediate, level 6 corresponds to Bachelor college education, level 7 to Master's, and level 8 to PhD. The framework was designed to be compatible with the ASEAN Qualifications Reference Framework and UNESCO International Standard Classification of Education (ISCED). An undergraduate program,

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namely level 6, requires 4 - 6 years of study. Most educational programs require 4 years of full-time studies. Veterinary Science, Pharmaceutical Science, and Architecture require 5 years. Medicine and Dentistry studies have a duration of 6 years. After successful completion of an educational program, students obtain a degree with a title corresponding to their area of study such as Bachelor (cử nhân), Lawyer (luật sư), Engineer (kỹ sư) or Medical Doctor (bác sĩ). An undergraduate cycle is typically comprised by 130 - 220 credits depending on the major. A Master's degree programme (Level 7) requires 2 - 3 years of full-time study and completion of 60 - 80 credits along with coursework, research, and a Master's thesis. Admittance to a Master's degree programme requires completion of Bachelor degree, either full-time or in-service and the passing of a competitive examination. A PhD degree programme, namely level 8, requires 4 - 6 years of study in a related field after completion of a Master's degree. It involves completion of coursework and a dissertation or research project.

Currently, there are over 1.2m people working in the ICT sector in Vietnam in sectors such as hardware, software, digital content, and others. The growth rate the ICT industry is 13 - 18% a year. The number of universities and colleges that offer ICT training programs also increased from 92 in 2010 to 160 in 2020. Higher education institutions in Vietnam offer undergraduate degree programmes, Master's degree programs and doctoral degree programmes in various ICT majors such as Computer Science, Electronics and Communication Engineering, Communications and Computer Networks, Information Technology, Information System, Information Security, Software Engineering, Multimedia Communication, Data Science, Artificial Intelligence, and more.

Vietnamese higher education institutions adopt a credit system that is based on student learning and is based on the corresponding European model. One credit corresponds to 15 hours of

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classroom instruction, 30 - 45 hours of practical training or 45 - 60 hours of research or thesis work. In a standard academic semester, students are required to complete at least 14 credits, which are further broken down into smaller modules. A typical undergraduate ICT program is completed in 4 years and is comprised of 130 - 150 credits. In terms of structure, ICT programs offer in the 1st year of studies basic ICT courses such as programming, including Java, C and C++) mathematics, computer architecture, data structures, algorithms, and more. In the 2nd year of studies, ICT programs cover topics such as databases, software engineering, computer networks, information security, operating systems, real-time systems, and some more advanced programming courses such as Python® and web programming. The 3rd and 4th years of study focus on 2 main aspects, namely specialized ICT courses and applications. In relation to specialized ICT courses, in Software Engineering majors typical 3rd and 4th year modules include quality assurance and testing and mobile application development. In Electronics and Communication Engineering, courses such as digital design or embedded system design are offered. On the other hand, the applications learning path of a Bachelor's degree program may include activities such as project implementation, practical training, and a degree thesis, which challenge students to put in practice the knowledge they have acquired during the previous years of study. Practical training exposes students to industry methods during a period of 12 weeks in which they apply structured writing, document organization and methodological as well as analytical problem-solving. These skills are further reinforced in the context of a 15-week thesis.

Students enrolled in an ICT Master's programme are expected to complete at least 75 credits, of which 60 credit are gained through coursework and 15 through the implementation of a Master's thesis. Modules are classified into compulsory and elective. Compulsory subjects provide the fundamentals of the advanced knowledge and skills required at the Master's level in a typical ICT

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major. Electives further build further knowledge that extends foundations. Students receive an interdisciplinary, research-oriented, and comprehensive education, both in breadth and in depth, that considers the up-to-date state of development in the individual disciplines involved. In the context of a Master's thesis, students build their capacity to work across disciplines and to understand and solve ICT problems in a systemic way.

Despite recent improvements, curriculum development in Vietnamese higher education institutions continues to follow content-based approaches which have led to inappropriately structured training programmes with a heavy focus on theoretical knowledge, while insufficient attention is paid to building soft skills that employees need to perform well in the era of the digital economy. ICT programs structures involve too many subjects and classroom teaching, significantly limiting students' time for self-learning, project-based learning, and co-op course work. Student assessment takes place largely through end-of-term or end-of-year exams. Competency-based periodic assessment is deployed to a lesser degree. As a result, graduates lack transversal skills such as problem-solving, leadership, entrepreneurship, communication, and teamwork.

2.6.2 Learning methodologies used in ICT education

In the past several decades the Vietnamese government has been attempting to modernise higher education. More specifically, it intends to transform teaching and learning approaches to produce human resources that meet the increasing demands of a knowledge-based economy. Regardless of the implementation of multiple innovative policies, Vietnamese literature often describes teaching and learning in Vietnamese higher education institutions as consisting of a traditional transmission-style approach, with passive and note-based learning, and examination-

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driven learning, and a rigid and hierarchical learning environment. The traditional teacher-led educational model, in which lecturers present educational material verbally to students who record what they hear, coupled with content-based curricula, focuses more on lecturing rather than student learning and skills development.

In ICT education, some Vietnamese higher education institutions and their faculty have attempted to introduce innovative teaching and learning activities, such as student presentations, group discussion, active learning, experiential, and blended learning. However, related learning activities are still scarce. There are several possible reasons for this situation. First, inadequately designed physical environment, for example the traditional lecture theater classroom layout, does not necessarily support effective group work or active learning. Second, there are no financial or non-financial incentives for organizations or their academic staff to modernize and upgrade their teaching methods, whether they are technology-based or off-line. Finally, despite opportunities to pursue technology-based innovation in learning based on digital platforms, universities have not yet fully exploited available options.

2.6.3 Methods for aligning developed skills to industry needs

According to the Ministry of Education and Training, there are approximately 50,000 graduated students enrolled in ICT majors each year. Statistics reported by the Ministry of Information and Communications in 2019 show that the number of job openings in the software and ICT industry increases by approximately 30,000 every year. The report also predicts that, in 2023, Vietnam will lack approximately 500,000 ICT workers and will need 78,000 new ICT employees every year.

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ICT training programmes have not met demand, especially for high quality engineers. Only 27% of ICT workers meet industry requirements. The rest need additional training for a minimum of 3 months. ICT students face many challenges such as the rapid evolution of technology in areas such as artificial intelligence, IoT, and blockchain. Technological growth introduces a need for coordinating continuous skills improvement among students towards developing needed human resources for addressing industry challenges.

In 2020, the Vietnam Chamber of Commerce and Industry (VCCI), UNICEF, and the Mekong Development Research Institute (MDRI) released a report on expanding educational objectives towards building skills for future employment considering current and projected desirable skills for employability of young individuals in ICT. The report shows that even though education attainment statistics can be used as indicators for predicting labor market performance and vulnerabilities, there is a significant gap between formal qualifications and actual performance in the field. Specifically, 4 out of 5 surveyed firms value creativity, teamwork, and active listening in their future young employes. Other findings show that Vietnamese youth still lacks formal technical training and transferable skills necessary to keep up with the 4th industrial revolution. Among the weakest technical skills reported by companies are foreign language and advanced IT. On the other hand, among the weakest transferable skills are management and communication.

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2.8 Nepal

2.7.1 Organization of curricula in ICT education

ICT education courses are offered in Nepal in general as well as technical education. For example, the National Centre for Educational Development (NCED) has been providing training to the teachers through National Radio and FM.

In secondary education, Computer Science is taught as an optional subject in schools, and specifically in grades 9 to 12. In higher education, Computer Engineering, Computer Science, and ICT programs at the Bachelor's and Master's Levels are offered by different colleges in various universities. Various training institutes conduct technical education and vocational training courses in computers and ICT. For example, Kathmandu University (KU) has been offering a Bachelor's in Computer Engineering program since 1994. Kathmandu University was the first university in Nepal to offer a Computer Engineering program. Tribhuvan University has been offering a Bachelor's in Education program in Computer Science since 1996.

The Government of Nepal, and specifically the Ministry of Education, has introduced ICT as a subject as well as ICT as a tool for instruction in school education through the National Curriculum Framework (NCF). Some universities, colleges, and schools are already offering ICT as a separate subject as well as ICT as a means of facilitating teaching and learning.

ICT curricula are developed by a separate central unit that belongs to the Ministry of Education. The unit focuses on curriculum development, teacher development, examinations, non-formal education, and teachers' records management. To support educators, 29 education training centers exist across the country under the umbrella of the government's central educational

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training initiative named National Centre for Education and Development (NCED). In addition, 1,053 resource centers are functioning under the District Education Offices (DEOs) across the country to further support educators.

Curricula for students aim to develop basic computer skills such as working with word processors, spreadsheet application, database management, email use, and internet application use to all secondary level students as a core soft or general skill. Additional optional or elective courses on ICT are offered in the context of vocational and professional programs. In higher education, 2 types of ICT curricula exist. The first is an academic curriculum. The other is a professional training program.

Curricula for teachers aim to support educators to integrate ICT education into broader educational offerings. To achieve this goal, every teacher needs basic ICT skills. These ICT skills can be obtained either by taking separate courses as part of human resource development programs or by integrating ICT in another subject curriculum that prepares teachers for their professional activities, such as mathematics, physics, English, economics, Nepali or other. This approach ensures that most schoolteachers have ICT literacy that allows them to deploy digital technology as a tool for facilitating the teaching and learning process. To achieve the desired level of ICT literacy, ICT curricula need to be developed for teacher preparation in the context of teacher development programs. Skills needed by teachers include email and internet use as well as the capacity to deploy teaching and learning digital tools, such as multimedia, e-libraries, and more. Typically, teachers at the secondary education level are graduates of higher education ICT-related programs who have received additional pedagogical courses.

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To support ICT education, interactive digital content needs to be developed to support curricula activities. NCF provides a broad framework for the development of school curricula. It is used as a reference point for developing curricula for each educational level, which are then translated into real classes. Well-designed interactive CD-ROM and web-based digital content is instrumental for providing students with access to digital resources and on-line data collections. The ICT in Education Master Plan 2013 - 2017 developed by MOE focuses on preparing digital material that targets students and teachers. Digital and interactive material developed and approved by the Ministry of Education may be used in schools. User-created content is also deployed. Finally, the deployment of open-source practices is promoted for the development of pedagogical software that contributes to the enhancement of the educational system.

2.7.2 Learning methodologies used in ICT education

Specific methodologies dedicated to ICT education do not appear to be documented in formal educational guidelines.

The ICT in Education Master Plan has 4 components on the development of infrastructure including connectivity, development of human resources, development of digital learning material and enhancement of the education system.

2.7.3 Methods for aligning developed skills to industry needs

Promotion of industry-academia collaboration (IAC) is included in IT Policy-2067. To promote ICT in education, the ICT in Education Master Plan defines roles in public-private partnerships, industry-academia collaboration and schools and community. This master plan describes the industry-academia partnership scheme. Industry-academia partnerships aim at fostering

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cooperation between public research organizations and private commercial enterprises. These partnerships stimulate long-term collaboration between the sectors and address the perceived or real barriers which inhibit the movement of researchers between the public and private research domains.

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3. Analysis of national or regional level state-of-the-art initiatives for building innovation skills in ICT education

3.1 Greece

3.1.1 Projects, strategies, initiatives at the national level that build innovation skills in ICT education

Initiatives are underway in Greece for promoting innovation skills in all educational sectors. Some of them are promoted by the Greek Ministry of Education, while others are collaborative research activities among Greek or European educational organizations.

The Skills Development Labs of the Institute of Educational Strategy of the Greek Ministry of Education (Skills Development Labs, 2021) aim to develop soft skills and competences among secondary education students and wider groups, including adults. To achieve this goal, the Ministry of Education organizes a continuous education instructor training program titled MIS 5092064 (Skills Development Labs, 2021). The training program is delivered on-line and is available to educators working in the public school system. The objective of the program is to empower educators to design meaningful activities for their students delivered in specific educational slots in formal curricula, titled Skills Labs. The initiative is complemented by the digital educational repository Photodentro (Photodentro, 2021), which includes a wealth of educational programs on diverse subjects that span wide subjects throughout educational curricula, such as STEM, environmental education, arts, history, and more. Educational content is supported in rich media, including text, images, videos, and more.

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Another area of interest in innovation skill development is educational robotics, that offer opportunities for the development of STEM knowledge as well as soft skills, such as critical and analytical thinking, among individuals of all ages, ranging from pre-school education to adults. Educational robotics encourage the synthesis of solutions, as participants develop constructs and program them to achieve specific educational objectives. Robotics are introduced in the curriculum of the Department of Electrical and Computer Engineering of the University of Thessaly as an optional subject in the 4th year of studies. In addition, the University of Thessaly offers educational robotics courses (Educational Robotics at the University of Thessaly, 2021) that target audiences beyond the university community, including school learners. The courses, which are offered in off-school hours, have already engaged more than 3.000 young students in the past 5 years. They develop innovation capacity and promote STEM education in a playful manner. Related initiatives are offered by private and public entities throughout Greece. Another example of recreational educational robotics that promote STEM skills is STEM-Education (STEM Education, 2021), an organization located in northern Greece, which offers educational programs for learners, educators, and schools, both face-to-face and virtually.

In relation to research activities, LEAP (LEAP, 2016) is an Erasmus+ project that was implemented from 2016 to 2018 by a consortium of organizations from Greece, Estonia, UK, Portugal and Spain. The project aimed at building experience and knowledge among higher education students on emerging lean and agile industry practices empowering them to effectively transition into the professional world. The project focused on engineering disciplines. LEAP deployed serious games that encourage learners to adopt industry roles, to think critically for addressing community and societal needs through agile engineering solutions, to practice on the application of industrial

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process management in the context of their higher education curricula and to consider environmental responsibility issues in service design and implementation.

3.1.2 Projects, strategies, initiatives on using design thinking in ICT education or other subjects

Design thinking is not broadly adopted in educational contexts in Greece. Existing activities are related mostly to research projects that aim to modernize educational practices through emerging learning design.

In this context, HIGH5 (High5, 2019) is an Erasmus+ project running from 2019 to 2022 implemented by a team composed of partners from Greece, Poland, Bulgaria, Portugal, and Estonia. The project aims at creating new integrated design learning methodology for higher education that is based on already existing methods and approaches. Integrated design combines problem-solving, design thinking, and critical thinking to promote innovative mindsets for sustainable development. Integrated design is a response to the complexity of the world and projects undertaken at universities, in companies and at various institutions. The learning method designed in the project are inspired by the needs of the European labor market, which requires professionals to be able to analyze a situation, define accurately a problem, provide suitable solutions, and be aware of the consequences of implementation of the chosen solution. The project focuses on the development of a Moodle®-based course for educators on adopting Integrated Design. In addition, it delivered 2 summer schools for students with a focus on introducing solutions through Integrated Design sustainability problems.

Over the past few years, there has been an effort to disseminate knowledge more broadly on the deployment of design thinking activities for promoting critical thinking skills. Design thinking

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seminars are delivered, although not very frequently, by organizations in Greece for the benefit of instructors at various levels, ranging from primary to secondary and higher education. The University of Thessaly Electrical and Computer Engineering Department has delivered a seminar on design thinking to educators in the town of Lamia in Central Greece in December 2020. In addition, in January 2021 the seminar was repeated virtually for an audience of over 400 educators in Greece, who had the opportunity to be exposed to design thinking principles. The seminars were organized in collaboration with the Regional Educational Authorities of Central Greece. Given that design thinking is a relatively new concept in Greece, the seminars familiarize educators with the methodology, which contributes to building innovation capacity among students through creative thinking, open mindedness, understanding of user needs through empathy, and establishment of associations between different situations that share common solution elements.

3.1.3 Projects, strategies, initiatives on using gamification in learning in ICT education or other subjects

Gamification is, to a certain degree, deployed in a non-official manner in educational contexts at the tertiary level in Greece. Educators often integrate gamification elements into learning practices in the form of questions or quizzes that they submit to students in class with the objective of receiving real-time feedback on student understanding of the principles presented and adjusting the content of lectures dynamically according to student responses. Popular applications, such as Kahoot®, help increase student engagement and classroom interaction through rewards and recognition. Another related tool is the Socrative® environment, a student response system in which educators can structure questions or small tests to be similarly

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delivered in a course. Typically, educators apply these practices in an ad-hoc and intuitive manner, without having received training. The practice is particularly popular among Computer Science and Engineering students, who are digital natives familiar with on-line collaboration. However, digital gamification tools are used with equally positive results in other age groups, for example secondary school students. In the context of COVID-19 challenges, in which courses were delivered mostly virtually, gamification offered an alternative for promoting student engagement from a distance through activities and quizzes integrated into virtual lectures for stimulating student engagement in an environment where course participants do not have face to face interaction.

In addition, research projects are implemented on the integrating of gamification elements into learning contexts. Coding4Girls (Coding4Girls, 2016) is an Erasmus+ project that was implemented from 2016 to 2018 by a consortium of organizations from Greece, Slovenia, Italy, Portugal, Turkey, Bulgaria and Croatia. The project aimed at addressing the gap between male and female participation in computer science education and careers by introducing early methodological learning interventions that make computer science attractive to all. It further introduced interventions that target the factors that lead girls to not choose computer science, namely misperceptions of the roles and professional careers and wrong assumptions related to insufficient skills. The main goal of the project was to attract girls by raising their awareness on the rich possibilities for professional and personal growth that computer science offers and by preparing them for future engagement in computer science careers. The project introduced a design thinking pedagogical approach that was heavily linked to human-centered solutions. This approach challenged learners to see the big picture before designing a detailed solution,

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encouraged them to consider wider community interests and challenged them to think entrepreneurially on how digital technologies can be used to address real-world problems.

ELMET (ELMET, 2020) is an Erasmus+ project implemented from 2020 to 2022 implemented by a consortium of organizations from Greece, Spain, Bulgaria and Cyprus. The project aims at developing a learning intervention that is based on gamification and escape rooms for addressing the needs of vulnerable individuals, both employed and unemployed. The main objective is to contribute to the development of innovative and updated vocational education opportunities by developing a set of resources in the form of a complete TOOLKIT that enables vocational education trainers and experts to design and use the educative escape games, including digital escape rooms, as new active learning methodology for developing the key abilities and competences demanded in today's changing working environment.

HERA (HERA, 2019) is an Erasmus+ project implemented from 2019 – 2021 by a consortium of partners from Greece, Portugal, Estonia, and Spain. The project promoted game-based learning for the development of problem-solving skills in Engineering higher education. Specifically, the project developed a game environment through which students can address complex real-world challenges based on scenarios designed by educators. The HERA environment provides a rich city-builder infrastructure with over 100 structures, such as residential buildings, industrial buildings, electricity providers, internet service providers, phone providers, sports and culture, educational buildings, roads and other infrastructure, small and larger businesses, parks, and more, through which an educator can design an interesting and non-trivial scenario on a topic of choice for the students to solve in groups. Each student has individual goals. Each team has group goals. Students must reconcile potential conflicts in order to address both, simulating real-life scenarios. The game has a scenario editor through which educators can design scenario objectives, define

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student roles, define individual targets on a number of parameters, such as pollution, energy coverage, school coverage, and others, and design a new city or re-use an existing one. Several scenarios are available for educators to use directly or to refer to for inspiration.

3.2 Portugal

3.2.1 Projects, strategies, initiatives at the national level that build innovation skills in ICT education

Examples of activities that promote innovation skill development in ICT in Portugal include the research project MODE-It (Mode-It, 2019), an Erasmus+ project running from 2019 to 2021 implemented by a team composed of partners from Germany, Lithuania, Turkey, Portugal and Romania. The project's objective is curricula modernization through innovative MOOC-based approaches to higher education course design and delivery. The idea is to integrate open on-line courses into formal education, making it more flexible and attractive for students. The project's target group is academic staff. The project's specific objectives are to enhance staff skills in designing and delivering MOOCs and MOOC-based curricula and in creating and delivering MOOC-based subjects within higher education curricula.

Another research project is BEACONING (BEACONING, 2016), co-funded by the Horizon 2020 Framework Program of the European Union running from 2016 to 2019 and implemented by a team composed of partners from Portugal, Spain, the United Kingdom, Germany, France, Romania, Italy, Poland, and Turkey. The project aimed at breaking educational barriers with contextualized, pervasive, and gameful learning. Its main objective was to create an educational platform that provides opportunities for the deployment of ICT in multiple ways that merge learning acquired in formal, non-formal and informal means developing the skills for today's abled

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and disabled learners and workforce. The BEACONING platform was designed to be a solution that exploits advances in user experience design, mobile communication, gamification, and other innovative learning methodologies to create a blended learning space. Its focus was on the STEM field. It introduced a cross-subject approach embedded in problem-based learning. The proposed methodology allows for contextualized learning within real-world problem-solving and applications. The project is also a good example of the use of gamification for educational purposes.

3.2.2 Projects, strategies, initiatives on using design thinking in ICT education or other subjects

Design thinking is not broadly deployed in Portugal. Activities on the integration of design thinking in learning are implemented mostly within research initiatives.

DTS (DTS, 2020) is an Erasmus+ project running from 2020 to 2022 implemented by a team of partners from Italy, Bulgaria, Portugal, and Turkey. The project aims at the professional development of teachers to promote design thinking skills and the academic success of students. More specifically, the project aims at empowering teachers to effectively prevent early school leaving by providing their learners with applicable skills and guidance. This will be achieved through training modules based on design thinking skills. Thus, DTS aims at increasing the academic success of educators, supporting their professional development, empowering teachers, trainers and educators through resources to help introduce design thinking skills, equipping teachers with a design thinking mindset, facilitating the adoption of design thinking educational practices, strengthening the capacity of educational authorities, policymakers, and

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decision-makers to promote and mainstream design-thinking educational practices and decreasing early school drop-out.

D-Think (D-Think, 2014) is an Erasmus+ project running from 2014 to 2017 implemented by a team of partners from Portugal, Finland, Italy, Poland, and Belgium. D-Think aimed at promoting the wider use of design thinking as a transversal learning tool by developing and making available an innovative digital course supported by mobile learning for education professionals and professional trainers. The aim of the project was to develop the capacity of higher education institutions and VET providers to, in turn, prepare their students to better respond to the challenges of the labor market and be able to stimulate the growth of flexible and innovative businesses in the future. The project positively impacted higher education institutions by stimulating the modernization of learning approaches and methodologies.

3.2.3 Projects, strategies, initiatives on using gamification in learning in ICT education or other subjects

Several initiatives are underway in Portugal on the promoting of gamification elements in learning contexts, with the objective of promoting classroom engagement and interactivity. Educational games are being developed for building theoretical knowledge on diverse educational subjects as well as soft skills. The AccoutinGame application was developed in 2019 by Rui Silva, professor at Trás-os-Montes e Alto Douro University (UTAD) in the context of an initiative that aimed at deploying serious games and gamification to teach accounting. The idea was to use the game as a learning resource in accounting courses and subjects taught at different national universities. In 2019, it had already been tested with more than 2,000 students from several parts of the country and enrolled in different higher education programs in the mentioned field.

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A related initiative is From Games to Mobile Learning (2012). This work started in 2012 at the Faculty of Psychology and Education Sciences of Coimbra University, coordinated by Professor Ana Amélia Carvalho. The project had a duration of 3 years and was implemented with the support of the European Regional Development Fund and of the Operational Competitiveness Program (COMPETE) as well as national funds. The implementation team was composed of researchers and professors. The project's main objective was to implement serious games as an educational resource at different school levels, specifically in the 1st and 2nd stages of primary, secondary, and higher education. The implementation team involved created 4 games, one for each level mentioned. The games' development considered student preferences previously gathered through a need analysis. The games were developed to be applied in the teaching of different subjects. The games that targeted basic education students were designed to be used in math and history classes. The game that targets secondary education students develops knowledge on Portuguese language and literature, focusing on one of the mandatory readings of that level (Os Maias). Finally, the game created for higher education was directed at Communication and Educational Science students.

UNLOCK (UNLOCK, 2020) is an Erasmus+ project running from 2020 to 2022 implemented by a team of partners from Portugal, Spain, Netherlands, Germany, Denmark and Lithuania. The project is coordinated by the University of Aveiro in Portugal. The project promotes creativity through game-based learning in higher education. Specifically, it aims at equipping higher education teaching staff to design, set, and facilitate escape room games in their learning experiences to foster the creativity and other entrepreneurial skills of higher education students. The end goal is to raise both students and educators' entrepreneurial skills, promoting their creativity and employability. The main results of the project are a pedagogical framework, a

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handbook and a MOOC on designing, conceiving and facilitating escape rooms games in higher education contexts.

GameCourse (GameCourse, 2018) is an Erasmus+ project running from 2018 to 2021 implemented by a team of professors and researchers and coordinated by Sandra Gama from the Institute of Systems and Computer Engineering, Research and Development, in Lisbon, Portugal (INESC-ID). The project aims at creating an educational platform that allows the operationalization of gamified teaching experiences through the employment of a blended learning approach that allows students to attend both practical labs and theoretical classes while participating in discussions and completing on-line projects and assignments through Moodle. The proposed learning intervention has already been applied in the Multimedia Content Production Course (MCP), a Master's of Science course in the Information Systems and Computer Engineering Department at Instituto Superior Tecnico (IST), Portugal.

PERTHA (PERTHA, 2015) is an Erasmus+ project running from 2015 to 2017 implemented by a team of partners from Portugal, France, and Spain. The project had two phases. The first consisted of developing a serious game for physiotherapy students, whose work is mainly focused on the elderly. The second consisted of creating a MOOC for universities and professionals in the field who would like to include the game in their training offers, create new clinical cases or develop add-ons aimed at other sources or specialties.

Finally, the JoSeES – Jogos Sérios no Ensino Superior: Impactos, Experiências e Expectativas report, in English Serious Games in Higher Education: Impacts, Experiences and Expectations was developed from 2016 to 2019 by a team of professors and researchers, coordinated by the Faculty of Psychology and Education Sciences of the University of Porto. Its main objective was to build a comprehensive framework of tools and to develop a set of methodologies that support a better

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use of serious games as educational tools. The project further addressed the response to gaps identified in the literature in relation to the impact of serious games in learning, with a specific focus on the effects on important aspects of civic and socio-political development education.

3.3 Estonia

3.3.1 Projects, strategies, initiatives at the national level that build innovation skills in ICT education

Estonia is committed to the concept of building an information society. This would involve the creation of well-functioning and secure environments for using and creating ICT solutions in Estonia. The primary steps to achieve this goal are outlined in the Digital Agenda 2020 for Estonia. This report outlines the main government goals in terms of infrastructure and educational innovations. The first priority is expanding infrastructure to increase access to digital resources to all citizens. The second is to ensure cyber security and stability of public networks. These are valid concerns when the history of Estonia in terms of cyber-attacks is considered. With the ICT sector accounting for 21% of growth in the Estonian GDP since 2010, it is clear that the government has a strategic priority to promote and encourage the development the sector.

The government has provided funding for ICT education programs for every grade level from kindergarten to continuing adult education. Special funds have been allocated to the regional governments to support those who wish to retrain in ICT based skills. The IT-Academy 2016+ program has been developed to support the development of innovative curricula and the use of industrial internships to ensure the quality of education. The basic strategy in Estonia can be summarized as making ICT skills ubiquitous in the country and allowing the innovation of products and services come from the population through entrepreneurship.

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Information society initiatives are complemented by the Estonian Education Strategy 2021 – 2035 (Estonian Educational Strategy, 2021), which was adopted by the government in November 2021 as a reference guide for important developments in the area of education. It is the basis of priority setting and funding decisions as well as for the development of implementation programs that support the achievement of strategic goals. The implementation of the Education Strategy is coordinated by the Ministry of Education and Research. The overall objectives of the strategy are underpinned by strategic goals, namely ensuring that learning opportunities that are diverse and accessible, the learning ecosystem enables smooth transition between educational levels, teachers and heads of school are motivated, the learning environment is learner-centered, and learning offerings design is responsive to societal and labor market needs. The Educational Strategy states that it is necessary to develop a digital solution for the management of individual educational paths and careers and assessment of skills, raise awareness of the opportunities and risks of the information society, and develop digital skills in all age groups aiming at digital engagement.

Digital solutions and the increasing level of digital competence have improved the accessibility, diversity and efficiency of Estonian education. General education schools and vocational schools have highly evolved digital infrastructures. The Ministry of Education and Research highlights the need to continue the development of digital competences and support the diversification of learning, including through digital solutions.

The importance of digital education is further highlighted in a report on the deployment of ICT in the Republic of Estonia (Põldoja, 2021). According to the report, ICT has been a focus area of educational development in Estonia since the mid-1990s, when the first national program was launched to support the development of digital infrastructures in schools, provide digital skill

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development training to teachers, and supply schools with educational software. The Estonian Lifelong Learning Strategy 2020 identifies digital education as one of 5 key areas. The current ICT development action plan for schools focuses on incorporating a digital culture into the learning process, providing necessary support by developing teachers' digital competencies, building digital learning resources and educational e-services, and improving the ICT infrastructure in schools. Despite coordinated investment, the actual integration of ICT into teaching and learning practices still varies significantly between schools.

Finally, Estonia is known for its advanced digital society infrastructure that has enabled the development of a wide range of secure e-services for individuals and organizations. In the last decade, an active ICT start-up ecosystem emerged in Estonia.

Research initiatives also exist, aiming to promote innovation skills in and collaborative thinking. An example is VIE (VIE, 2021), an Erasmus+ project running from 2021 to 2023 implemented by a team composed of partners from Greece, Romania, Spain, Portugal, and Finland. The project aims to address the need of the educational sector for high engagement virtual collaboration environments that can support learning in the COVID-19 era, where work may need to be flexibly transferred from a face-to-face to a virtual setting and back in a short notice without disrupting the learning process. While most educational activities can be supported by learning management systems or similar services, more needs to be done to support group collaboration from a distance. The project addresses this need through the development of on-line services for conducting project work in the classroom and beyond, anywhere, anytime.

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3.3.2 Projects, strategies, initiatives on using design thinking in ICT education or other subjects

A number of initiatives are underway for promoting innovative thinking skills in Estonia. The Digital is Physical is a yearly conference that is held in Estonia since 2018, aiming to highlight design thinking success stories within Estonia and the Baltic region, to promote networking, and to showcase tools that can be used in design thinking methodology. The 2021 conference included a workshop titled The Digital is Physical, examining sustainability in digital products and other talks associated with the ICT field that have appeared in the program books.

The Bachelor's curriculum at Tartu University includes a Design Thinking and Digital Marketing program (Tartu University Design Thinking and Digital Marketing, 2021), which provides knowledge and skills in design thinking combined with digital marketing. It helps learners, through their acquired knowledge and skills, to create a competitive advantage for organizations through new thinking approaches. Design thinking and design knowledge in general help create a significant competitive advantage and differentiation in the marketing activities of organizations compared to their competitors and enable them to address emerging business challenges in an effective and stakeholder-oriented way. The curriculum is designed for anyone wishing to develop their creativity and skills in digital marketing.

3.3.3 Projects, strategies, initiatives on using gamification in learning in ICT education or other subjects

Gamification is applied by individual teachers rather than at an institutional level as a strategic educational approach. Gamification deployment is focused on the trinity of gamification methods, namely the use of points, badges, and leaderboards. While the advantages of including

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gamification in increasing student engagement are well established, it seems that universities are either reluctant to apply the procedures or reluctant to publicize their use. This suggests that any use of gamification in ICT education is a grassroots movement. But there are few examples.

A thesis by Marika Zirk (Zirk, 2021) aims to design ways for introducing gamification in Software Engineering. The thesis analyzes whether and how gamification could be applied in the context of education and more precisely in Software Engineering higher education. The thesis introduces a set of guidelines for undertaking gamification. It describes and evaluates a gamification plan of a course based on theoretical materials.

Educational technology compass (ETC, 2021) is an overview of technology trends for education, produced by the Education and Youth Board of Estonia in cooperation with education and technology specialists. The first Education Technology Compass report was published in 2019. It focuses on five areas, namely artificial intelligence, smart, analytics and big data, virtual and augmented reality, and privacy. The 2020 issue of the report discusses gamification and game-based Learning as well as personalized learning, highlighting the benefits of the approach in the increase of student engagement, the achievement of educational goals, and the retention of knowledge.

3.4 Italy

3.4.1. Projects, strategies, initiatives at the national level that build innovation skills in ICT education

Data on the development of the digital economy and society available at the national and international level shows that Italy displays a significant digital skills shortage.

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According to Eurostat, only 42% of Italians aged 16 - 74 have digital skills at least at the primary level, as compared to 58% in the EU, which negatively impacts the broad use of digital services. Italy was the last among European countries to deploy the internet (Eurostat, 2019). Approximately 17% of individuals aged 16 - 74 have never surfed the net. This percentage is almost double the EU average of 9%.

In this context, the National Strategy for Digital Skills was developed in 2020 based on key challenges identified by the Sustainable Development Goals (SDGs) of the United Nations. The strategy was adopted upon the publication of the corresponding Functional Plan. This plan identifies more than 100 actions to be implemented and sets out objectives to be achieved by 2025.

The plan indicates the National Strategy implementation actions and outlines the objectives and measures for each under 4 identified axes, namely higher education and training, workforce, specialist ICT skills, and citizens. The plan identifies short, medium, and long-term actions.

The low level of digital skills negatively impacts growth. Despite improvements, a survey carried out by the Digital Skills Observatory confirms the gap between available and demanded skills. While Italian graduates in the ICT sector are highly qualified and find employment soon after graduating the supply of skilled personnel is low as compared to labor market demands. The presence of women in technical fields is also low. On the other hand, young individuals use ICT technologies to a great extent. However, they often use the technology as end-users. The above demonstrates that ICT education needs to be modernized to promote innovation and the integration of ICT in broad fields and disciplines.

Current policies are producing results, but they are often still insufficient. Since 2018, job openings for experienced ICT professionals have exceeded 100,000, which corresponds to over

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half of all openings in the ICT sector. To address demand, several initiatives have been introduced for creating a pool of professionals with industry-demanded skillsets with the support of ministries and the regional authorities, including provinces and municipalities. Related actions focus on classroom and workplace training. They build incentives for combined education and work experiences. Related initiatives are implemented by public or private laboratories, technological and industrial districts centers of expertise.

On the other hand, formal course curricula offered by Italian universities focus on building ICT skills for the future. Consulta dei Presidenti degli enti pubblici di ricerca, in English translated as Consultation of the Presidents of public research bodies (CONPER), has documented a significant number of initiatives supporting digital skills development in enabling technologies and their applications in different fields or domains. Based on the current situation on ICT skills development, one of the priorities is to ensure the continuous updating of ICT study paths with a greater focus on business innovation.

3.4.2 Projects, strategies, initiatives on using design thinking in ICT education or other subjects

In relation to the deployment of design thinking in ICT education, an analysis was conducted in Italy on 289 innovators that use the methodology. If those, 208 may be characterized as adopters with an average experience of 4 years and minimum 12 months. 81 may be characterized as wannabe, who have been using the method on average for 6 months but always less than 1 year. The study documents how design thinking is adopted by professionals in different corporate roles, such as top managers, designers, marketing experts, business developers, and information technology experts. The study shows that the demand for new approaches for innovation drives

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market change. 279 start-ups were documented at an international level offering digital tools, solutions, and services for supporting design thinking. A total of 2.1 billion dollars in funding has been raised, of which 7.6 million by start-ups. Among these, only 4 are Italian, a sign of a still embryonic national ecosystem. However, this is still a step forward as compared to the previous year when no design thinking companies were registered in Italy.

Given the apparent positive impact resulting from the adoption of design thinking principles, the method is gradually being integrated into higher education ICT curricula. The following are projects, initiatives, and university courses that deploy or promote design thinking.

In this context, several projects are underway for promoting innovative skills in ICT education. The Innovative Design of School Education Processes project was launched in 2012. It was implemented by Associazione nazionale dirigenti e alte professionalità della scuola (ANP) and Telecom Italia Foundation. The dissemination activities of the project have so far reached approximately 9,000 teachers and school managers. 100 teachers from schools of all types and levels were selected to participate in 25 workshops delivered by expert trainers, namely school managers and professors of Politecnico di Milano, in which they designed teaching methods and tools supported by emerging technologies following the service design thinking method.

The ITS 4.0 initiative was launched by MIUR with the technical supervision of Professor Micelli of the Ca' Foscari University with the objective of enhancing 2-year ITS programs by introducing a professional training offering that brings schools and businesses closer to 4.0 technologies and concepts through design thinking. A learning path is initiated as a result of a client request. Clients

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may include businesses, consortia or public bodies interested in introducing change or improving a product or process.

In addition, several universities are introducing initiatives for promoting innovative skills. The Design Thinking and Processes course is offered in the Design and Engineering Master's curriculum of Politecnico di Milano. It aims at stimulating critical reflection for developing understanding on how design has evolved its inception to today. The University of Parma offers the Design Thinking Lab course in the Trade and Consumer marketing degree curriculum. And Ca' Foscari University of Venice offers the Active Learning Lab, an innovative teaching lab designed by Professor Vladi Finotto in 2016. It targets students and graduates from all Ca' Foscari Master's degrees. The initiative is an innovative educational workshop of 6 weeks that challenges students to develop innovative products and services following a market research approach.

The private sector also contributes to the development of innovation skills. The Samsung Smart Thinking project was launched in March 2016 in collaboration with LAGO, a prominent Italian design brand, the project brought together more than 44,000 students and nearly 1,500 teachers to experiment with design thinking. In the context of the project, 1,700 primary and secondary-school classes from around Italy were invited to design effective and innovative ways to improve the world.

3.4.3 Projects, strategies, initiatives on using gamification in learning in ICT education or other subjects

Following is a description of projects, initiatives, and university courses related to gamification in education or other sectors.

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GamificationLab is a university laboratory dedicated to research and teaching in Human-Machine Interaction, gamification, analog games, digital games, and digital simulations. GamificationLab belongs to the Department of Informatics of Sapienza at the DigiLab Interdepartmental Research Center. Lab members design, implement, and evaluate digital applications, particularly for mobile devices, gamification tools, videogame products, simulations and highly interactive applications. Students participating in workshops are involved in the development of projects under the supervision of educators and tutors. The working groups are provided with all the necessary support for ideation and planning, including design, needs analysis and storyboarding, prototyping and experimentation, developing and testing, deploying, and use analysis.

Among other projects, the lab has developed the SapienzaApps® published on the iOS® and Android® stores. More than 50 applications have been published since 2010, including Infostud® SeismoCloud® and applications on cultural heritage such as the Man Roma® application for G. Sergi della Sapienza Museum of Anthropology and the SafeArt® application for monitoring the transport of works of art. Furthermore, the lab has developed gamifications solutions and simulators, typically for training and educational purposes, serious games and video games in collaboration with leading companies, institutions, public bodies and Sapienza® departments.

The 42 Roma Luiss initiative is a prime example of a gamified university. The key characteristic of the university is that all actors are equal. There is no hierarchy, professors, or exams. What counts is the result of an individual's programming work. Learning paths are based on peer-to-peer learning and learning-by-doing. Students begin their educational journey by addressing a real challenge and testing themselves through multiplayer video games. Players often avoid training sessions or tutorials in favor of virtual experimentation. Subsequent engagement is dependent on the preferences of participants, who contribute based on what they do best and what excites

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them most, modifying the rules as a project evolves. The results of participants' contribution are immediately visible. This allows them to enjoy immediate recognition by other working groups that use the developed solutions.

Another interesting example of innovation skill building is the Organic Chemistry program of the Faculty of Agricultural Sciences and Technologies of the University of Padua, in which traditional activities have been integrated with gamification, which is applied in small groups of students working on different challenges that are aligned to course objectives. The program was designed according to the logic of The Organic Game, in which a competition is launched for guessing the precise structure of a complex molecule. Gameplay introduces clues on an extensive body of knowledge that allows participants to refine hypotheses towards the final goal, which is the discovery of the molecule's design and name.

3.5 Malaysia

3.5.1 Projects, strategies, initiatives at the national level that build innovation skills in ICT education

At national level, multiple initiatives have been carried out for promoting ICT education. These initiatives include those driven by the government sectors, private agencies, and the public (Zainal & Zainuddin, 2020).

Some of the earlier initiatives on enriching ICT education include the Smart School Program (Chan, 2002), the Celik Digital Program and others. These initiatives were rather small in scale and slower in manner. Recognizing the need to speed up the initiatives and expand them into a bigger agenda, the Ministry of Education Malaysia has invested very serious effort in building innovation in ICT Education. This was achieved through the development of The National ICT Human

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Resource Taskforce under the Ministry of Higher Education (MOHE). The ICT Human Capital Development Framework (IHCDF) was published in 2010. This framework aims at raising the ICT workforce competencies in general, producing resilient ICT graduates and inculcating strong research and development (R&D), commercial, and professional culture in ICT to help transform Malaysia into a net producer of ICT software, applications, and innovation for the global market.

To support this national agenda, various programs and initiatives have been introduced by the government and its agencies. They include PEMANDU with the Government Transformation Program (GTP), Economic Transformation Program (ETP), MDeC with Multimedia Super Corridor (MSC), and Digital Malaysia (DM) initiatives (MDC, 2005).

One initiative that has been institutionalized is teaching programming in primary and secondary schools. It is in implementation since 2017. it aims at developing a standard ICT curriculum or computing for strengthening the ICT foundations of students in Malaysia's educational system. While programming as a subject has been introduced formally in schools, non-formal curricula such as programming, apps development competitions, robotics competitions, and other ICT training programmes are increasingly offered by public and private institutions and other agencies, such as ROBOCON®.

Currently discussions are underway on the 4th industrial revolution. The importance of innovation in ICT education is at the top of the agenda especially in the higher education sector. Serious effort is being investing into ensuring that ICT education is properly designed and delivered. One of the key transformational initiatives in the higher education agenda during the 2016 – 2018 academic year was to strengthen ICT curricula through demand-driven approaches. This includes rebranding outdated ICT programs. For example, Bachelor in ICT programs may be converted into

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Bachelor in Data Science or other more relevant and up-to-date offerings that reflect emerging ICT jobs. Newly designed educational programs are sometimes also offered through integrated university-industry curricula branded as 2u2i, namely 2 years in university and 2 years in industry. The ministry has matched universities and companies such as Google®, Microsoft® or SMEs through the Industrial Linkages department. University administrations are also encouraged to pursue ICT certification by local and international certification bodies in ICT, such as the Malaysian Testing Board (MSTB), Microsoft®, and others. Through this initiative, ICT graduates experience added value in their educational efforts by receiving upon graduation not only an ICT degree but also certification recognized by industry.

Malaysia Digital Economy Corporation (MDeC) is an agency under the Prime Minister's office that has been working very closely with the Ministry of Higher Education in shaping future ICT talent for Malaysia (MDEC, 2021). The organization acts as one of the national authorities engaged in academic program approval at the ministry level. MDeC further delivers ICT educational programs not only in the context of education but also informally to the general public. One of the bold initiatives between MDeC and higher education institutions is the Premier Digital Tech Institution Program. In this program universities selected by MDEC receive special incentives and packages to work with relevant ICT companies.

The latest MDeC initiative is its collaboration with the Sunway Education Group (SEG). Through this initiative MDeC officially admitted its first cohort of students to the 42KL campus, Malaysia's first coding school with zero tuition fees, zero teachers, and zero traditional classrooms. 42KL (MDEC, 2021) is supported by Anchor Partners, and specifically the Sunway® Group, CIMB® Bank, DHL®, Roland Berger®, Carsome®, Huawei®, Standard Chartered®, SIDEC®, HSBC®, Tenaga Nasional, FWD® Insurance, and Celcom®. Participants engaged in an immersion bootcamp in

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which they were tested on their determination and hunger to solve complex puzzles with their peers through coding.

Apart from the above initiatives related to curricula and content design, innovation in ICT education in Malaysia cannot be achieved outside the scope of a holistic ecosystem. Hence the Ministry of Education has launched the ICT Transformation Plan 2019 - 2023 (Kementerian-Pendidikan-Malaysia, 2019) in January 2019.

3.5.2 Projects, strategies, initiatives on using design thinking in ICT education or other subjects

Malaysia aspires to develop a holistic ICT education program the focus of which is not only to solve problems through computational thinking. In the process of computational thinking, emphasis in also given to end users' needs and interests. Design thinking has been used in various occasions. It's benefits in ICT education are increasingly recognised.

The Malaysia Global Innovation and Creativity Centre (MaGIC) was established in 2014 as an agency under the Ministry of Science, Technology, and Innovation (MOSTI). MaGIC facilitates, navigates, and enables the ecosystem with the mission of strengthening Malaysia's position as an emerging innovation nation. In driving innovation in Malaysia, MaGIC has been training many individuals in design thinking, including professionals working in a community of start-ups, investors, and ecosystem players, through its capacity building programmes.

Genovasi Malaysia on the other hand is a private entity launched in 2012 as a means for equipping professionals in Malaysia with an innovation mindset using the design thinking methodology. The program originally aimed at enhancing the quality of public services. Genovasi Malaysia is a

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founding member of the Global Design Thinking Association (GDTA) that aims at maintaining global standards in design thinking training and practice. GDTA members include those from Germany, China, South Africa, the UK, and the USA. The Coach Exchange Programme (CEP) was formalised under the GDTA to foster cross-cultural exchange and further enhance coaching practices. Genovasi was expanded based on demand by the private and education sectors. Genovasi Sdn. Bhd. is the holding company of Genovasi d.School Malaysia and Genovasi University College. Genovasi d.School Malaysia is a learning institute dedicated to the teaching of design thinking for professionals at all levels. Genovasi University College is a design thinking-dedicated institution of higher learning geared towards Industry 4.0 readiness. Genovasi Malaysia initiated the Design Thinking Association of Malaysia (DTAM), that aims at protecting and promoting design thinking practices and developing practitioners through design thinking-related activities and events. Genovasi has conducted various training events on design thinking funded by the ministry and targeting schools and higher learning institutions. However, the Ministry of Higher Education has not mandated design thinking as a compulsory component in academic curricula. The use of design thinking in ICT curricula hence is embedded voluntarily at the initiative of educational program coordinators. Although it is voluntary in nature, design thinking is always part of Human-Computer Interaction courses offered by higher learning institutions. In addition, the computing programme standard regulated by the Malaysian Qualification Agency requires ICT curricula to include an element of design that enables students to develop user-friendly IT solutions in relevant areas. Design thinking is a good fit in this context.

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3.5.3 Projects, strategies, initiatives on using gamification in learning in ICT education or other subjects

Gamification in education, and especially in ICT education, has received special attention in 2016, a year after the Malaysia National Higher Education Blueprint 2015 - 2025 was launched. Under Shift 9: Globalised Online Learning, the ministry has set up a special taskforce on gamification led by Universiti Pendidikan Sultan Idris, Perak Malaysia. Many higher learning institutions have explored gamification. These efforts are not confined to ICT Education. In some cases, especially before the pandemic, one of the National Teaching Award recipients from Universiti Malaysia Sarawak used gamification successfully as a means for delivering his course. The transformation in his teaching was originally inspired by student-centred learning approaches implemented as a result of national key performance indicators that all public universities need to fulfil (Jamaludin, 2018). After discussions, the lecturer and students adopted rich gamification elements in the course, including a treasure hunt, indoor games and more. The impact to student learning was significant; as a result, the lecturer was recognised through a prestigious National Teaching Award in 2016.

Recognizing that gamification can also be equally impactful in ICT education in class or via e-learning, the ministry is currently finalising the Gamification Guidebook. All public universities are required to biannually report numbers of micro-credentials that integrate gamification. In consultation with industry on the way forward in e-learning for universities in Malaysia, academics have been advised to seriously consider the inclusion of gamification in e-learning curricula.

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3.6 Pakistan

3.6.1 Projects, strategies, initiatives at the national level that build innovation skills in ICT education

National Policy Pakistan formulated its first ever National Information and Communication Technology (NICT) Strategy for Education through a consultative process in 2004 – 2005 in the context of the Ministry of Education and Education Sector Reform Assistance (ESRA) Program 2010. The NICT strategy acknowledges the potential for ICT in education for improving the quality and accessibility of education, strengthen teacher education and contribute to gains in learning. The strategy outlines rich actions for ministries, education departments and district education offices for enhancing ICT education. These include the establishment of an on-line educational portal with appropriate content for students, collecting and adapting international open resources, maximizing opportunities for professional development through ICT, such as interactive radio instruction (IRI), television, open distance learning and on-line resources that are context-specific and geographically appropriate, adapting international ICT standards for education, providing distance learning to a large number of individuals by establishing virtual classroom education programs using online, internet or video facilities, establishing a national educational intranet (linked to the internet) to enable sharing of electronic libraries of teaching and research materials among educational institutions and faculty and enhance ICT infrastructure in schools with a focus on schools above grade 8.

The National Education Policy introduced by the Ministry of Education in 2009 and adopted by all federating units emphasizes the use of ICT in education. The policy promotes the use of ICT in-line with the 2004 – 2005 NICT Strategy. It provides guidelines for integrating ICT into education

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and strengthening non-formal educational systems. The policy highlights that "ICT shall be utilized creatively to assist teachers and students with a wide range of abilities and from varied socio-economic backgrounds."

Given the decentralized nature of the educational system, Pakistan requires a unique and differentiated approach to work with the provinces. In 2018, the Federal Ministry of Education and Professional Training published the National Education Policy Framework, as guidance for the provinces in re-emphasizing the importance of using technology in education for enhancing teacher and student knowledge, improving access to free educational content, providing off-line content solutions and options in remote areas and strengthening education management systems.

The Pakistan Economic Survey Report 2018 – 2019, produced by the Government of Pakistan. Economic Adviser's Wing, Finance Division in 2019, recognizes the importance of digital solutions for the economic growth and transformation of under-served populations. The report describes how, with the advancement of technologies and the proliferation of digital platforms and enabling apps, user behavior is shifting from voice and data-centric to app-centric services. Under Vision Pakistan 2025, the Ministry of Information and Technology has planned to increase broadband spectrum currently at 3% to 30% by 2025 across the country. Finally, the guiding framework for the recently introduced Single National Curriculum 19 also mentions the use of ICT.

The government of Pakistan recognizes the economic benefits that ICT brings to all sectors and strives to build a strong digital ecosystem (Ministry of IT and Telecom, 2018). The Telecom sector in Pakistan is deregulated and provides a level playing field for the telecom companies operating

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in Pakistan for increasing connectivity and quality of services across Pakistan. Likewise, the Universal Service Fund is increasingly expanding ICT infrastructure in hard-to-access geographical areas on a priority basis. At the household level, ownership of TV is high in Pakistan (74%), as is ownership of mobile phones (76%). In contrast, only 6% of households own a radio. Similarly, ownership of computers (14%) and access to the internet (25%) are both low. According to the Pakistan Telecommunication Authority (PTA) (2019) and the Techjuice report (2020), 76% of the population possess basic feature mobile phones and 56% of the population own smartphones. The ASER (2019) and PTA (2019) reports reveal that 91% of households use WhatsApp® and 70% use SMS. Access to WhatsApp® use is similar across urban and rural households (93% and 90%), while access to SMS services is more prevalent among urban (80%) than rural households (59%).

In relation to ICT educational programs, 423 federal government educational institutions in ICT exist in the capital city providing educational services to over 220,000 students from prep to post-graduate level. The Federal Directorate of Education (FDE), with the guidance and visionary leadership of Director General (EDU), aims at promoting the use of ICT in educational institutions. The organization has identified as a high priority the effecting monitoring and control over the 423 educational institutions employees' attendance, time response, productivity, performance and profile management. Initiatives are in place for enhancing the human resource management of 9,663 teaching and 4,423 non-teaching staff through recruitment, transfer, posting, retirement and pension plans, in-service training and capacity building, supervision, and promotion of academic and co-curricular activities, planning and development of new educational schemes, financial management, and audit of educational institutions and security. Examples of initiatives include the Prime Minister's ICT scholarships for youth from rural areas and approval of the implementation of blended learning in 200 classrooms in the following academic year. To support

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these programs, equipment is currently being procured, including a Smartboard system in 75 female institutions procured through the collaboration of JAZZ and Smart Learn Pakistan. This system will be extended to more institutions in the near future.

In addition, the HEC Pakistan introduced several initiatives to promote innovation. The authority has established an Office of Research, Innovation, and Commercialization (ORIC) at each higher education institute. The ORIC at each university coordinates research activities, from the development of a research proposal to the commercialization of research products. In addition, HEC has established the Business Incubation Centre (BIC, 2021) at each higher education institute. The BIC at each higher education institute provides basic infrastructure and allied facilities for researchers and young entrepreneurs who are interested in developing early-stage business ventures. It has introduced the Ignite initiative (Ignite, 2021), which provides financial assistance to final year undergraduate students in ICT-related disciplines at the higher education institutions in Pakistan to support them in developing protypes of their final year projects. The aim of this program is to increase creativity, innovation, and hands-on skills for preparing students for their future roles as professionals.

Finally, the government has launched distance collaboration tools, such as e-taleem® and noonacademy®, that allow secondary education activities to continue on-line during the COVID-19 pandemic.

3.6.2 Projects, strategies, initiatives on using design thinking in ICT education or other subjects

Despite the deployment of emerging learning design, such as active and problem-based approaches, in higher education design thinking is currently not deployed in Pakistan. This

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highlights the need for introducing initiatives such as ICT-INOV that aim to build the capacity of educational organizations to promote innovation among students, helping build the problem-solvers of tomorrow that will drive growth and community well-being.

3.6.3 Projects, strategies, initiatives on using gamification in learning in ICT education or other subjects

Gamification is also not currently deployed in Pakistani higher education institutions. ICT-INOV is a great opportunity for building the capacity of educators to integrate game-based approaches that, combined with design thinking, promote creative thinking and long-term engagement in learning.

3.7 Vietnam

3.7.1 Projects, strategies, initiatives at the national level that build innovation skills in ICT education

In the context of industry 4.0, the Vietnamese traditional education still fails to create proactiveness among students. The government has introduced regulation to enhance the quality of education to meet future needs. In resolution No.29-NQ/TW (2013), the Prime Minister emphasized the need for radical and comprehensive renovation of education and training to meet requirements of modernization and industrialization in the socialist-oriented market economy and international integration. Regarding higher education, the resolution challenges Vietnamese higher education institutions to focus on training skilled professionals, cultivate the gifted and develop learners' personal qualities, creativity and ability of self-learning. The government focuses on initiatives that complement the network of higher education institutions with

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occupational structure and training programs that contribute to the national human resources development plan. Some of these occupational training programs reach the regional or international level. Vietnam's higher education institutions aim at addressing requirements for the development of technology, job creation, national growth and international integration. On May 2017, the Prime Minister issued Directive No. 16/CT-TTg on strengthening access to the 4th industrial revolution, which is supported by several initiatives. Particularly, regarding ICT education, the Prime Minister requested a radical switch in policies, content, and methods of education so that Vietnam can have knowledgeable and skilful human resources. The directive provides 5 different strategic initiatives for enhancing ICT education in the era of industry 4.0.

The 1st strategic point is related to combining teaching and learning with practice. Education should not focus only on theory; it is essential to put theory into practice. Science, Technology and Mathematics (STEM) education is strengthened. Students can experience, explore, and discover technology associated with the knowledge developed in the curriculum. They are encouraged to be creative to contribute to the development of new technologies. The Ministry of Education and Training (MOET) has piloted STEM education at 15 lower and upper secondary schools in Ha Noi city, Hai Duong, Hai Phong, Nam Dinh, and Quang Ninh provinces. The pilot results indicate that STEM education directs students to search for ideas, join after-school clubs and make a change in the way science is taught and learned.

The 2nd point refers to providing diversified educational paths. Each student has a different pace of learning and individual interests. Therefore, the educational program should be diversified to cater to personalized learning needs and learning styles. The new curriculum reduces content in primary education. It further introduces a strong division at secondary and vocational education.

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The 3rd point involves encouraging lifelong learning. A key objective of education is to discover and nurture talent. For this reason, education centres and community learning centres are encouraged to continue nurturing a knowledgeable new generation. The government emphasizes solutions for comprehensive upgrading of the national education system towards open education, lifelong learning and fostering a learning society.

The 4th step refers to promoting teaching and learning foreign languages, especially English, and strengthening the application of ICT in learning and management. The Ministry of Education has proposed amendments to the current programs on teaching and learning foreign languages for the period of 2017 – 2025 with new orientations that aim at making a breakthrough in the quality of teaching and learning of foreign languages for different learning and training levels and at encouraging the introduction of foreign languages into learning starting from the kindergarten level. Special attention is paid to the integration of ICT in education management. The education sector continues to promote digitization in management, aiming at building a communication system that ensures information flow between the Ministry of Education and education and training institutions and developing a common database that documents the entire sector. In addition, the Vietnamese educational strategy ensures that learners are digitally and technologically literate at all levels of education, which is necessary for having access to scientific and academic content and innovation. In the new general education curriculum, foreign languages and computer science have become compulsory subjects from the 1st grade of primary school.

The 5th step refers to providing capacity building and broadening the role of higher education institutions. To enhance the competitiveness of human resources, in addition to constantly improving capacity in scientific research and teaching, higher education institutions must be

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pioneers in realizing their missions of promoting innovation. Their impact is no longer limited to educating and changing the lives of students. Universities must serve as supporters of innovation, providing a launching platform for future entrepreneurs and start-ups to maintain the development pace of industry. The Ministry of Education has submitted a request to the Prime Minister to approve the Scheme for Supporting Students' Start-ups by 2025, which directs educational institutions to upgrade their training programs by involving managers and employers, to develop and publish learning outcome standards, to support the coordination between higher education institutions and businesses that support labour in training and to strengthen cooperation with businesses in order to link training with domestic and foreign labour market needs.

3.7.2 Projects, strategies, initiatives on using design thinking in ICT education or other subjects

In recent years, Vietnam has introduced many policies and strategies to modernize education and promote progressive educational methods. The network of higher education institutions aims at building high-quality human resources to meet the needs of the digital economy and society. However, there is currently no specific policy or guideline focusing on design thinking in education in general as well as promoting design thinking in higher education. The ICT-INOV project will be a good opportunity to build the capacity of higher education institutions in Vietnam to deploy design thinking for promoting innovation skills among students.

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3.7.3 Projects, strategies, initiatives on using gamification in learning in ICT education or other subjects

Gamification is widely practiced in teaching in Vietnam by teachers from primary schools to higher education. Examples of activities include introducing playful and game-like elements to the learning process to engage students. Although many teachers recognize the usefulness of gamification in student-centred teaching, there has been no official strategy introduced by the Ministry of Education for this educational method. The ICT-INOV project will be a good opportunity to build the capacity of higher education institutions in Vietnam to integrate gamification in learning.

3.8 Nepal

3.8.1 Projects, strategies, initiatives at the national level that build innovation skills in ICT education

There is an absence of a consolidated ICT in education policy in Nepal. However, the IT Policy (2010), School Sector Reform Plan (SSRP) 2009 - 2015, and the Three-Year Plan 2011 - 2013 of the Government of Nepal (GON) provide some policies and strategies for the development and integration of ICT in education. For example, IT Policy (2010) introduces provisions for expanding internet to all schools, coordinating, and collaborating with national and international institutions to develop skilled human resources for continuous, relevant, and quality education, promoting industry-academia collaboration (IAC), and formulating and implementing special ICT program focusing on students, teachers, and schools with the objective of developing competent human resources. The School Sector Reform Plan states that “ICT assisted teaching/learning will be

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implemented and expanded in all schools". Similarly, SSRP has made a policy provision to develop ICT infrastructure in education and provide alternative modes of schooling through the use of ICT.

The three-year plan of GON for the period 2011 – 2012 (NPC, 2011) included policy measures related to ICT in education such as school staff being encouraged to use ICT in education to increase access to quality education in rural areas, reducing the digital divide, and integrating ICT into all aspects of education.

In addition, the Ministry of Education developed an ICT in education master plan for the period 2013 – 2017, which aimed at expanding equitable access to education, enhancing the quality of education, reducing the digital divide, and improving educational system service delivery.

3.8.2 Projects, strategies, initiatives on using design thinking in ICT education or other subjects

Design thinking is not broadly deployed in Nepal. Some isolated work has taken place to introduce design thinking in education, mainly at Kathmandu University. A virtual workshop on design thinking has been delivered by the university, but this has not been followed by additional follow-up initiatives. To this end, ICT-INOV provides a significant opportunity for training educators and supporting staff in the design and delivery of educational activities based on design thinking for promoting innovative student mindsets.

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3.8.3 Projects, strategies, initiatives on using gamification in learning in ICT education or other subjects

Use of gamification in learning in ICT education in Nepal is very limited. Some initiatives were discussed at the National Conference on ICT Integrated Pedagogy for Effective and Meaningful Learning (2021).

Gamification may be deployed in the context of software application or service design for addressing specific customer needs. It has also been used for addressing social issues, such as raising awareness on gender-based violence (Popeau, 2021).

In higher education, some efforts include instructor training on design thinking. An example is a workshop that took place at the Municipal College of Medical Sciences, Nepal in April 2021. The workshop targeted faculty members, who had the opportunity to engage in practical activities. The workshop was organized by the Department of Microbiology in collaboration with the University of Edinburgh. Presentations in the workshop highlighted the need to continuously update educator skills for making interaction with students interesting. Gamification was mentioned as an emerging approach for promoting learner participation in the educational process. Participants reviewed tools such as EducaPlay® and Kahoot® as well as gamification platforms.

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4. Analysis of practices in your university for building innovation skills in ICT education

4.1 University of Thessaly

4.1.1 Current methods and practices for building innovation skills

The University of Thessaly is committed to providing high quality education that develops industry-demanded skills. In this context, the university continuously integrates emerging pedagogical design supported by digital technologies. Active, problem-based, project-based, gamified, and other learning approaches are integrated into courses for the benefit of students promoting their innovation capacity and urging them to think out of the box.

The integration of emerging learning design is often piloted through research projects that focus on educational technologies. The University of Thessaly was actively engaged in the ALIEN: Active Learning in Engineering Education Capacity Building in Higher Education Erasmus+ project (ALIEN, 2017), through which problem-based learning was promoted as a strategic educational approach in engineering higher education applied in diverse courses in the School of Engineering. Through problem-based learning, which is broadly deployed in Engineering, the University of Thessaly aims to build the problem-solvers of tomorrow that possess the foundational knowledge and soft skills that enable them to work in interdisciplinary teams for introducing solutions to today's complex problems.

In addition to the above, design thinking may also contribute to the innovation capacity of students. The University of Thessaly is introducing a course on design thinking in the spring semester of the 2022 – 2023 academic year. The introduction of the course is in-line with the

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results of the evaluation and certification of department, which was very positive and highlighted the importance of introducing into the curriculum a design course. The course is offered at the graduate level, and specifically in the Master's in Computer Science and Technology program. The course will also be made available to undergraduate students in their 4th and 5th year of studies. The course encourages innovative thinking among students with the objective of developing the problem-solvers of tomorrow that have the knowledge, skills, and capacity to address the pressing challenges of the 21st century in industry and society. The course is designed as a hands-on experience. Students are exposed to problems, which may be introduced by industry representatives or faculty at the University of Thessaly, to which they design innovative solutions, even if none appears to exist at first glance, by applying design thinking principles of problem discovery, empathy, problem re-definition, ideation, prototyping, and evaluation. The course is a direct outcome of the ICT-INOV project activities. It demonstrates the tangible impact of the project on the learning practices and the curriculum of the department for the benefit of students.

Innovation capacity at the University of Thessaly is developed through entrepreneurship education, which is organized as common courses delivered jointly to all Engineering departments. Through entrepreneurship education students learn how to bring innovative ideas to the market by going through the steps of converting a concept to a product or service. Students become exposed to practices related to feasibility analysis, product design, and product placement often seeking user input for validating their ideas before designing a final solution. Furthermore, the University has introduced a Unit of Innovation and Entrepreneurship (MOKE, 2021), which provides consulting and support services for students, and to a lesser degree

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academics, that wish to turn innovative ideas into start-up companies. The unit is also linked to the Employability and Career Office of the university.

4.1.2 Current use of design thinking in educational practices

Design thinking has only been so far deployed in the Educational Technologies course. Design thinking is currently used in Course ECE329: Educational Technologies. The course focuses on the deployment of technology as an educational tool in lifelong learning contexts that target the needs of specific groups including school learners, higher education students, adult learners, vocational learners, professionals and others. The course analyses traditional and emerging learning methodologies including collaborative learning, explorative learning, active learning, mobile learning, problem-based learning, project-based learning, active learning, game-based learning and more. It focuses on how technology, and most importantly ICT, can be combined with emerging pedagogies towards the enhancement of learning processes and experiences in formal, informal, and non-formal learning. The course furthermore focuses on how technology can contribute, in combination with pedagogical models, towards the development of basic, transversal skills including analytical thinking, critical thinking, entrepreneurial thinking, problem solving, ability to work in a team, etc. During the course of Educational Technologies, students are exposed to active and problem-based learning in the context of formal projects leading to credits. Starting in the 2021 – 2022 academic year, students deploy design thinking in the context of the ICT-INOV project for designing digital services or applications that best address actual needs of specific user groups. The design thinking methodology helps students identify user needs in the broad area of technology-enhanced learning, understand the actual parameters of a

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problem, brainstorm, and synthesize feasible and viable solutions that help achieve educational objectives for specific target groups.

Through project ICT-INOV, the design thinking methodology will be integrated into a broad set of courses in the Department of Electrical and Computer Engineering over the span of the project implementation period and beyond, providing an opportunity to develop innovation skills in thematic areas that span software engineering, game development, STEM, operating systems, and more. Existing collaboration of the Department of Electrical and Computer Engineering with other departments of the University of Thessaly, such as the Department of Civil Engineering and the Department of Digital Systems, will further allow the dissemination of design thinking in additional Engineering principles. On the other hand, the University of Thessaly collaborates with other universities in Greece, such as the Hellenic Open University and the University of the Aegean, to which design thinking methodologies will be disseminated for promoting its adoption beyond the university and the ICT-INOV consortium. In the same context, the University of Thessaly is collaborating with Secondary Educational Authorities in the areas of Thessaly and Sterea Ellada in central Greece for fostering innovation skills in other educational sectors, such as school education. The educational authorities are responsible for introducing innovative learning design in all public and private general and vocational education schools in an area of approximately 1m inhabitants. Finally, the University of Thessaly collaborates with private educational institutions, such as the post-secondary educational organization Demetra (Demetra, 2021) on the development of innovation capacity in tertiary vocational education.

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4.1.3 Current use of gamification in educational practices

Gamification practices are fostered through research and educational practices of the Creative Technologies Learning Lab (CTLL, 2021) research group integrates emerging design, pedagogies, and ICT for generating innovative, rewarding, and effective learning experiences that build the knowledge and skills needed by industry and society in today's world. This research group participates or leads R&D projects that focus on educational innovation through digital technologies. The group has implemented over 40 projects that integrate emerging pedagogical design, such as active, problem-based, project-based, community-based, game-based, and other approaches with digital technologies, such as web services, educational applications, social media, and digital learning games for addressing needs of diverse groups, such as pre-school and school learners, students, professionals, adults, vocational workers, and others.

Gamification is further integrated into courses at the Department of Electrical and Computer Engineering of the University of Thessaly. Course ECE516: Design and Implementation of Digital Games focuses on the design and implementation of digital games and covers subjects that include: what is the definition of games and play, characteristics of digital games, game taxonomies and game genres, understanding different groups of users, designing a game concept, elements of game worlds, designing a game story, designing game characters, what are the core mechanics of games, typical game dynamics and the experience of users, game balancing, elements of chance, characteristics of on-line games, creative play, marketing principles, and more. The course was balanced between theory and practice. A significant part of the course work was on the design and implementation of a digital game. Upon completing the course, the students were able to apply game design principles to implement further games and applications. The course has weekly laboratory work that takes place in the computer laboratories of the

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Department of Electrical and Computer Engineering. At the beginning of the course students follow the tutorial examples as well as practical presentations of the functionality of popular game design platforms, such as Unity®. Upon completion of this segment of the work, which spans a couple of weeks, students use the laboratory to design and implement their own games in teams. During laboratory sessions students have the opportunity to collaborate with their peers towards game implementation, to get help on technical questions and to receive guidance for a smooth implementation.

Course ECE9251: Serious Games focuses on the design and implementation of serious games, namely games that have been designed from the beginning for educational purposes. This is in contrast with games that have been designed for entertainment but are deployed in educational contexts. Serious games offer advantages in learning, because their educational design means that learning does not have to be adjusted to the game features; rather the game is developed for seamless integration into learning. Serious games are used to build skills and competencies, training for crisis management, health, as well as promoting positive attitudes and perceptions. Popular sectors in which serious games are used include formal education, business training and health. The course activities balance theoretical and practical work. The theoretical work involves game design concepts similar to those described above for course ECE516: Design and Implementation of Digital Games. Theoretical work also includes pedagogical principles, such as the benefits of active, experiential and problem-based learning and supporting research work of well-known researchers including Papert, who introduced the concept of microworlds, namely simplified representations of the real-world that are relevant in game design (Papert, 1980), and Piaget, a psychologist that worked on the cognitive development of individuals among topics in his book Genetic Epistimiology (Piaget, 1968). Practical work involves the design and

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development of a serious game with educational objectives that addresses specific educational or training needs of a well-defined target group. Students begin the work by building a game concept, which they present to the class. Given the background of the participants, game development may take place through digital tools, such as Unit®, JavaScript®, or the simple to use Scratch® and AppInventor® environments that are appropriate for non-developers. It may also take place in the form of physical, non-digital prototypes. At the end of the course students present their games to the class.

Gamification is the focus of implementation of thesis projects in the Department of Electrical and Computer Engineering, which are obligatory semester-long activities in Engineering curricula. Students implement projects that focus on the design and implementation of serious games that address the needs of diverse user groups, such as primary education students, secondary education students, higher education students, vocational students, individuals that face learning difficulties, individuals that face exclusion, and more. The projects help develop theoretical knowledge in various subjects, such as STEM, history, music, languages, literature, and others, as well as soft skills. The implemented games deploy gamification elements, such as clear goals, rewards, difficulty adjustment, roles, a sense of affiliation, and more to promote elevated engagement in the learning process. To develop these learning games, students deploy popular game development platforms, such as UNITY®. Similar work takes place in the context of course ECE462: Special Subjects, a semester-long project-based activity. Student projects are available publicly in the digital library of the University of Thessaly.

Other departments of the University of Thessaly also focus on gamification principles in learning. The Learning Technologies and Mathematics Education of the Pedagogics Department of Early Education (LTME, 2021) supports teaching and research related to mathematics education and

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technology use in formal and informal settings. The lab aims to address diverse learner and educator needs through specifically organized programs of research, lifelong learning ,and knowledge dissemination. Work includes the design and inclusion of contemporary digital media and technologies into learning and playful experiences. The lab applies didactic and pedagogical design and places emphasis on the social study of the potential relations amongst human and non-human participants such as activity structure, materials, mathematics, and technologies.

4.2 Porto Polytechnic

4.2.1 Current methods and practices for building innovation skills

In Portugal, the legal definition of the strategic aspects of a higher education institution is outlined in the institutional statutes, a legal document that is approved by the Ministry of Education and is published in the official legal journal. The institutional statues define the vision, mission and objectives of the institution amidst other aspects, such as government entities, their responsibilities and duties the integrated units and other special units, etc. The Porto Polytechnic statutes do not mention specifically innovation skills and active learning but include references to the objective of promoting learning through diversified learning experiences and promoting academic training whenever possible through applied research, simulated or real professional situations, all of which are related to acquiring innovation skills. The Polytechnic´s statutes also include a reference to the need to implement strategies that lead to the improvement of teaching practices of educators so that they are better able to build the skills of their students. All these aspects are defined and passed on to the schools and special units that form the Polytechnic.

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4.2.2 Current use of design thinking in educational practices

The special unit that is more directly related to active learning practices through design thinking is the Porto Design Factory, now PORTIC, a unit for non-academic degrees, mostly post-graduate. Some of the most interesting activities include the post-graduate programs in Product Development and in Maker!® Innovation.

The Engineering School of the Porto Polytechnic has a Development Plan for 2019 - 2022 which proposes the implementation of actions meant to promote the systematic adoption of active learning methodologies that allow students to acquire transversal competences needed for their professional future, including innovation skills. The implementation of these new learning methodologies is the responsibility of the program director, who is assisted by a group of professors he/she nominates.

4.2.3 Current use of gamification in educational practices

The GILT (Games, Interaction, and Learning Technologies) R&D group focuses on educational technologies and their application in innovative pedagogical methodologies. This mission is integrated with post-graduate programs at the Master's of Science and PhD levels, instigating students to learn in a proactive form by being a part of a team that designs, develops and tests ongoing projects. Emphasizing the relevance of collaboration, GILT participates in or leads international collaborative projects and joint initiatives with other academic and commercial institutions which promote innovation in the education field. Internally, GILT is the promoter and supporter of several game-based learning and gamification approaches.

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4.3 Tallinn University

4.3.1 Current methods and practices for building innovation skills

Tallinn University is committed to supporting the sustainable development of Estonia through high quality research and study, education of intellectuals, public discussion, and promotion of academic partnerships. This commitment is evident in the striving for evidence-based innovative practices in education. The university is partnered with schools all around the country to support new practices in teaching and learning. This creates a link between educational research and practice that speeds up innovation in both areas.

In 2013 Tallinn University founded the Center for Innovation in Education, which aims at studying and supporting innovation within education in Estonia. Part of center's work is in recognizing innovation in the fields of Estonian education and supporting those wishing to engage in innovative practices through data driven research. It also provides mentoring support programs, training courses and analysis of educational programs all aimed at increasing the innovation of education.

4.3.2 Current use of design thinking in educational practices

The University of Tallinn offers a course at the Master's level on Disainimõtlemine ja generatiivsed uuringud or in English Design Thinking and Generative Research. The aim of the course is to introduce students to the types of problems that can be solved using design thinking. This is achieved through a series of workshops and seminars during the semester (TLÜ ÕIS, 2021).

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4.3.3 Current use of gamification in educational practices

Gamification seems to be applied by individual teachers rather than at an institutional level in ICT. Most of the applications are focused on the trinity of gamification methods, the application of points, badges, and leaderboards (PBL). While the advantages of including gamification in increasing student engagement are well established, it seems that the three main universities are either reluctant to apply the procedures or reluctant to publicize their use. This suggests that any use of gamification in ICT education is a grassroots movement. There have been examples of gamification used in classes including gamification design and level design courses within the Digital Learning Games Master's program. The program offers a full set of courses that address all aspects of game design practices, including the inception of a game concept, story development, graphics design, character development, game world development, game fairness and balancing, and more.

4.4 EU-TRACK

4.4.1 Current methods and practices for building innovation skills

To encourage the emergence of an orientation towards innovation in processes and management styles organizations must identify internally desirable skills. Competence is a persistent pattern of behaviour resulting from a set of knowledge, skills, abilities, and motivations. Competence models formalize this behaviour and make it explicit. They prescribe the ideal models needed for outstanding performance. They also help evaluate the performance of the different professional groups present in an organization.

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Innovation skills are transversal and often crucial for professionals in charge of managerial or coordination roles in strategic sectors. To maintain competitive advantage, an organization needs to be open to change.

EU-TRACK practices innovation on 2 levels, managerial and educational, which is related to the organization's training offerings. At the management level, the organization's competence model for innovation focuses on promoting creativity, resourcefulness, mind openness, vision, and change management.

Creativity refers to generating ideas. EU-TRACK uses problem-solving approaches and strategies. It further applies synthesis and reorganization for more effectively addressing problems by restructuring information. Problem-solving activities foster critical thinking through the logical identification of the strengths and weaknesses of specific solutions and for enabling individuals to re-evaluate their views considering emerging information. Finally, creative problem-solving is a method that encourages the deployment of new ideas and alternative viewpoints to solve problems.

Resourcefulness is practiced through a proactive approach that encourages seeking solutions to possible problems before they arise and introducing improvements. This is followed by problem identification for identifying the actual nature and cause of problems and the underlying dynamics. The process is facilitated by the identification of valuable sources of information and the collection and use of validated data. Resourcefulness is supported by independent thinking, or thinking out of the box, even if this may sometimes be against popular opinion. Finally, technical knowledge in understanding and using technology to improve work processes.

Open-mindedness is practiced as the willingness to listen to the suggestions of others and to analyse new solutions. In research, open-mindedness is related to being up to date with current

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innovations or trends in a specific sector. It can be fostered through collaboration and receiving and evaluating the opinions of others to reach a creative, shared solution. It can be further supported through involvement in non-work-related interests and being open to seeking information from associated sectors and other areas that may be useful to the problem-solving process.

Vision is pursued by striving to recognize and understand change in each context or predicting future outcomes. Vision is related to understanding the short and long-term impact of change, analysing scenarios by applying strategic thinking and evaluating multiple alternative hypotheses before deciding which solutions to adopt, and identifying and assessing future trends and risks based on current strengths, weaknesses, opportunities, and threats.

Change management refers to assessing the situational forces that can promote or inhibit a prospect of change. It requires challenging to the status quo through willingness to act against the way things have traditionally been done when tradition hinders performance improvement. It is practiced through willingness to take calculated risks when necessary, empowering team members to find innovative solutions, recognizing and rewarding those who take initiatives and act creatively, and facilitating the institutionalization of change initiatives.

At the educational level innovation is practiced through the design and delivery of training offerings to students. It is essential to maintain flexibility in time management, disciplinary articulation, and coordination of learning environments. Innovative teaching methods are combined with traditional ones. Educator training also integrates innovative learning methodologies.

EU-TRACK curricula are always dynamic, interdisciplinary, and, whenever possible, linked to a computational approach. Training offerings aim at developing foundational skills as well as

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transversal competencies necessary in a constantly evolving professional environment. For this reason, learning is linked to knowledge that is increasingly dynamic, holistic, and situated.

4.4.2 Current use of design thinking in educational practices

EU-TRACK has been involved in various activities related to design thinking. In addition to engaging in the Coding4Girls project described earlier in this report, the organization has engaged in the following activities.

TEAMSTAR (TEAMSTAR, 2020) is an Erasmus+ project implemented from 2020 to 2022 by a team composed of partners from Greece, Latvia, Bulgaria, and Italy. The project aims at building entrepreneurial and STEM skills in school education through gamified processes that deploy escape rooms. The project builds critical thinking among learners while it also reinforces educator networks for the exchange of good practices. Furthermore, the project aims at bridging gaps in digital skills facilitating young individuals' transition to the job market, defining a common method for digital entrepreneurship following the EntreComp Framework, designing a new curriculum for the promotion of new digital careers and enhancing learning through design thinking approaches.

The Exploring, Creating, and Constructing educational activity aimed at improving STEM skills through tinkering, a term referring to scientific exploration, and educational robotics in multidisciplinary learning contexts.

Tinkering enables learners to understand science concepts on their own by investigating tools and materials and exploring hypotheses. Tinkering and constructing build the capacity of students for innovative problem-solving by engaging them in hands-on and creative building projects that combine science, technology, engineering, and math. This approach helps build a variety of skills

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and mindsets related to classroom activities. Furthermore, by exposing students to engineering and technology through tangible, manageable, and adjustable tools and activities tailored to their needs, it prepares students to actively engage in life and professional activities in the real-world. The activity combined the application of computational design thinking and educational robotics targeting learners aged 9 – 11 years. The method utilized a novel platform developed through the Coding4Girls Erasmus+ project (see description above), which combines design thinking and game-based learning. The activity introduced physical computing through the assembling and programming of an infrared-controlled robot-car. The educational objective of the activity was to develop programming skills in a manner that allows their transfer to the real world. The proposed method helped keep students motivated and result-oriented throughout the course.

4.4.3 Current use of gamification in educational practices

EduRobot is a training course that aims at improving knowledge and skills related to the introduction of educational robotics. Students learn how to use tools that reinforce skills ranging from computational thinking and coding to robotics. The regular training activity has been structured for promoting the gradual development of know-how and competencies. Students are initially exposed to free-form exploration which is followed by the structured creation of robots. Learning activities deepen theoretical knowledge through tinkering based on simulations and practical exercises. Moreover, participants explore robotics through the kits based on the Arduino® and Micro-bit® platform and programming through Scratch®, the object-oriented programming language developed by MIT Media Lab®, and other similar software for teaching.

The Enhancing Student Learning through Research-based Approaches course exposes students to research-based learning. Students are encouraged to deepen knowledge and skills necessary for

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carrying out individual research in and out of the classroom. Learning is supported by digital technologies.

The research-based learning methodology deployed in the course contributes to the understanding of research practices, such as formulating precise questions and monitoring progress towards pre-defined goals. Moreover, it helps enhance student soft skills such as ability to work independently, teamwork, project management and ability to work with uncertainty. Students become thoughtful, motivated, collaborative, and innovative learners capable of meaningfully engaging in their inquiries and thriving in a world of constant change.

The course structure includes theoretical deepening, group work and practical exercises through which learners gradually developed desired skills.

The Robotics course, which is based on fundamental problem-based learning, intends to introduce students in a unified manner to aspects of physics, electronics, and programming directly related to robotics. Students identify the project or problem they want to work on. The difficulty of the activities varies depending on student age. By the end of the course, students will have implemented a programmable bot, a BeeBot® analogue, a line-follower and a couple of remotely IR or Bluetooth-controlled robots.

The STEM Skills development through Arts and Mini-game Design course aims at developing STEM skills by establishing connections between art and science. Starting from a specific example that demonstrates combining STEM and art in specific mathematics and science topics, the course deploys mini-games development to make the scientific study more effective. Going a step further, the course challenges students to develop their own mini games.

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4.5 University of Malaya

ICT education in the Universiti Malaya started way back in 1965 operationalized through the Computer Centre. It started to offer a Diploma of Computer Science postgraduate program in 1974. The Bachelor, Master's, and PhD in Computer Science programs were offered in the early 1980s and 1990s. The Faculty of Computer Science and Information Technology (FCSIT) was established in 1994. The Bachelor of Information Technology was introduced in 1996. The university has 5 departments related to ICT education, namely Artificial Intelligence, Information Systems, Computer Systems and Technology, Software Engineering and Library and Information Science.

Courses related to ICT targeting students within the faculty and outside are offered mainly by the FCSIT with the support of teaching staff from the 5 departments mentioned above. For example, the elective university course Fun with Robots is currently being offered to students in Universiti Malaya by educators from other faculties. ICT courses, such as programming, are also offered in the Faculty of Engineering (FE), Mathematics Department from the Faculty of Science and the Centre for Foundation Studies in Science, Universiti Malaya taught by lecturers from the respective faculties. Other examples of ICT courses or programs conducted in the Universiti Malaya are the Executive Diploma in Information Technology, delivered by the University of Malaya Centre for Continuing Education (UMCCed).

4.5.1 Current methods and practices for building innovation skills

The Universiti Malaya teaching practices are tightly linked to the eight domains of learning outcomes set by the Department of Higher Education (DHE), Malaysia. Practical and problem-

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solving skills are considered as the key to building innovation capacity. Additional skills, such as entrepreneurial knowledge, social skills, and responsibility are indirectly related to innovation skills. The Universiti Malaya follows the standard set by the Malaysian Qualifications Agency (MQA) established under DHE. Therefore, methods and practices in the Universiti Malaya for building innovation skills are based on practical and problem-solving skills.

Student assessment follows the integrated student assessment model by i-CGPA (Jabatan-Pendidikan-Tinggi, 2021). Based on this model, evaluation considers a number of factors, which include foundational knowledge, practical skills, social skills, and responsibility, ethics and values, communication, problem-solving, information management, and entrepreneurship.

Learning objectives are set independently for each Bachelor's program in ICT. The Computer Systems and Networks program aims at building student capacity to analyze, design, develop, model, and maintain computer systems and network technology using appropriate methodologies and tools. It further builds student ability to develop applications for addressing organizational challenges, apply quantitative and qualitative data analysis techniques, systematic and analytical skills, and use of appropriate tools in the context of organizational problem-solving. The Artificial Intelligence program aims at building student capacity to use computer tools and technologies in designing and developing intelligent systems with attributes of human intelligence and to apply the concepts of Computer Science and Artificial Intelligence techniques in problem-solving. The Information Systems program aims at building student ability to apply use software engineering techniques towards developing computer systems, to apply quantitative and qualitative data analysis techniques, and to use appropriate tools in information systems development in the context of organizational problem-solving. The Data Science program aims at building student capacity to engage in practical training that involves collecting, cleaning,

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and exploring data to extract information and gain insights. It further builds student ability to apply Data Science concepts and methods to solve problems in a real-world context with effective data-driven solutions. The Software Engineering program aims at building student ability to analyze, design, develop, and maintain software solutions by applying principles, methodologies, standardized, techniques, and tools to ensure software quality. It further builds student ability to apply logical and analytical thinking skills and scientific approaches in software development to solve real-world problems. The Multimedia program builds student capacity to apply techniques and skills and use tools and software to solve problems and develop information technology applications. It further builds student ability to apply quantitative and qualitative data analysis techniques, as well as systematic and analytical skills, and use appropriate tools in the context of organizational problem-solving. From the above, it becomes apparent that all programs focus on building innovation-related skills through activities such as analysis, design, development, modelling, maintenance, application of tools, and others.

Finally, the most recent plan for Future-Proof Skill Sets for Malaysian graduates introduced by the Ministry of Education includes creativity and innovation as desirable skills among others, such as holistic entrepreneurial and balanced, resilience, leadership, compassion, and mindfulness, values and ethics, flexibility, and adaptability, critical thinking, problem-solving and communication, and language proficiency (Ministry-of-Higher-Education, Framing Malaysian Higher Education 4.0, Future Proof Talent, 2018). Through this plan, the Universiti Malaya focuses more specifically on creativity and innovation activities in teaching and learning besides other skills, such as problem solving, critical thinking, and entrepreneurship.

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4.5.2 Current use of design thinking in educational practices

Design thinking is deployed at the University of Malaya. Indirectly, design thinking generally has been applied in the FCSIT as well as other faculties in the Universiti Malaya because of the Program Learning Outcomes initiative.

The design thinking concept at the University of Malaya was formally introduced in a training program for lecturers all over Malaysia by the Ministry of Higher Education Entrepreneurial and Public-Private Research Network Unit around the year 2016. The program was called the Entrepreneur Educator Enhancement Program (3EP). Part of the module was on design thinking, which was delivered by the Innovation Academy, University College Dublin (Nevin, 2021). Subsequently, a few lecturers from the Universiti Malaya joined the 3EP and started to use design thinking as part of their students' teaching and learning activities. The design thinking concept was spread throughout the country. However, the design thinking module under the 3EP was not specific to ICT education.

Design thinking is also deployed at the Centre for Internship Training and Academic enrichment (CITrA). CITrA University Malaya conducted a 3-day intensive course on design thinking in spring 2019 addressing 450 students in Universiti Malaya. The students had the opportunity to work on 2 challenges, namely redesigning the mall of tomorrow and the AirBnb® experience.

In addition, design thinking is deployed in FCSIT University of Malaya, where designing in the context of software development, information systems, network, artificial intelligence and multimedia technology are common practices, especially related to capstone or final year projects and project-based learning. For example, in the final year project typical activities deployed by students involve identifying ICT-related problems, defining the objectives of the project to solve the problem, conducing literature review on existing systems solutions, identifying user needs

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through observation, surveys and interviews, conducting requirements analysis, modeling, and designing systems and user interfaces, implementation, and prototype evaluation.

This process is usually iterative in nature. Students have regular meetings with supervisors and collaborators. A panel of evaluators is to each project. The role of the panel is to evaluate the project at least 4 times throughout implementation process.

Examples of final year project titles for semester 2 of academic year 2019 – 2020 include Malay as a foreign language for international students, development of mobile apps, QR apps for student attendance monitoring, reading assistant for young learners, registration prayer rotation and Kharat system for mosque, dept control systems, shipment status system for couriers, real-time mobile chat and chat box, prophet Muhammad's daily dhikr app, and a lot more. However, design thinking theory and practices as outlined by IDEO®, Stanford Design School, otherwise known as d.School (Dam & Teo, 2020), is not widely practiced in the FCSIT. A quick survey among faculty members and lecturers showed that design thinking has been used in group project assignments in the Information Systems program in the year 2019, targeting approximately 100 students.

4.5.3 Current use of gamification in educational practices

Although gamification is a popular alternative teaching method for active learning, not many adopt it in teaching and learning activities. There are several courses known to have conducted game-based learning mostly related to programming such as programming, data structures, algorithms, big data design and applications, and database management systems. A recent study (Habib et. al, 2021) showed that gamification was deployed for teaching graphs and sorting to a

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group of 193 students. The activities conducted were sponsored by the Universiti Malaya Learning Improvement and Teaching Enhancement Research (UM-LITER) Grant in year 2016 titled Enhancing Understanding of Programming Concepts through Physical Games led by Dr Raja Jamilah Raja Yusof (Adec, 2021). In the same context, gamification was deployed for teaching concepts and algorithms such as swapping, merge sort, selection sort, insertion sort, radix sort, graph theory, and bubble sort.

Another, game-based learning activity sponsored by the UM-LITER grant in 2017 titled Enhancement of Computer Programming Skills Among Undergraduate Computer Science Students Through an Integrated Approach Based on Problem Solving and Communication Skills was led by Dr Unaizah Hanum Obaidellah (Adec, 2021). A total of 72 first year Computer Science major undergraduates enrolled in the Fundamental of Computer Programming program were involved. Students were divided into groups of 6 individuals to complete programming activities. The groups competed for the fastest finishing with correct answers to receive complementary rewards in the form of snacks and stationeries.

One last example of game-based learning is related to activities conducted by Dr Adeleh Asemi in Big Data Design and Application program, targeting 68 students, and Database Management Systems program, targeting 8 students. Game based learning involved competitive activities through Kahoot®. Questions were distributed and answered by students competitively. At the end of the competition, the answers to the questions were discussed.

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4.6 Universiti Tenaga Nasional

4.6.1 Current methods and practices for building innovation skills

With the changing landscape of learning, University Tenaga Nasional (UNITEN) has taken a bold step by introducing the blended learning approach in teaching and learning. As part of the university's strategic plan initiatives, blended learning aims at enhancing academic excellence and globalizing on-line learning. This is achieved by combining face-to-face and on-line learning experiences through which students learn via electronic and on-line media as well as traditional face-to-face teaching where they complement other in terms of skills and capabilities. It is hoped that both students and lecturers at UNITEN can enjoy an enriching teaching and learning experience that celebrates knowledge creation and the technological tools that drive them. Students in the 21st century are digital natives that need to drive their own learning. They can no longer sit behind desks and listen to lectures throughout their campus life. With powerful learning tools in their hands, they need to be stimulated, engaged, and challenged to create and innovate. They need to be prepared for the demands of the 21st century job market. By using learning management systems such as Moodle, blended learning implementation can be easier by incorporating digital course information, course materials and resources, class activities, and assessment in one platform. In addition, external systems and applications may be integrated into learning management systems. Examples include Panopto® videos, Kahoot®, Padlet®, Mentimeter®, Coggle®, and more. These tools facilitate learning, reflection, discussions, and collaboration. Virtual reality and augmented reality technologies are also used for certain courses, especially for multimedia and visual media programs.

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4.6.2 Current use of design thinking in educational practices

Design thinking is currently neither systematically nor structurally applied at UNITEN. The university has introduced other initiatives involving innovative approaches in teaching and learning, such as blended and virtual learning. Some ICT courses use design thinking either partially or completely based on the individual lecturer's knowledge and initiative. More frequently, active learning is being deployed for developing knowledge and skills through activities inspired by real-life. It is hoped that ICT-INOV project activities will provide the necessary training in a structured way, promoting the adoption of design thinking in ICT courses can be systematically implemented and monitored in producing future ready ICT graduates.

4.6.3 Current use of gamification in educational practices

As digital gaming is becoming trendy among youngsters, including university students, using digital game-based learning as an instructional method that incorporates serious games with the goal of engaging learners seems to be a viable approach. Digital games, simulations, virtual environments and mixed reality or media provide opportunities for education or training through responsive narrative or story, gameplay or encounters. Gamification in learning involves using game-based elements such as point scoring, peer competition, teamwork, and leaderboards to drive engagement, help students assimilate new information and test their knowledge. Thus, educators teaching courses such as Software Engineering, Requirement Engineering and System Analysis and Design at UNITEN have adopted serious games for facilitating processes such as requirements elicitation and analysis to help students understand better the related concepts and processes.

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4.7 ISRA University

4.7.1 Current methods and practices for building innovation skills

ISRA University has established the Board of Studies (BOS) of the Department of Computer Science and the Board of Faculty (BOF) in Engineering, Science, and Technology (FEST). The members of these boards are industry professionals. The BOS and BOF hold meetings twice a year to discuss issues related to the curriculum and gather feedback for designing revisions. The involvement of professionals ensures that industry needs are also incorporated into the curriculum.

Furthermore, the Department of Computer Science at ISRA University has created a Corporate Advisory Council (CAC) on the recommendation of HEC. The CAC is comprised of senior faculty members and professionals. The purpose of CAC is to establish links with industry, provide training, organize workshops, and participate in research and development activities for mutual benefit in industry and academia.

Furthermore, ISRA University was a partner in an Erasmus+ Capacity Building in Higher Education project entitled Active Learning in Engineering Education (ALIEN, 2017), which aimed at introducing active and problem-based learning (PBL) in classrooms. As a part of the ALIEN project, multiple workshops were conducted at the FEST, ISRA University and various faculty members are as a result now using PBL practices in their courses.

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4.7.2 Current use of design thinking in educational practices

Design thinking is not currently deployed at ISRA University. ICT-INOV introduces a great opportunity for promoting the capacity of educators to foster the development of innovation skills among their students, complementing traditional, existing innovation-building practices.

4.7.3 Current use of gamification in educational practices

Similarly, gamification is not currently deployed at ISRA University. ISRA University stands to gain from the organization's participation in the ICT-INOV project for further promoting the adoption of emerging learning design, such as gamification approaches, into existing learning and teaching practices.

4.8 National University of Computer and Emerging Sciences

4.8.1 Current methods and practices for building innovation skills

The National University of Computer and Emerging Sciences (NUCES) deploys active learning in ICT and engineering disciplines. The organization has well established labs for practical experimentation of programming-related courses. The organization offers a diverse range of elective courses options to allow students to become acquainted with modern subjects. The organization has recently introduced undergraduate programs in Cyber Security, Artificial Intelligence, Data Science and Software Engineering. The purpose is to develop among students skill sets that are required by the industry, including critical and analytical thinking, innovation capacity, and entrepreneurial mindsets.

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4.8.2 Current use of design thinking in educational practices

Design thinking is deployed at NUCES in the context of human computer interaction and user experience design courses. Students are assigned mini-projects and they are asked to deploy design thinking for project development following the steps of problem discovery, empathy for user needs analysis, problem-definition, brainstorming, prototyping, and evaluation. The methodology, however, is not widely deployed. This underscores the opportunities introduced by the ICT-INOV project towards modernizing existing educational practices to foster innovation.

4.8.3 Current use of gamification in educational practices

Gamification is deployed in courses such as programming fundamentals, object-oriented programming, and web-programming. The lab instructors use gaming concepts and elements, such as clear missions, recognition, rewards, group work, and more, in the context of programming basics exercises.

4.9 Tribhuvan University

4.9.1 Current methods and practices for building innovation skills

Implementing ICT in education in Nepal is a high priority in education. The ICT Masterplan 2013 2017 considers the use of ICT in education as one of the strategies for achieving the broader goals of education. ICT is a significant tool for improving classroom delivery, maximizing access to teaching and learning content and enhancing the effectiveness and efficiency of educational governance and management.

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The Information and Communication Technology Centre (ICTC) was established in 2014 at the Institute of Engineering (IOE) to conduct various types of training, sponsored courses, and problem-based research in the field of Engineering and Technology, especially in the area of Information and Communication Technology. The Institute of Engineering has enormously benefited by the wide range of perspectives and talent contributed by students, faculty, and staff from a variety of backgrounds. The ICTC has been delivering both long-term and short-term training courses related with current ICT trends. The differentiating factor between these two categories of courses is their duration; short-term courses have a duration of less than 3 months, while long-term courses have a longer duration.

Similarly, an independent research organization National Innovation Centre was established in the central campus of Tribhuvan University in 2012.

4.9.2 Current use of design thinking in educational practices

Design thinking is not currently deployed at Tribhuvan University. In this respect, ICT-INOV is a great opportunity for integrating innovative skill development methods in learning practices. According to a research article published in the Tribhuvan University Journal (Subedi & Sharma, 2018) highlights how strategies from design thinking are gradually adapted for developing, improving, and deploying the methodology in semester courses.

4.9.3 Current use of gamification in educational practices

Gamification and active learning have only recently started to be deployed at Tribhuvan University in teaching and learning. Early exposure to active learning design, including the deployment of games and simulations in broader blended learning contexts that combine

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traditional instruction with ICT were first initiated in learning in the context of capacity building in higher education project ALIEN (ALIEN, 2017), in which the organization participated as a partner. The project helped develop educator skills and competencies in designing learning activities that deploy digital technology to engage students in learning by doing, rather than listening and seeing. The result of this work for the design and deployment of learning processes built around open digital educational resources that promoted student engagement and enriched classroom interaction. The project significantly contributed to enhancement of the university's academic environment by developing industry needed skills among students, while at the same time building instructor capacity on innovative learning design.

4.10 Kathmandu University

4.10.1 Current methods and practices for building innovation skills

Innovation at Kathmandu University is promoted through emerging learning design and industry – academia collaboration. Project-based teaching and learning is a strategic educational approach adopted by Kathmandu University for building innovation skills. The Department of Computer Science and Engineering has been very closely following this practice. As a result of innovative learning design, the department graduates are employed in challenging and rewarding professional roles in different sectors, such as academia, industry, government, non-government, private, and others, both within Nepal and beyond. The department employs qualified faculty members from Nepal and abroad with the capacity of integrating emerging learning frameworks in instructional practices. The curriculum is regularly revised. Finally, cooperation between the university and industry, particularly software companies, help bridge the gap between skills developed through formal learning and demanded in the professional world. These links are

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further strengthened via apprenticeships. Specifically, final year students are required to engage in a 3-month internship in the semester before their graduation. This practice benefits students, who become exposed in real-world working environments and develop their problem-solving capacity.

On the other hand, Kathmandu University School of Engineering deploys community-based learning in collaboration with Himal Partner. The university has developed a community education project in which students visit the community, identify problems and design solutions. Some groups of students implement this community related work as their thesis project. Through this activity, students and educators can understand societal challenges and mobilize their knowledge and creative thinking for the common good.

Finally, the university has developed a multimedia studio for recording and editing lectures delivered by faculty members who are interested in disseminating their material to students through the organization's e-learning platform. Kathmandu University has been deploying Moodle® throughout the COVID-19 pandemic to ensure the seamless continuation of teaching and learning in a virtual environment.

4.10.2 Current use of design thinking in educational practices

This concept of design thinking is mostly practiced in semester projects in the Department of Computer Science and Engineering. Students are divided into groups of 4 – 5 individuals. Group members identify a problem to work on, conduct surveys and interviews and brainstorm for understanding user needs. Once requirements are defined, students synthesize a solution. Team

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members introduce a rich pool of suggestions, go through thorough discussions and select a viable idea that is implemented into a prototype collaboratively.

4.10.3 Current use of gamification in educational practices

Gamification in educational practices is very new at Kathmandu University. The methodology started to be deployed in the context of broader problem-based learning activities. Course activities are broken down into different parts which are prioritized. Implementation is monitored through milestones. At each milestone students are evaluated and receive points based on their performance. During the Covid-19 pandemic, which forced virtual teaching approaches, some educators used in their courses the concept of gamification by assigning badges upon task completion, which were considered for computing final grades.

4.11 Von Neumann Institute

4.11.3 Current methods and practices for building innovation skills

Von Neumann Institute has established the Active Learning Laboratory, which is used by students under lecturers' guidance in both the Information and Communication Technologies and Quantitative Finance graduate programs, namely the two specializations offered by the organization. With the laboratory's resources, lecturers and students can work together in their courses more interactively and innovatively using the virtual machine enabled server, wireless connection hub, and a large monitor to work on-site. In the case of remote work, Von Neumann Institute provides a VPN connection through an internet broadband network and a VMWare installed server. Von Neumann Institute has introduced the solution of supporting both physical and virtual working environments as strategic educational design. The students can access

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educational content for their courses through laptops in the laboratory or through an internet connection from their own location. This solution has demonstrated advantages, especially in the COVID-19 pandemic.

The strategy of Von Neumann Institute is to create a highly interactive environment and to provide a more innovative approach that enhances student learning experience. Students may select actively the subjects in their learning program. The organization's laboratories are available to students 24/7, providing workstations for independent work and spaces for collaborative activities. In addition, Von Neumann Institute organizes weekly seminars, hackathons, and other events for promoting student innovation capacity.

4.11.4 Current use of design thinking in educational practices

Von Neumann Institute engages in scientific programs, which are supported by the infrastructure in the organizational laboratories. The laboratories, include the Active Learning Laboratory, are used by lecturers, researchers, and students for collaboration beyond classroom activities. Students develop skills and knowledge through projects and curricula course work under the supervision of lecturers and researchers. To promote design thinking in Von Neumann Institute, lecturers collaborate on the design of a Design Thinking Laboratory. They further contribute to the design and development of the ICT-INOV gamified digital learning platform and educational activities that are based on design thinking and are deployable in curricula courses. Given that laboratory space and equipment is limited, lecturers have developed a schedule for lab use, in which students register to gain access. The infrastructure will be initially deployed in the courses Advanced Programming in Science and Business Process Modelling, and in more courses in the near future.

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4.11.5 Current use of gamification in educational practices

Von Neumann Institute has been applying gamification in diverse curricula courses. This activity was initiated by the ALIEN Erasmus+ project, which focused on active and problem-based learning. As an example, gamification is deployed in the context of the Enterprise Architecture course. The course is part of the Information and Communication Technology graduate program. It is also offered in the Information and Communication Technology graduate program at the Polytechnic University of Ho Chi Minh City. During the course, students study, present, and discuss the general definition of enterprise architecture. They select a business scenario to build an enterprise architecture on. Gamification is applied through popular applications, such as Kahoot®, through which students create games under teacher guidance on the practical application of knowledge and techniques on developing enterprise architectures. Students play the games they designed. After each game round, the lecturer poses questions on erroneous or unclear answers, encouraging students to discover more on the missed points. The activity concludes with discussions that foster the effective understanding of course content and ensure that student responses during gameplay are conscious.

Gamification is also applied in the Information Technology Management course, which is part of the Information and Communication Technologies graduate program at John von Neumann Institute. During the course, students study different information technology solutions to a given scenario. Gamification is applied through popular tools, such as Kahoot®, through which lessons become more interactive. Similarly to the Enterprise Architecture course, students create games on course content under teacher guidance, play the games, and discuss concepts addressed.

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Gamification is also applied in the Management Informatics Systems course, which is offered in the Information and Communication Technology graduate program at John von Neumann Institute. This course is also offered in the Information and Communication Technology undergraduate program in Ho Chi Minh University of Technology and the Information and Communication Technology graduate program in the University of Economics and Finance. Students work in groups and are familiarized with information systems management roles and practices. Kahoot® is deployed for reviewing and reinforcing new knowledge. Students develop and take quizzes the strengthening the understanding of course concepts. Subsequently, students use Office® software, modeling tools, and Dropbox® to build and share their results within their classmates and lecturer in a shared-ownership document.

4.12 Hanoi University

4.12.1 Current methods and practices for building innovation skills

Since 2006, Hanoi University has established an interdisciplinary study program on Information Technology which focuses on software engineering, computer networks and information systems. Approximately 200 students are enrolled in the program every year. To succeed in the program, a student needs to have knowledge of and to master a variety of skills including mathematics, logic, problem solving, algorithmic thinking and programming, creative thinking, problem solving, decision making, and professional competencies.

The university applies diverse approaches to help ICT students develop innovation skills, including restructuring ICT curricula towards on-the-job training, integrating and building interdisciplinary knowledge, and deploying new technologies in teaching and studying.

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Students enjoy a learning-by-doing experience that is supported through the following:

Simulations, often used in scientific research, allow enriching of learning activities through iterative processes of object model design and implementation. Simulations can be particularly useful as a substitute for costly equipment by enabling the modelling, development, operation, and interaction with similar or related objects in a laboratory. Results from educational activities implemented through simulation tools can be subsequently verified with real-world measurements. Many simulations can be developed on computer hardware and software. They can facilitate research and development activities. They help develop students' modelling, integration, testing, graphical design, and communication skills.

Case studies, which are established based on actual situations that IT workers and their stakeholders usually are exposed to. Their learning objectives are to encourage students to exchange experiences related to situations that introduce dilemmas and to analyze and resolve the problems involved. Students introduce solutions to diverse problems within a specific framework that may involve limited time or resources. They make their own decisions, sometimes using advice and support from stakeholders. Exposing students to a variety of scenarios helps them develop their creativity, initiative, and self-confidence that will be valuable in addressing challenges in their future professional careers. Case-study exercises contribute to the development of skills on solution formulation, estimation, and quantitative analysis capabilities.

Real-world projects, which are typically complex activities that challenge students to break down work into tasks and integrate solutions to achieve a result. To successfully implement a real-world project, students need to build skills and knowledge from different disciplines as well as the ability

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to work individually and in teams. Typical activities in a real-world ICT project include requirements engineering, design thinking, product development, testing, maintenance, and decision-making. By engaging in these activities independently or as a member of a group, students develop different technical and interpersonal capabilities in their search for the most practical solution or result. Successful completion of real-world projects contributes to the development of skills in assumption making, design, implementation, writing, communication and presentation.

4.12.2 Current use of design thinking in educational practices

Hanoi university, and specifically the Faculty of Information Technology, has implemented a series of activities in which learning takes place through in school or real-world development and implementation of a software product, a network system or an information system. Some activities currently practiced include observing the work of others, reflecting on one's own work, theorizing through concept development, analysis, and synthesis based on past observations or experiences, experiencing or learning by doing through action, activities, and behavior observation as well as learning through testing, experimentation, or evaluation of options.

These activities have been found to yield positive impact on the quality of ICT training and education. Students develop interpersonal and communication skills through interaction with different stakeholders in their actual projects. They are motivated to acquire new skills and knowledge in software design and development by working with real customers and understanding real problems in the industry. They effectively develop theoretical IT knowledge by practicing it in real-world projects. They are exposed to design thinking in the context of active

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and problem-based learning methodologies. And, finally, they become more dynamic and independent in their development, application, review, and evaluation of IT concepts.

4.12.3 Current use of gamification in educational practices

Hanoi University participated in the ALIEN Erasmus+ project, which focused on the adoption of active and problem-based learning methodologies, including gamification. As a result of the ALIEN project, the Information Technology faculty of Hanoi University currently applies active learning in several courses. In this context, gamification has to a certain degree been integrated into curricula activities. However, until now Hanoi University has not implemented a formal project or strategy that focuses explicitly on gamification as a teaching and learning method.

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5. Conclusions

This report presented an analysis of the current situation in countries in which the ICT-INOV consortium has project partners in relation to practices at the regional, national, and organizational level towards building innovation skills among higher education ICT students. The analysis demonstrated that emerging learning design, and particularly problem and project-based learning, are broadly deployed for promoting foundational knowledge as well as soft skills, such as collaboration capacity, independent learning, and critical thinking. These approaches further facilitate the smooth transition of graduates from the academic environment to the world of work. The analysis demonstrated that design thinking and gamification are not yest widely used. While projects and activities do exist in Estonia, Greece, Portugal, Italy, and Malaysia they are almost non-existent in Pakistan, Nepal, and Vietnam. In addition, even in the countries where these approaches are in use, a lot more can be achieved for their integration into teaching and learning practices for the benefit of students. This demonstrates that the ICT-INOV project fills a gap in higher education in terms of further promotion innovative and entrepreneurial mindsets among both students and educators. Design thinking mindsets among university students and educators can help establish links between academia, industry, and society for addressing business challenges and well-being of communities. This is particularly important in developing nations in Asia, where higher education institutions can significantly contribute to growth through innovation. Towards this end, ICT-INOV implements a learning intervention that aims at building the capacity of participating universities in deploying design thinking and gamification supported by digital technologies that help enrich classroom interaction as well as collaboration, brainstorming, idea sharing and prototype design anywhere and anytime.

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