# The future challenges of scientific and technical higher education

Stefano Cesco, Vincenzo Zara, Alberto F. De Toni,
Paolo Lugli, Alexander Evans, and Guido Orzes*

doi: http://dx.doi.org/10.18543/tjhe-8(2)-2021pp85-117

Received: 23 June 2020
Accepted: 4 May 2021

---

**Abstract:** The world is experiencing significant changes, including exponential growth of the global population, global warming and climate change, biodiversity loss, international migration, digitalization, smart agriculture/farming, synthetic biology, and most recently a global human health pandemic. These trends pose a set of relevant challenges for the training of new graduates as well as for the re-skilling of current workers through lifelong learning programs. Our paper seeks to answer two research questions: (1) are current study programs suitable to prepare students for their professional future and (2) are study programs adequate to deliver the needs of current and new generations of students? We analyzed the professional figures and the skills required by the job market, as well as the number of students enrolled in technical-scientific HE study programs in Europe. We discuss the needs of future students considering how the teaching tools and methods enabled by digitalization might contribute to increasing the effectiveness of training these students. Finally, we

---

* **Stefano Cesco** (stefano.cesco@unibz.it) is Full Professor in Agricultural Chemistry at the Free University of Bozen-Bolzano (Italy) and President of the Italian Scientific Society of Agricultural Chemistry.

* **Vincenzo Zara** (vincenzo.zara@unisalento.it) is Full Professor of Biochemistry at the University of Salento (Lecce). He was Rector of the University of Salento and delegate of the Italian conference of rectors for teaching.

* **Alberto F. De Toni** (alberto.detoni@uniud.it) is Scientific Director of CUOA Business School and Full Professor of "Operations Management" and "Management of Complex Systems" in the degree in Management Engineering at the University of Udine (Italy).

* **Paolo Lugli** (paolo.lugli@unibz.it) is Full Professor and Rector of the Free Univeristy of Bozen-Bolzano (Italy). He conducts research on nanoelectronics and molecular electronics.

* **Alexander Evans** (alex.evans@ucd.ie) is the Dean of Agriculture and Head of the School of Agriculture & Food Science in University College Dublin (Ireland).

* **Guido Orzes** (guido.orzes@unibz.it) is Associate Professor in Management Engineering at the Free University of Bozen-Bolzano (Italy) and Member of the Scientific Committee of the CUOA Business School.

*More information about the authors is available at the end of this article.*

shed light on the different types of HE study programs that can meet the educational challenges of the future.

**Keywords:** HE system; education; challenges; Industry 4.0; engineering; agriculture.

## I. Introduction

In the last decades, the world has experienced a number of significant trends. Most dramatically, we have experienced an exponential growth in global population, which has now reached almost 8 billion people.[1] The climate has changed, reaching a global mean warming of 1°C above the pre-industrialization period and leading to many storms and hurricanes, even outside their traditional areas.[2] Global biodiversity loss (both in water and soil) has been 100 to 1,000 times higher than naturally occurring levels.[3] The world's oil reserves are limited and are expected to be consumed in the near future;[4] the same is happening for non-renewable natural sources used for the production of some fertilizers in the agricultural sector (e.g., rock phosphate). Social inequality has continued to rise together with international migration. Finally, the current overconnected, globalized world has suffered a global health epidemic in the form of coronavirus disease 2019 (COVID-19) caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).

These trends clearly show that our society deserves a new growth model since the current one, based on mass consumption, threatens sustainable societies in their widest sense. Many countries are aware of this issue and the United Nations have defined 17 Sustainable Development Goals (SDGs) and 169 target actions for the year 2030, among which no poverty, zero hunger, good health and well-being, quality education, gender equality, climate action, life below water and life on land are all important elements.

---

[1] United Nations, *World population Prospects 2019* (United Nations Department of Economic and Social Affairs, 2019), https://population.un.org/wpp/Publications/Files/WPP2019_Highlights.pdf.

[2] Juan J. González-Alemán et al., "Potential increase in hazard from Mediterranean hurricane activity with global warming," *Geophysical Research Letters 46,* no. 3 (2019): 1754-1764.

[3] Jurriaan M. De Vos et al., "Estimating the normal background rate of species extinction," *Conservation biology* 29, no. 2 (2015): 452-462.

[4] Mehmet İlhan İlhak et al., "Experimental study on an SI engine fuelled by gasoline/acetylene mixtures," *Energy* 151 (2018): 707-714.

Furthermore, digital technologies (e.g., 3D printing, advanced robotics, autonomous vehicles, and the Internet of Things), new materials (e.g., bio- and nano-based) and new processes (e.g., data driven production, artificial intelligence, synthetic biology) are completely changing how foods, products, and services are produced, distributed, sold and used in the world.[5] This has profound implications for the primary (mining and agricultural activities), secondary (manufacturing and biomedical industrial activities), and tertiary (services) sectors.[6,7] Scholars, practitioners and policy makers have therefore started to devote significant attention to this phenomenon, which has been referred to as digitalization, smart agriculture/smart farming, synthetic biology, or bio-inspired manufacturing, depending on the application context. While technological issues were initially considered the key element for the successful transition towards the above-mentioned paradigms,[8,9] recent studies acknowledged that employees' skills and organizational aspects are even more relevant.[10,11,12] We live indeed in exceptional and exponential times:[13] the amount of new technical information is doubling every two years; between 15,000 and 18,000 new species are identified each year;[14] according to the former US Secretary of Education, Richard Riley, the top ten most-in-demand

[5] OECD, 2017. The Next Production Revolution: Implications for Government and Business. OECD Publishing, Paris.

[6] Alejandro Germán Franka et al., "Industry 4.0 technologies: Implementation patterns in manufacturing companies," *International Journal of Production Economics 210* (2019): 15-26.

[7] Pablo J. Zarco-Tejada, Neil Hubbard, and Philippe Loudjani, *Precision Agriculture: An Opportunity for EU Farmers—Potential Support with the CAP 2014-2020* (Joint Research Centre of the European Commission, 2014), http://www.europarl.europa.eu/RegData/etudes/note/join/2014/529049/IPOL-AGRI_NT%282014%29529049_EN.pdf.

[8] Jay Lee, Behrad Bagheri, and Hung-An Kao, "A cyber-physical systems architecture for industry 4.0-based manufacturing systems," *Manufacturing Letters 3* (2015): 18-23.

[9] Yufeng Ge, J. Alex Thomasson, and Ruixiu Sui, "Remote sensing of soil properties in precision agriculture: A review," *Frontiers of Earth Science* 5, no. 3 (2011): 229-238.

[10] Dominik T. Matt et al., "Urban production–A socially sustainable factory concept to overcome shortcomings of qualified workers in smart SMEs," *Computers & Industrial Engineering*, *139* (2020): 105384.

[11] Silvia Fareri et al., "Estimating Industry 4.0 impact on job profiles and skills using text mining," *Computers in Industry* 118 (2020): 103222.

[12] Alok Raj et al.,"Barriers to the adoption of industry 4.0 technologies in the manufacturing sector: An inter-country comparative perspective," *International Journal of Production Economics* 224 (2020): 107546.

[13] Karl Fisch, Scott McLeod, and Jeff Brenman, *Did you know; Shift happens-Globalization; information age* (2015).

[14] Benoît Fontaine et al., "New species in the Old World: Europe as a frontier in biodiversity exploration, a test bed for 21st century taxonomy," *PLoS One* 7, no. 5 (2012): e36881.



• p-ISSN: 2340-8170 • e-ISSN: 2386-3137 • Volume 8, Issue No. 2, May 2021, 85-117 •
doi: http://dx.doi.org/10.18543/tjhe-8(2)-2021pp85-117 • http://www.tuningjournal.org/

jobs in 2010 did not exist in 2004, and today's learners will have changed jobs 10 to 14 times by the age of 38.[15] The current scenario is completely changing the needs of different professional groups as well as the skills required by them. Scholars argue that in general (a) low skill jobs are likely to be replaced by automation; (b) more skilled workers will be needed to manage automated processes; and (c) new jobs will emerge, such as data analysts, geospatial information systems experts, as well as new types of human resources and organization development specialists.[16,17]

This poses significant challenges for the training of future employees as well as to re-skill current workers through lifelong learning programs. In addition, the characteristics of the learners have also changed, requiring a prompt resetting of the course structures and teaching approaches. In 2018/2019, the first *Generation Z* students obtained their master's degrees, while in 2028 the first Generation *Alpha* students will enter the HE system.

The context presented above poses two significant questions for the technical-scientific[18] Higher Education (HE) system: (1) are current study programmes in this field suitable to prepare students for their professional future and (2) are they adequately directed at the future characteristics and needs of current and new generations of students (Generations Z and *Alpha*)?

This paper seeks to start answering these questions by (1) analyzing the professional figures and the skills required by the job market, as well as the number of students enrolled in technical-scientific HE study programs with a focus on the top five European countries by Gross Domestic Product - GDP (i.e., Germany, UK, France, Italy, Spain) (Section II); (2) presenting the characteristics of the future students and discussing how the teaching tools and methods enabled by digitalization might contribute to increasing the effectiveness of training such students; and (3) shedding light on the different types of HE study programs (Bachelor's and Master's degrees, professional and multi-disciplinary degrees, dual study programs, post-secondary non-

---

[15] Ola Erstad, "Educating the digital generation," *Nordic Journal of Digital Literacy* 5, no. 1 (2010): 56-71.

[16] Anne Bremer, "Diffusion of the "Internet of Things" on the world of skilled work and resulting consequences for the man-machine interaction," *Empirical Research in Vocational Education and Training* 7, no. 8 (2015).

[17] World Economic Forum, *The Future of Jobs. Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution* (2016), http://www3.weforum.org/docs/WEF_Future_of_Jobs.pdf.

[18] With technical-scientific, we mean the following ISCED Field of Education and Training (UNESCO, 2015): natural sciences, mathematics and statistics (code 05); Information and Communication Technologies (code 06); Engineering, manufacturing and construction (code 07); and Agriculture, forestry, fisheries and veterinary (code 08).

tertiary programs, distance/blended learning, and lifelong learning) that can meet the educational challenges of the future (Section IV). Based on these analyses, we then identify a set of issues that should be considered by HE institutions, students, and policy makers to improve the efficiency and the effectiveness of the HE system (e.g., increase the number of graduates, prepare students for the jobs of the future based on disruptive paradigm changes in science and technology, and adequately leverage new teaching tools and methods), thus significantly contributing to the development of HE in both its theory and practical components.

## II. Job market and current students

In Europe it has been forecast that in the next few years there will be a decrease in employment for people with low qualification levels and a simultaneous increase in employment for workers with higher education levels (i.e., Bachelor's and Master's studies) for different scientific and technical occupations (see Table 1). This skill shortage and skill mismatch are issues that have been analyzed and discussed in detail in the literature.[19,20]

**Table 1**

Forecast employment changes in Europe by occupation (percentage change)

| Occupation | Forecast Employment Change (2015 to 2025) | | |
|---|---|---|---|
| | Education level | | |
| | Low | Medium | High |
| Production and specialized services managers | -0.4% | 0.2% | 0.7% |
| Science and engineering professionals | 0.2% | 0.7% | 0.9% |
| Business and administration professionals | -0.2% | 0.8% | 1.0% |
| Information and communications technology professionals | -0.4% | 0.6% | 1.0% |

[19] Giorgio Brunello and Patricia Wruuck, "Skill shortages and skill mismatch in Europe: a review of the literature" (IZA Discussion Paper No. 12346, 2019)..

[20] Kea Tijdens, Miroslav Beblavý, and Anna Thum-Thysen, "Skill mismatch comparing educational requirements vs attainments by occupation," *International Journal of Manpower* 39, no. 8 (2018): 996-1009.

| Occupation | Forecast Employment Change (2015 to 2025) | | |
|---|---|---|---|
| | Education level | | |
| | Low | Medium | High |
| Information and communications technicians | -0.3% | 0.6% | 1.1% |
| Market-oriented skilled agricultural workers | -0.5% | 0.6% | 1.8% |
| Market-oriented skilled forestry, fishery and hunting workers | -0.4% | 0.8% | 1.5% |
| Health professionals | -0.3% | 0.5% | 1.1% |
| Health associate professionals | 0.6% | 1.5% | 1.6% |

Qualification level (1) low: ISCED 1-2, (2) intermediate: ISCED 3-4, (3) high: ISCED 5-6.

Note that these forecasts did not include the effects of Brexit or the Covid-19 pandemic.

Source: Cedefop[21]

The evolution of jobs, skills and competences required by such trends as digitalization, smart agriculture and synthetic biology is therefore receiving increasing attention from both academics and practitioners.[22,23,24] In this new context, in order to successfully perform their tasks, employees must be able to adapt to new roles, activities and scenarios[25,26] and this has consequently changed the skills required by the job market for the new workforce. In this regard, while new and deeper technical skills are needed to deal with the latest automation and digital technologies,[27] soft skills, including social and personal skills, are becoming increasingly important to manage the complexities of the work place and to quickly adapt to the frequent changes

[21] Hanbury, Prosser, and Rickinson, "The differential impact", 469-483.

[22] Lara Bartocci Liboni et al., "Smart industry and the pathways to HRM 4.0: implications for SCM," *Supply Chain Management: An International Journal* 24, no. 1 (2019): 124-146.

[23] Carl Marnewick and Annlizé L. Marnewick, "The Demands of Industry 4.0 on Project Teams," *IEEE Transactions on Engineering Management* 67, no. 3 (2020): 941 - 949.

[24] Mirjana Pejic-Bach et al., "Text mining of industry 4.0 job advertisements," *International Journal of Information Management* 50 (2020): 416-431.

[25] Markus Lorenz et al.,*Man and machine in industry 4.0*. (The Boston Consulting Group, 2015).

[26] Liboni et al.,"Smart industry," 124-146.

[27] Marta Pinzone et al., *Jobs and skills in Industry 4.0: an exploratory research*, in: "IFIP International Conference on Advances in Production Management Systems" (Cham: Springer, 2017), 282-288.

in labor markets.[28],[29] There is a significant amount of research dealing with the optimal set of skills that new graduates should possess to be competitive in the job market and these studies often differ in terms of field of education, industry, data collection methods and skills classification.[30,31,32] However, it is possible to identify a set of core or basic skills that are common to many studies, and we have summarized these in Table 2. It is worth underlining that some of the referenced studies do not explicitly refer to digitalization, smart agriculture or synthetic biology and they simply talk about new skills required nowadays by companies/farms, but they still represent an important source for our discussion.

In line with other analyses, we classified the identified skills into four categories: technical, methodological, personal and social.[33,34,35]

1) ***Technical skills*** represent a "must have" and this includes the digitalization scenario[36] and they reflect the specific knowledge required in a certain domain[37]. As underlined by Pejic-Bach,[38] a peculiarity of the digitalization context is the multidisciplinarity of skills and knowledge that is required to the new workforce, which needs to possess not only the most traditional skills in a specific area, but also more advanced knowledge related to the new technologies (including information and communication technologies).
2) ***Methodological skills*** refer to the abilities of decision-making and problem solving,[39] as well as critical thinking and analytical skills,

---

28 Lorenz et al., *Man and machine in industry 4.0*.

29 Chiara Succi and Magali Canovi, "Soft skills to enhance graduate employability: comparing students and employers' perceptions," *Studies in Higher Education* 45, no. 9 (2019): 1-14.

30 Fátima Suleman, "The employability skills of higher education graduates: insights into conceptual frameworks and methodological options," *Higher Education* 76, no. 2 (2018): 263-278.

31 Mercedes Teijeiro, Paolo Rungo, and Mª Jesús Freire, "Graduate competencies and employability: the impact of matching firms' needs and personal attainments," *Economics of Education Review*, 34 (2013): 286-295.

32 Martin Humburg and Rolf van der Velden, "Skills and the graduate recruitment process: evidence from two discrete choice experiments," *Economics of Education Review*, 49 (2015): 24-41.

33 Fabian Hecklau et al., "Holistic approach for human resource management in Industry 4.0," *Procedia CIRP* 54 (2016): 1-6.

34 Liboni et al., "Smart industry," 124-146.

35 Succi and Canovi, "Soft skills," 1-14.

36 Pinzone et al., "Jobs and skills," 282-288.

37 Marnewick and Marnewick, "The Demands of Industry 4.0".

38 Pejic-Bach et al., "Text mining of industry 4.0 job advertisements," 416-431.

39 Hecklau et al., "Holistic approach," 1-6.

namely the ability to examine and structure a large amount of information.[40]

3) ***Personal skills*** represent individual abilities, attitudes and resilience.
4) ***Social skills*** reflect relational aspects and issues related to working and collaborating with colleagues.[41,42,43]

These last aspects are very important when an interdisciplinary approach needs to be applied in order to solve complex problems/issues. For a recent literature review on 21st century and digital skills, the interested reader might also see Van Laar.[44]

**Table 2**

Skills required in the future job market

| Category | Skill | Exemplary references |
|---|---|---|
| Technical | Technical skills | |
| Methodological | Problem solving | Hecklau et al. (2016); Cacciolatti et al (2017); Easterly et al. (2017); Marnewick and Marnewick (2020); Peña Miguel et al. (2020) |
| | Analytical skills | Hecklau et al. (2016); Cacciolatti et al (2017); Suleman (2018); Succi and Canovi (2019) |
| | Critical thinking | Cacciolatti et al., 2017; Easterly et al. 2017; Suleman, 2018; Marnewick and Marnewick, 2020 |
| | Decision making | Hecklau et al. (2016); Easterly et al. (2017); Succi and Canovi (2019) |
| Personal | Flexibility | Hecklau et al. (2016); Easterly et al. (2017); Liboni et al. (2019) |
| | Learning skills | Hecklau et al. (2016); Suleman (2018); Succi and Canovi (2019); Liboni et al. (2019) |

40 Succi and Canovi, "Soft skills," 1-14.

41 Hecklau et al., "Holistic approach," 1-6.

42 Suleman, "The employability skills," 263-278.

43 Liboni et al., "Smart industry," 124-146.

44 Estervan Laar et al., "The relation between 21st-century skills and digital skills: A systematic literature review," *Computers in human behavior 72* (2017): 577-588.

| Category | Skill | Exemplary references |
|---|---|---|
| Personal | Resilience | Liboni et al. (2019) |
| | Ability to work under pressure | Hecklau et al. (2016); Succi and Canovi (2019); Liboni et al. (2019) |
| Social | Communication skills | Hecklau et al. (2016); Cacciolatti et al (2017); Easterly et al. (2017); Suleman (2018); Succi and Canovi (2019); Liboni et al. (2019); Marnewick and Marnewick (2020) |
| | Teamwork | Hecklau et al. (2016); Cacciolatti et al (2017); Easterly et al. (2017); Suleman (2018); Succi and Canovi (2019); Liboni et al. (2019); Marnewick and Marnewick (2020); Peña Miguel et al. (2020) |
| | Leadership skills | Hecklau et al. (2016); Cacciolatti et al (2017); Succi and Canovi (2019); Liboni et al. (2019); Marnewick and Marnewick (2020) |

Some additional observations can be made by looking at the number of students enrolled in HE programs. While the EU has achieved its general 2020 goal of raising the rate of tertiary educational attainment to at least 40% of the population who are aged 30-34, some EU countries (e.g., Italy, Germany, Romania, Portugal, Bulgaria, Czech Republic) are still significantly below this threshold.[45] Tables 3 and 4 show the number of students enrolled in Bachelor's (Table 3) and Master's (Table 4) degrees in the top five European countries by GDP (i.e., Germany, UK, France, Italy, Spain) in the period 2013-2017, focusing on four technical-scientific subject areas: (1) Natural sciences, mathematics and statistics (SCI), (2) Information and Communication Technologies (ICT), (3) Engineering, manufacturing and construction (ENG), (4) Agriculture, forestry, fisheries and veterinary (AGR). The gender issue is represented in the two tables by the percentage values shown in brackets (% of male students enrolled in each area).

In considering the data in Tables 3 and 4, it emerges that there has been a substantial increase in the enrollment of ICT students, in both Bachelors' and

[45] European Union, Education and Training Monitor 2019, https://ec.europa.eu/education/sites/education/files/document-library-docs/volume-1-2019-education-and-training-monitor.pdf.


**Tuning Journal for Higher Education**
© University of Deusto • p-ISSN: 2340-8170 • e-ISSN: 2386-3137 • Volume 8, Issue No. 2, May 2021, 85-117 •
doi: http://dx.doi.org/10.18543/tjhe-8(2)-2021pp85-117 • http://www.tuningjournal.org/

Masters' studies, and this clearly reflects the need for deep ICT capabilities in the technological job market of nowadays.[46] An increase in the enrollments, although smaller, can be seen also in the agricultural sector, where a higher level of education increase is predicted by 2025 (see Table 1). Different situations are instead characterizing the SCI and ENG sector. As regards the former, we observe an increase in students at the Bachelors level and a decrease at the Masters level. This pattern can be reasonably ascribed to different causes. In fact, it may be that a Bachelor's degree in such subject areas, which provides deep analytical and problem-solving skills especially for mathematics and statistics, is sufficient to find an appropriate job and it does not motivate students to continue their educational programs. On the other hand, it may also represent a new trend characterized by an enrollment growth that has not been evident in Masters studies yet. As regards the engineering sector, the enrollment of students slightly decreased in both Bachelor and Master studies. This is quite surprising not only because such studies provide many technical skills required by the job market, but also because they should help students develop all the other soft skills shown in Table 1, in particular those related to problem solving, analytical and critical thinking.

With respect to the gender balance of students, it varies across subject areas, countries, and levels of education (see Table 3 and 4). At the Bachelors level, male students prevail in the five technical-scientific areas considered (with the exception of AGR in the UK), while, if we consider all students/ programs, there is a slight prevalence of females (with the exception of Germany). The most unbalanced subject areas are ICT and ENG, with an average of 83% and 77% of male students, respectively. At the Masters level, the presence of males is still prevalent in ICT and ENG areas, while in the other areas the situation is balanced (SCI) or unbalanced towards females (AGR). No significant changes between 2013 and 2017 can be observed.

The different analyses presented above highlight a set of significant issues that in our view deserve to be carefully considered by HE institutions, students, and policy makers. First, *there is a significant need of more graduates (both Bachelors and Masters) and trained people*. While this need exists both in Europe and the USA, it is stronger in some European countries (in particular Italy, Germany, Romania, Portugal, Bulgaria, Czech Republic). The reasons behind the differences among the different countries may be due to (1) the initial situation, (2) the study programs that do or do not meet the needs/expectations of the students or of the job market, (3) cultural aspects, (4) demographic changes, or (5) other reasons.

[46] Liboni et al., "Smart industry," 124-146.

**Table 3**

Students enrolled in Bachelor's degrees in technical-scientific fields (in brackets the percentage of males)

| | Total[47] | | SCI | | ICT | | ENG | | AGR | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **2013** | **2017** | **2013** | **2017** | **2013** | **2017** | **2013** | **2017** | **2013** | **2017** |
| **Germany** | 1,635,907 (56%) | 1,859,807 (54%) | 134,350 (58%) | 155,769 (56%) | 121,792 (82%) | 158,654 (79%) | 421,109 (82%) | 439,879 (79%) | 22,987 (66%) | 24,642 (64%) |
| **Spain** | 1,085,012 (46%) | 1,211,630 (46%) | 57,668 (50%) | 83,193 (51%) | 44,226 (86%) | 44,869 (88%) | 174,831 (74%) | 154,760 (75%) | 13,283 (66%) | 11,343 (67%) |
| **France** | 931,748 (42%) | 1,041,756 (41%) | n.a. | n.a. | 22,165 (89%) | 25,800 (87%) | n.a. | n.a. | 1,480 (56%) | 1,030 (56%) |
| **Italy** | 1,108,260 (45%) | 1,102,137 (46%) | 101,727 (41%) | 101,157 (43%) | 20,975 (87%) | 25,251 (88%) | 192,313 (73%) | 180,547 (75%) | 29,967 (55%) | 34,655 (55%) |
| **United Kingdom** | 1,526,720 (45%) | 1,597,284 (44%) | n.a. | n.a. | 66,940 (84%) | 79,449 (85%) | n.a. | n.a. | 14,071 (30%) | 14,694 (26%) |
| **TOTAL** | 6,287,647 (47%) | 6,812,614 (47%) | 293,745 (51%) | 340,119 (51%) | 276,098 (84%) | 334,023 (83%) | 788,253 (78%) | 775,186 (77%) | 81,788 (55%) | 86,364 (54%) |
| | | +8.35% | | +15.79% | | +20.98% | | -1.66% | | +5.59% |

Note: n.a. stands for data not available.

*Source: Eurostat,* https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_uoe_enrt03&lang=en.

[47] Total number of students enrolled in Bachelor's degrees in all fields (not only technical-scientific).

**Table 4**

Students enrolled in Master's degrees in technical-scientific fields
(in brackets the percentage of males)

| | **Total[48]** | | **SCI** | | **ICT** | | **ENG** | | **AGR** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **2013** | **2017** | **2013** | **2017** | **2013** | **2017** | **2013** | **2017** | **2013** | **2017** |
| **Germany** | 930,366 (46%) | 1,033,258 (47%) | 110,178 (49%) | 112,032 (50%) | 34,627 (84%) | 45,040 (80%) | 120,561 (75%) | 153,717 (75%) | 13,269 (33%) | 15,545 (37%) |
| **Spain** | 514,369 (45%) | 334,537 (42%) | 28,630 (46%) | 9,061 (52%) | 11,756 (84%) | 6,702 (80%) | 88,027 (64%) | 55,419 (62%) | 14,016 (41%) | 11,911 (35%) |
| **France** | 831,956 (47%) | 922,890 (47%) | n.a. | n.a. | 26,469 (81%) | 32,796 (82%) | n.a. | n.a. | 10,525 (37%) | 10,487 (37%) |
| **Italy** | 727,019 (40%) | 696,171 (41%) | 29,064 (43%) | 34,773 (42%) | 3,879 (80%) | 3,435 (82%) | 111,136 (62%) | 102,475 (64%) | 15,244 (43%) | 14,208 (42%) |
| **United Kingdom** | 423,592 (42%) | 434,851 (40%) | n.a. | n.a. | 12,023 (77%) | 12,619 (73%) | n.a. | n.a. | 2,770 (40%) | 4,052 (37%) |
| **TOTAL** | 3,427,302 (44%) | 3,421,707 (44%) | 167,872 (47%) | 155,866 (48%) | 88,754 (82%) | 100,592 (80%) | 319,724 (68%) | 311,611 (69%) | 55,824 (39%) | 56,203 (38%) |
| | | -0.16% | | -7.15% | | +13.34% | | -2.54% | | +0.68% |

Note: n.a. stands for data not available.

*Source: Eurostat,* https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_uoe_enrt03&lang=en.

[48] Total number of students enrolled in Master's degrees in all fields (not only technical-scientific).



p-ISSN: 2340-8170 • e-ISSN: 2386-3137 • Volume 8, Issue No. 2, May 2021, 85-117 •
doi: http://dx.doi.org/10.18543/tjhe-8(2)-2021pp85-117 • http://www.tuningjournal.org/

Second, *there is a significant need of more graduates (both Bachelor and Master) and trained people in the fields/disciplines that are in higher demand by the job market,* which is changing/evolving at a very rapid rate. This is therefore a continuous challenge, which depends not only on the match between the job market and the HE study programs, but also on the attractiveness to students of the HE study programs.

Third, *there is a significant need for more graduates (both Bachelor and Master) and trained people with the "right" set of competences, i.e., both technical or domain specific and "soft" skills (methodological, personal and social)*. While traditionally the soft skills have been considered as subordinated to the technical or domain specific skills, the recent trends (such as digitalization, smart agriculture and synthetic biology) and the rapidly evolving job market have made these skills fundamental. This opens up the following question: do the current study programs effectively provide the skills, tools, methodologies, and approaches required by the job market?

Finally, as shown in Table 3 and 4, *some subject areas (i.e., ICT and ENG) are characterized by a significant gender imbalance, in particular at the Bachelors level, which does not seem to have been reduced from 2013 to 2017*. How can this imbalance be leveled-off in the near future? Which policy interventions and awareness campaigns might be carried out? In order to analyze whether the HE system is able to adequately address the four needs identified above, we discuss the characteristics of the students and the "new" teaching tools and methods in Section III and the current HE programs in Section IV.

## III. Characteristics of students, "new" teaching tools/methods and assessment

The generation theory proposes that the era in which people are born and grow up in determines their development and views of society and the world.[49],[50] Five generations have been recognized and are characterized by a set of distinctive features: (1) the *Baby Boomer* generation (born from 1946 to1964); (2) *Generation X* (born from 1965 to1980); (3) *Generation Y* (born from 1981 to 1994, also known as Millennials); (4) *Generation Z*

[49] William Strauss and Neil Howe, *Generations: The History of America's Future, 1584 to 2069* (New York: William Morrow & Company, 1991).

[50] Sezin Baysal Berkup, "Working with generations X and Y in *generation Z* period: Management of different generations in business life," *Mediterranean Journal of Social Sciences* 5, no. 19 (2014): 218-229.

(born from 1995 to 2009); and *Generation Alpha* (born from 2010 to 2025). While HE professors and teachers – as well as many students of lifelong learning programs – belong to the *Baby Boomer, and X and Y Generations*, the current students of the HE system belong to *Generation Z*. This generation has the following characteristics:[51] (1) they are materially endowed and technologically saturated; (2) they are digital integrators (technology is integrated into almost all areas of their lives) or digital natives (i.e., "native speakers of the digital language of computers, communication, video games and the Internet");[52] (3) they are globally focused; (4) they are visually engaged (preferring to watch a video on a topic rather than reading a book or an article); and (5) they are socially defined (extensively connected to and shaped by peers). In contrast, the HE students of the near future (from 2028 onwards) will instead belong to *Generation Alpha*. While the features of this generation still need to be fully defined, scholars propose that they will be even more digitally connected and visual engaged, e.g., using smartphones, tablets and wearable devices more naturally, growing up with the familiar voices of Siri, Alexa, and Google Assistant, spending more time on devices than face-to-face social time, and using You Tube as a major outlet for self-education.[53],[54] In general, scholars argue that *Generation Z* and *Alpha* students "think and process information fundamentally differently from their predecessors".[55],[56],[57] These include: they are "multiprocessing" i.e., they do several things simultaneously; they learn at higher speeds, making random connections and processing visual and dynamic information more effectively; and they prefer discovery-based learning.[58]

---

[51] Mark McCrindle, M. and Emily Wolfinger, *The ABC of XYZ: Understanding the global generations* (University of New South Wales, 2009).

[52] Sue Bennett, Karl Maton, and Lisa Kervin, "The 'Digital Natives' Debate: A Critical Review of the Evidence," *British Journal of Education Technology* 39, no. 5 (2008): 775-786.

[53] Tiziano Botteri and Guido Cremonesi, "Millennials e oltre!: Nuove generazioni e paradigmi manageriali" (Milano: Franco Angeli, 2019).

[54] Bruce I. Carlin, Li Jiang, and Stephen A. Spiller, "Millennial-style learning: Search intensity, decision making, and information sharing," *Management Science* 64, no. 7 (2018): 3313-3330.

[55] Marc Prenksy, "Digital natives, digital immigrants," *On the Horizon 9*, no. 5 (2001): 1–6.

[56] Ildikó Horváth, Innovative engineering education in the cooperative VR environment. In 2016 7th IEEE International Conference on Cognitive Infocommunications (CogInfoCom) (pp. 000359-000364), IEEE (2016).

[57] Arlene J. Nicholas, Preferred Learning Methods of *Generation Z*, Northeast Business and Economics Association 46th Annual Conference (2019).

[58] Bennett, Maton, and Kervin, "The 'Digital Natives' Debate", 775-786.

As a consequence the HE systems has to cater for the coexistence of different generations of both teachers and learners with different characteristics, preferences, styles, and needs. This mix of Generations in HE institutions blurs the boundaries between Generations and is reflective of society in general, and presents challenges around issues of teaching and learning, and of expectations. HE institutions have recognized and are beginning to responding to these challenges. We observe a changing face of learning with less emphasis on information acquisition and more emphasis on understanding and decision making.[59] The HE system has adopted two paradigm shifts in the last few years: from *teaching* to *learning* (i.e., "teaching is valuable if and when it leads to learning, but not otherwise")[60] and also from *learning* to *learners*, focusing on individual students' progress through the curriculum and on individual differences among students, and developing learners that can keep learning for their lifetime. The second shift has been enhanced by the increasing adoption of the learning-by-doing approach, theorized by philosopher John Devey, which is based on the fact that students learn best when they are actively involved in meaningful and important tasks.[61] The two abovementioned paradigm shifts are increasingly important for preparing students for work and careers in which (a) jobs and the competences required are changing very rapidly,[62] and (b) information and knowledge is easily accessible *via* the Internet.[63] Despite the abovementioned changes, a large majority of HE institutions still rely mostly on the traditional frontal lecture model[64],[65] and this is probably because senior members of staff are from the *Baby Boomers* and *X Generations*.

[59] Harvey Siegel, *Educating reason*. Routledge (2013).

[60] Robert B. Barr and John Tagg, "From Teaching to Learning: A New Paradigm for Undergraduate Education," *Change* 27, no. 6 (1995): 12-25.

[61] Ghassan Frache, Hector Nistazakis, and George S. Tombras, "Reengineering engineering education: developing a constructively aligned learning-by-doing pedagogical model for 21st century education", in *2017 IEEE Global Engineering Education Conference (EDUCON)* (IEEE, 2017), 1119-1124.

[62] Wim Westera, "Competences in education: a confusion of tongues," *Journal of Curriculum Studies* 33, no. 1 (2001): 75-88.

[63] Chong Siong Choy and Choi Yong Suk, "Critical factors in the successful implementation of knowledge management," *Journal of Knowledge Management Practice* 6, no. 1 (2005): 234-258.

[64] Gianni Barbato, Roberto Moscati, and Matteo Turri, "Is the role of academics as teachers changing? An exploratory analysis in Italian universities," *Tuning Journal for Higher Education* 6, no. 2 (2019): 97-126.

[65] Marco Ronchetti, "Using video lectures to make teaching more interactive", *International Journal of Emerging Technologies in Learning* 5, no. 2 (2010): 45-48.

A very wide set of teaching tools and methods, enabled by the digitalization, has also been tested or introduced in HE in recent years. Video-based learning (VBL) has a long history as a teaching tool. The first experiments were indeed carried out during the Second World War to train soldiers, and is currently very popular.[66] The effectiveness of this tool lies in the suggestion that students remember 10% of what they read, 20% of what they hear, 30% of what they see, and 50% of what they see and hear.[67] Even more effective, despite being less popular due to their higher implementation barriers (e.g., availability/suitability, resources required and risks), are serious games.[68,69] These games exploit the notion that (a) students remember 70% of what they say and write[70] and (b) motivated students achieve better results.[71] Similarly, e-learning tools can be used to enhance challenge-based learning, i.e., a teaching methodology that engages students to resolve real-world challenges. More recently, other technology-oriented teaching tools have been investigated. A technology with a very high potential to enhance teaching is augmented and virtual reality.[72] The ambition of this is to allow students to virtually walk through laboratories, factories, fields, and forests, and other geographical areas anywhere in the world. Similarly, eye-tracking has started to be employed in education to highlight cognitive load, detect behavioral response, and adapt presentation elements.[73] Teacherbots (virtual teaching assistants based on Artificial Intelligence)[74] also have great potential and most likely for online courses. However, while all the teaching tools and methods mentioned above have significant potential, they are still only used at an experimental level and mainly for productivity-enhancement (teaching

---

[66] Ahmed Mohamed Fahmy Yousef, Mohamed Amine Chatti, and Ulrik Schroeder, "The state of video-based learning: A review and future perspectives," *International Journal on Advances in Life Sciences* 6, no. 3/4 (2014): 122-135.

[67] Edgar Dale, *Audiovisual Methods in Teaching* (New York: Dryden Press, 1969).

[68] Jonathan Lean et al., "Simulations and games: Use and barriers in higher education," *Active Learning in Higher Education 7*, no. 3 (2006): 227-242.

[69] Mehmet Kosa et al., "Software engineering education and games: a systematic literature review," *Journal of Universal Computer Science* 22, no. 12 (2016): 1558-1574.

[70] Dale, "Audiovisual Methods in Teaching".

[71] Rosemary Garris, Robert Ahlers, and James E. Driskell, "Games, motivation, and learning: A research and practice model," *Simulation & gaming*, 33, no. 4 (2002): 441-467.

[72] Rula Al-Azawi et al.,"Exploring the Potential of Using Augmented Reality and Virtual Reality for STEM Education", in *Learning Technology for Education Challenges: 8th International Workshop* (Springer, 2019), 36.

[73] Jonathan L. Rosch, and Jennifer J. Vogel-Walcutt, "A review of eye-tracking applications as tools for training", *Cognition, Technology & Work 15*, no. 3 (2013): 313-327.

[74] Maderer, J., "Artificial intelligence course creates AI teaching assistant" (Georgia Tech News Center, May 2016).

high number of students with few resources) rather than for pedagogical reasons.[75] Furthermore, challenges remain including (1) whether the new teaching tools and methods really do enhance the learning process at a large scale and (2) whether the teachers and professors – mostly belonging to the *Baby Boomers, Generations X* and *Y* – are able to exploit the potential of such new teaching tools and what training they require.

There are many tools and methods enabled by digitalization that might be beneficial for the efficiency and effectiveness of teaching. Let us think for instance of the use of augmented and virtual reality as well as simulation tools in clinical and medical training, to allow students to try different surgeries or other cares in a "protected" environment without any risks for the patients or the students themselves. While these new tools and methods are only adopted at an experimental level, and mostly by the professors who have developed them and have therefore the knowledge for using them in their teaching activities (e.g., computer science or artificial intelligence professors), we predict that they will be more widely adopted in the coming years.

Finally, distance learning and e-learning tools have been increasingly adopted by HE institutions all over the world[76] and this has accelerated at an unprecedented rate as a result of the Coronavirus pandemic. Some of the tools mentioned above for on-campus education, such as serious games, augmented and virtual reality, and virtual teaching assistants, might also be effectively employed in case of e-learning. Besides them, there are also tools more specifically designed for e-learning, such as dashboard applications,[77] microblogging platforms,[78] geoportals[79] and social networks.[80] Furthermore, a prominent role in this context is played by e-learning platforms, such as

[75] Sian Bayne, "Teacherbot: interventions in automated teaching," *Teaching in Higher Education* 20, no. 4 (2015): 455-467.

[76] Asma Ali Mosa Al-araibi et al.,"A model for technological aspect of e-learning readiness in higher education," *Education and Information Technologies* 24, no. 2 (2019): 1395-1431.

[77] Katrien Verbert et al., "Learning analytics dashboard applications," *American Behavioral Scientist* 57, no. 10 (2013): 1500-1509.

[78] Martin Ebner et al., "Microblogs in Higher Education–A chance to facilitate informal and process-oriented learning?", *Computers & Education* 55, no. 1 (2010): 92-100.

[79] Marianna Sigala, "Investigating the role and impact of geovisualisation and geocollaborative portals on collaborative e-learning in tourism education," *Journal of Hospitality, Leisure, Sport & Tourism Education* 11, no. 1 (2012): 50-66.

[80] Eva Kassens-Noor, "Twitter as a teaching practice to enhance active and informal learning in higher education: The case of sustainable tweets", *Active Learning in Higher Education* 13, no. 1 (2012): 9-21.

Moodle (Modular Object-Oriented Dynamic Learning Environment), or by videoconference and online collaboration software, such as Microsoft Teams, Skype, or Zoom.[81] For a detailed review of e-learning and e-mentoring see papers by Rodriguez and by Tinoco-Giraldo and their colleagues.[82,83] While the restrictions during the COVID/19 pandemic have completely changed the education landscape (see the conceptual paper by Cesco and colleagues),[84] the use of the abovementioned tools – with the exception Moodle and its basic functions of an online repository – have been until recently mostly limited to online Universities.

One significant challenge for distance learning and e-learning tools within HE institutions is that *while the students are often ready to use the e-learning tools/methods, it is not always the case for the teachers/professors, who might not be able to effectively teach their technical or domain specific skills through these new tools*.

Taking into account the different generations of students and teachers/professors, we currently have *"digital immigrants"* (Baby Boomers, *Generations X* and *Y*) teaching *digital natives* (*Generations Z* and *Alpha*).[85] While this might not be a significant problem for the teaching of technical or domain specific skills, it is more problematic for the "soft" skills (methodological, personal and social) that have emerged to be particularly important skills for new graduates. This might also be one of the main reasons why some current HE programs tend to focus mostly on technical or domain specific skills and consider the "soft" skills as subordinated to them.

The challenge for the HE system is therefore to become better able to teach both technical (domain specific) skills and "soft" skills (methodological, personal and social) by considering the characteristics, needs, and expectations of the different generations of students and leveraging the new digitally enabled teaching tools and methods. This can be achieved only through Faculty/staff who understand the different generations and are able to use the abovementioned teaching tools to great effect. There is therefore a need to both

[81] Dan Benta,, Gabriela Bologa, and Ioan Dzitac, 2014, "E-learning platforms in higher education. case study", *Procedia Computer Science* 31 (2014): 1170-1176.

[82] Helena Rodrigues et al., "Tracking e-learning through published papers: A systematic review," *Computers & Education 136* (2019): 87-98.

[83] Harold Tinoco-Giraldo, Eva María Torrecilla Sánchez, and Francisco José García-Peñalvo, "E-Mentoring in Higher Education: A Structured Literature Review and Implications for Future Research," *Sustainability* 12, no. 11 (2020): 4344.

[84] Cesco Stefano et al., "Higher Education in the First Year of COVID-19: Thoughts and Perspectives for the Future", *International Journal of Higher Education* 10, no. 3 (2021): 285-294.

[85] Prenksy, "Digital natives, digital immigrants".

rejuvenate HE Faculty/staff and also to train the more senior teachers/professors who are, thanks to their experience, the ones with the stronger technical (domain specific) skills. This need is particularly significant in some European countries, such as Italy (see the detailed analysis carried out by Labini and Zapperi),[86] in which despite the requests and the declarations of policy makers, the average age of the academic staff is still high (35% of the Faculty are 55 or older).[87] The digitally enabled teaching tools and methods – as well as the different generational characteristics – might also be leveraged to increase the participation of female students in particular in ICT and ENG programs, where the gender imbalance is particularly poor (see Section II).

Finally, the definition of internationally recognized reference points (e.g., learning outcomes and competencies) for different subject areas – as well as of suitable approaches to assess them – is also particularly important for making HE programs comparable, compatible, and transparent across countries. In this respect it is worth mentioning the project *TUNING Educational Structures in Europe*, which has proposed an approach to (re-) design, develop, implement, and evaluate high-quality HE programs, ensuring standardization but at the same time also preserving the rich diversity of European HE systems.[88] This approach has been extensively applied in many subject areas both in Europe and around the world. The TUNING project defines *competencies* as qualities, abilities, capacities or skills that are developed by and that belong to the students, and *learning outcomes* as measurable results of a learning experience which allows us to ascertain to which level a competence has been obtained (or enhanced).[89] The Holistic assessment approach to fully acquire a competence foresees the three main aspects of knowledge, skills, and attitudes (or behaviors).[90] A similar standardization initiative – focused on the ENG area – is the EUR-ACE Accreditation proposed by the European Network for Accreditation of Engineering Education (ENAEE).[91]

---

[86] Francesco Sylos Labini and Stefano Zapperi, *I ricercatori non crescono sugli alberi* (Gius. Laterza & Figli Spa., 2011).

[87] Eurostat, https://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do.

[88] Marja Kaunonen et al., "Tuning educational structures in Europe: Guidelines and reference points for the design and delivery of degree programmes in nursing. Tuning educational structures in Europe" (University of Groningen, 2018).

[89] Kees Kouwenaar, "Changing paradigms: towards competency-assessment in admission to master's programmes in Europe: a review," *Tuning Journal for Higher Education* 3, no. 1 (2015): 99-135.

[90] Julia González, J. and Robert Wagenaar, Tuning Educational Structures in Europe II. La contribución de las universidades al proceso de Bolonia. (University of Deusto Press, 2006).

[91] https://www.enaee.eu/eur-ace-system/.

## IV. HE programs

At the core of HE systems are ***the "traditional" Bachelor's and Master's degrees*** (possibly followed by doctoral degrees) that follow the Bologna process on many European countries. Within the technical-scientific field, these degrees belong to the following thematic areas:[92] Natural Sciences, Mathematics and Statistics (biology, biochemistry, environmental sciences, natural environments and wildlife, chemistry, earth sciences, physics, mathematics, statistics); Information and Communication Technologies (computer use, database and network design and administration, software and applications development and analysis); Engineering, Manufacturing and Construction (chemical engineering and processes, environmental protection technology, electricity and energy, electronics and automation, mechanics and metal trades, motor vehicles, ships and aircraft, manufacturing and processing, food processing, materials, textiles, mining and extraction, architecture and town planning, building and civil engineering); and Agriculture, Forestry, Fisheries and Veterinary (crop and livestock production, horticulture, forestry, fisheries, and veterinary). The focus of these "traditional" degrees has evolved in the last few years and they now provide to students not only a deep knowledge of the relevant subject matters (see above), but also a set of transversal skills, that are recognized as being increasingly important in the current scenario (see Section II). These skills include the ability to analyze and evaluate data, critical thinking, problem solving, ethics, organizational & collaboration skills, independence, adaptability & resilience, and interpersonal skills.[93,94] While the knowledge of the subject matters can be primarily taught through *in classroom activities* (lessons and exercises), the other skills tend to be better acquired *outside the classroom*, e.g., during field/company visits, group work, internships, co-curricular experiences, and on-campus/off-campus jobs.[95]

Alongside the "traditional" Bachelor's and Master's degrees, which are usually focused on a specific thematic area, some Universities have launched

---

[92] UNESCO Institute for Statistics. (2015). International Standard Classification of Education Fields of Education and Training 2013 (ISCED-F 2013): Detailed Field Descriptions.

[93] European Network for Accreditation of Engineering Education - ENAEE (2020), https://www.enaee.eu/eur-ace-system/standards-and-guidelines/#standards-and-guidelines-for-accreditat ion-of-engineering-programmes.

[94] Luis Mayor et al., "Skill development in food professionals: a European study," *European Food Research and Technology 240,* 5 (2015): 871-884.

[95] Adam Peck et al., "The co-curricular connection: The impact of experiences beyond the classroom on soft skills", *NACE Journal* 76, no. 3 (2016): 30-34.

interdisciplinary and multidisciplinary programs. Some of these programs – such as management engineering, ecology, mechatronics, bioinformatics, agribusiness and public health – have been consolidated and are currently regarded as traditional programs. Others have been introduced more recently and are still at an experimental stage. Some interesting examples are represented by the degrees in medicine and biomedical engineering, in cyber physical systems, management and informatics, and digital art and technologies.[96]

To leverage these activities outside the classroom mentioned above, many European countries have launched a set of ***Higher Vocational Education and Training (VET) programs***, such as: post-secondary programs outside higher education at ISCED levels 4 or 5; qualifications acquired based on the recognition of non-formal and informal learning (e.g., Master craftsperson qualifications); and various continuing vocational education and training CVET programs outside the formal system.[97] In the five countries considered in this paper, examples of these programs are: the Higher National Certificates and Higher National Diplomas in UK; the Advanced technician certificate (BTS - *Brevet de technicien supérieur*) in France; the Higher technical institutes (ITS) in Italy; and the higher-level cycles of Professional Training leading to Higher Technician diploma in Spain.

Other ***Higher VET programs*** *in a broad sense*, which are formally part of the HE system, are also offered in most European countries. For example these can be short cycle higher education, professional bachelor's and professional master's degrees or dual studies programs at Bachelor or Master levels (or even at Doctoral level). Prominent examples of professional degrees are those offered by the German *Fachhochschulen* (or University of Applied Sciences).[98] Other countries – such as Italy[99] – have instead launched these programs only very recently (in academic year 2018-2019).

The goal of the higher VET programs (both in a strict and in a broad sense) is to offer a training that is more practically oriented and to attract students that are not interested in traditional Bachelor's and Master's

[96] Nadezda Kunicina et al., "Student Engagement in Cross-Domain Innovation Development and Its Impact on Learning Outcomes and Career Development in Electrical Engineering", in *2019 IEEE Global Engineering Education Conference,* (IEEE, 2019), 661-668.

[97] Daniela Ulicna, Karin Luomi Messerer, and Monika Auzinger *Study on higher Vocational Education and Training in the EU* (European Union Directorate-General for Employment, Social Affairs and Inclusion, 2016).

[98] Guy Neave, "Foundation or Roof? The Quantitative, Structural and Institutional Dimensions in the Study of Higher Education", *European Journal of Education* 24, no. 3 (1989), 211-222.

[99] Lauree professionalizzanti (professionalizing bachelor degrees) introduced by the DM n. 987 of 12.12.2016.


**Tuning Journal for Higher Education**
© University of Deusto • p-ISSN: 2340-8170 • e-ISSN: 2386-3137 • Volume 8, Issue No. 2, May 2021, 85-117 •
doi: http://dx.doi.org/10.18543/tjhe-8(2)-2021pp85-117 • http://www.tuningjournal.org/

degrees, providing them more advanced but still immediately useful and practical skills. While these programs might significantly contribute to address one of the issues identified in Section II (i.e., to increase the number of graduates and trained people), their impact in practice is still limited considering the number of students enrolled (the students of these programs are less than 15% of the number enrolled to Bachelor's degrees in Europe).[100]

Another very important set of VET programs is represented by the ***lifelong learning programs***. These are aimed at upskilling or reskilling employees during their working career. They have been long neglected by European Universities and mostly left to professional chambers or other training institutions, with some prominent exceptions (e.g., the Master in Business Administration). Only recently European universities have started to acknowledge the importance of these programs and to extend their teaching offer in this direction.[101] A key aspect in these programs is the recognition (or accreditation) of prior learning, which varies significantly across countries and HE institutions.

All the programs presented above might be offered both on campus and as distance/online learning. Full online Bachelor and Master degrees still represent a minority of HE programs in Europe and are often offered by online Universities. However, these full-online programs are gaining popularity in North America and Asia and are offered also by traditional HE institutions.[102] More popular all over the world are online VET programs as well as the Massive Open Online Courses (MOOCs), open-access online courses that allow unlimited (massive) participation.[103]

Finally, it is worth mentioning programs for ***training the trainers.*** All five countries analyzed in this paper have specific programs for training teachers at different levels from kindergarten to High School. However, little emphasis has been placed on the pedagogical training of University professors, lecturers and teachers, despite the paramount importance of this topic. A prominent exception is in the United Kingdom, where there is a long tradition of teaching development programs for new academic staff[104] and this is now increasing in other European countries.

---

[100] Eurostat, https://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do.

[101] Nina Volles, "Lifelong learning in the EU: changing conceptualizations, actors, and policies," *Studies in Higher Education 41,* no. 2 (2016): 343-363.

[102] Olaf Zawacki-Richter and Adnan Qayyum, *Open and Distance Education in Asia, Africa and the Middle East: National Perspectives in a Digital Age* (Springer, 2019).

[103] Kaplan and Haenlein, "Higher education and the digital revolution", 441-450.

[104] Andria Hanbury, Michael Prosser, and Mark Rickinson, "The differential impact of UK accredited teaching development programmes on academics' approaches to

In summary, while the current offering of HE programs is wide and varied, and is properly organized at multiple levels, most of the attention of HE institutions is currently still focused mainly on "traditional" Bachelor's and Master's degrees. This highlights certain issues and opportunities – in addition to those identified in Sections II and III – that should be considered by HE institutions, students, and policy makers.

First, the *current higher VET programs (both in a strict and in a broad sense) do not attract a significant number of students compared to traditional Bachelor's degree and, therefore, they do not significantly contribute to increasing the number of graduates and trained people*. This issue might be traced back to different factors (both internal and external) that deserve to be analyzed in detail. *Internal factors* include the low attractiveness of the current offer of VET programs among prospective students due to their narrow thematic or applied/practical focus, the low awareness of their existence, and the low number of VET programs (and related study places) currently offered. Moreover, the rather conservative nature that characterizes the academic environment, making it less inclined to provide new, innovative and progressive HE programs compared to the classic one (classical forms of Bachelors and Masters programs), certainly contributed to this limited diffusion of VET programs, at least at the University level. A further aspect that should be considered is related to which institutions should offer the VET programs, i.e., only Universities, only professional chambers/associations, only *ad-hoc* training institutions, all these actors separately, or all these actors together (through some forms of cooperation/joint-ventures). In this respect, it should be noted that Universities carry out not only didactic activities but also research and this allows them to be at the frontiers of knowledge in the different disciplines. Professional chambers/associations and *ad-hoc* training institutions cannot therefore in our view exclude Universities when designing and teaching VET programs without losing this novel knowledge which is the basis for cutting edge education. Other *factors external* to the VET programs – such as the employability and career development opportunities of graduates as well as the legislation and regulations – might also play a significant role in affecting the low intake/enrolment. It is worth noting that EU member states are considering the future of VET programs and their regulation, including as part of the Covid-19 recovery strategy.[105] In this respect, policy makers should consider:

teaching," *Studies in Higher Education* 33, no. 4 (2008): 469-483.

[105] https://ec.europa.eu/education/policies/eu-policy-in-the-field-of-vocational-education-and-training-vet_en.

(1) a rationalization of VET qualifications to remove duplications, increase value to employers and individuals, and improve transparency and functionality; (2) a reorganization of them into clusters, routes or vocational pathways; (3) legal value of the degree and positioning with respect to a "traditional" HE degree; (4) a fine-tuning of the "direct" access path to the professions/job markets.[106]

Second, *European Universities have long neglected lifelong learning programs and have only recently started to acknowledge their importance*. Leaving these programs in the hands of professional chambers or other training institutions has some advantages (for instance it might contribute to ensure that the subjects taught are relevant/useful for the practice) but also some significant risks. First and foremost is the focus on the current, rather than future, needs of particular sectors or professions (rather than of the society as a whole). The reasoning concerning the need to involve Universities – whose mission includes not only teaching but also research (i.e., knowledge development) – in VET programs in order to transfer novel and cutting-edge knowledge applies also to lifelong learning programs.

Third, *online Bachelor and/or Master degrees represent a minority of HE programs in Europe and are mostly offered by telematic universities*. Considering the changing needs and characteristics of students presented in Chapter 3, and the trends in USA and Asia concerning online programs, European HE institutions should consider launching online study programs to expand their teaching offer and also to making some courses/modules available online to meet the needs of some categories of students (for instance working students or students living in remote areas). This might also contribute to achieving one of the goals highlighted in Chapter 2, i.e., to increase the number of graduates and trained people. However, this requires significant infrastructural investments, training of the teachers/professors, and re-thinking of teaching methods, formats, and activities. Particular attention must be devoted to the re-design of some training activities that currently require physical presence to develop critical practical skills (e.g., lab exercises and company internships).

Fourth, *while some training-the-trainers programs exist, insufficient emphasis is placed on the pedagogical training of HE teachers/professors in many countries*. This is critical and in particular considering the different generations of students and teachers and the "new" digitally enabled teaching

[106] Bridget Wibrow and Joanne Waugh, "Rationalising VET qualifications: selected international approaches" (Research summary, National Centre for Vocational Education Research, September 2020).


**Tuning Journal for Higher Education**
© University of Deusto • p-ISSN: 2340-8170 • e-ISSN: 2386-3137 • Volume 8, Issue No. 2, May 2021, 85-117 •
doi: http://dx.doi.org/10.18543/tjhe-8(2)-2021pp85-117 • http://www.tuningjournal.org/

methods/opportunities. HE institutions should therefore reflect on whether it would be appropriate to include some (mandatory) programs on pedagogical concepts and teaching methods for newly appointed teachers/professors. In addition, making some form of education training could be mandatory for those seeking promotions in their HE system.

## V. Conclusions

In this paper we sought to answer two significant questions for the technical-scientific HE system: (1) are current study programs in this field suitable to prepare students for their professional future and (2) are study programs adequate to deliver the needs of the current and new generations of students (*generation Z* and *Alpha*)? To do this we carried out a set of different analyses.

We first considered the number of professionals and the skills required by the job market, as well as the number of students enrolled in technical-scientific HE study programs in the top five European countries by GDP. These analyses allowed us to identify three significant issues that should be considered by HE institutions, students, and policy makers: *(1) there is a significant need for more graduates (both Bachelor and Master) and trained people, (2) these graduates are needed in specific fields/disciplines according to the job market, and (3) that graduates require the "right" set of competences that are both technical, domain specific skills, and "soft" methodological, personal and social skills.*

We then discussed the characteristics of the different generations of students and of their teachers/professors, and the new teaching tools and methods enabled by technology. This allowed us to highlight the paradox that we currently have of *digital immigrants* teaching *digital natives* and that this can lead to problems particularly in the teaching of "soft" skills, as well as the fact that *the new tools and methods have so far mainly been adopted at an experimental level, by those who developed them, and are not widely used.*

Finally, we analyzed the different types of HE study programs offered by European universities and highlighted that: (1) the *current higher VET programs do not attract a significant number of students compared to traditional Bachelor's degrees; (2) European universities have neglected lifelong learning programs and have only started to acknowledge their importance and invest in them very recently;* and *(3) online Bachelors and Masters degrees represent a minority of HE programs in Europe and are mainly offered by telematic universities.*

All the challenges and reasonings for the HE system presented in this paper are part of a series of more general challenges (or paradoxes) that both our universities and our society is currently facing. These challenges can be connected with the UN Sustainable Development Goals (SDG) cited in the introduction section.

In summary, the HE system faces a twofold challenge: (1) developing novel knowledge through research activities and improving innovation, and (2) finding effective ways to transfer this knowledge to the students whose diversity is increasing and who have different and continuously changing needs and skills. This challenge is now more important than ever considering the disruptive paradigm in science and technology, the rapid evolution of the job markets and the emergence of new teaching tools and methods enabled by the digitalization. Considering its current status and the means at its disposal, we consider that many HE systems will successfully adapt to overcome these challenges.

## Bibliography

Al-araibi, Asma Ali Mosa, Mohd Naz'ri bin Mahrin, Rasimah Che Mohd Yusoff, and Suriayati Binti Chuprat, "A model for technological aspect of e-learning readiness in higher education," *Education and Information Technologies* 24, no. 2 (March 2019): 1395-1431.

Al-Azawi, Rula, Ali Albadi, Raziyeh Moghaddas, Jonathan Westlake, "Exploring the Potential of Using Augmented Reality and Virtual Reality for STEM Education", in *Learning Technology for Education Challenges: 8th International Workshop* (Springer, 2019), 36.

Barbato, Gianni, Roberto Moscati, and Matteo Turri, "Is the role of academics as teachers changing? An exploratory analysis in Italian universities," *Tuning Journal for Higher Education* 6, no. 2 (May 2019): 97-126.

Barr, Robert B., John Tagg, "From Teaching to Learning: A New Paradigm for Undergraduate Education," *Change* 27, no. 6 (November/December 1995): 12-25.

Bartocci Liboni, Lara, Luciana Oranges Cezarino, Charbel José Chiappetta Jabbour, Bruno Garcia Oliveira, and Nelson Oliveira Stefanelli, "Smart industry and the pathways to HRM 4.0: implications for SCM," *Supply Chain Management: An International Journal* 24, no. 1 (March 2019): 124-146.

Bayne, Sian, "Teacherbot: interventions in automated teaching," *Teaching in Higher Education* 20, no. 4 (April 2015): 455-467.

Bennett, Sue, Karl Maton, and Lisa Kervin, "The 'Digital Natives' Debate: A Critical Review of the Evidence," *British Journal of Education Technology* 39, no. 5 (August 2008): 775-786.

Benta, Dan, Gabriela Bologa, and Ioan Dzitac. I., 2014, "E-learning platforms in higher education. case study", *Procedia Computer Science* 31 (2014): 1170-1176.

Berkup, Sezin Baysal, "Working with generations X and Y in *generation Z* period: Management of different generations in business life," *Mediterranean Journal of Social Sciences* 5, no. 19 (September 2014): 218-229.

Botteri, Tiziano, and Guido Cremonesi, "Millennials e oltre!: Nuove generazioni e paradigmi manageriali" (Milano: Franco Angeli, 2019).

Bremer, Anne, "Diffusion of the "Internet of Things" on the world of skilled work and resulting consequences for the man-machine interaction," *Empirical Research in Vocational Education and Training* 7, no. 8 (August 2015).

Carlin, Bruce I., Li Jiang, and Stephen A. Spiller, "Millennial-style learning: Search intensity, decision making, and information sharing," *Management Science* 64, no. 7 (July 2018): 3313-3330.

Brunello, Giorgio and Patricia Wruuck Skill shortages and skill mismatch in Europe: a review of the literature, IZA Discussion Paper No. 12346, 2019, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3390340.

Cacciolatti, Luca, Soo Hee Lee, and Cecilio Mar Molinero, "Clashing institutional interests in skills between government and industry: An analysis of demand for technical and soft skills of graduates in the UK", *Technological Forecasting and Social Change*, 119 (June 2017): 139-153.

Cesco, Stefano, Vincenzo Zara, Alberto F. De Toni, Paolo Lugli, Giovanni Betta, Alexander C.O. Evans, Guido Orzes, "Higher Education in the First Year of COVID-19: Thoughts and Perspectives for the Future", *International Journal of Higher Education* 10, no. 3 (March 2021): 285-294.

Choy, Chong Siong, and Choi Yong Suk, "Critical factors in the successful implementation of knowledge management," *Journal of Knowledge Management Practice* 6, no. 1 (June 2005): 234-258.

Dale, Edgar, *Audiovisual Methods in Teaching* (New York: Dryden Press, 1969).

De Vos, Jurriaan M., Lucas N. Joppa, John L. Gittleman, Patrick R. Stephens, and Stuart L. Pimm, "Estimating the normal background rate of species extinction," *Conservation biology* 29, no. 2 (April 2015): 452-462.

Matt, Dominik T., Guido Orzes, Erwin Rauch, and Patrick Dallasega, "Urban production–A socially sustainable factory concept to overcome shortcomings of qualified workers in smart SMEs," *Computers & Industrial Engineering*, *139* (January 2020): 105384.

Easterly III, R. G., Anna J. Warner, Brian E. Myer, Alexa J. Lamm, and Ricky W. Telg,"Skills Students Need in the Real World: Competencies Desired by Agricultural and Natural Resources Industry Leaders," *Journal of agricultural education*, 58(4) (2017), 225-239.

Ebner, Martin, Conrad Lienhardt, Matthias Rohs, Iris Meyer, "Microblogs in Higher Education–A chance to facilitate informal and process-oriented learning?", *Computers & Education* 55, no. 1 (August 2010): 92-100.

Erstad Ola, "Educating the digital generation," *Nordic Journal of Digital Literacy* 5, no. 1 (2010): 56-71.

European Union, Education and Training Monitor 2019, https://ec.europa.eu/education/sites/education/files/document-library-docs/volume-1-2019-education-and-training-monitor.pdf

Fareri, Silvia, Gualtiero Fantoni, Filippo Chiarello, Elena Coli, and Anna Binda, "Estimating Industry 4.0 impact on job profiles and skills using text mining," *Computers in Industry* 118 (June 2020): 103222.

Fisch, Karl, Scott McLeod, and J. Brenman, *Did you know; Shift happens-Globalization; information age* (2015).

Fontaine, Benoît et al., "New species in the Old World: Europe as a frontier in biodiversity exploration, a test bed for 21st century taxonomy," *PLoS One* 7, no. 5 (May 2012): e36881.

Frank, Alejandro Germán, Lucas Santos Dalenogare, and Néstor Fabián Ayalac, "Industry 4.0 technologies: Implementation patterns in manufacturing companies," *International Journal of Production Economics 210* (April 2019): 15-26.

Garris, Rosemary, Robert Ahlers, and James E. Driskell, "Games, motivation, and learning: A research and practice model," *Simulation & gaming*, 33, no. 4 (December 2002): 441-467.

Ge, Yufeng, J. Alex Thomasson, and Ruixiu Sui, "Remote sensing of soil properties in precision agriculture: A review," *Frontiers of Earth Science* 5, no. 3 (2011): 229-238.

Frache, Ghassan, Hector Nistazakis, George S. Tombras, "Reengineering engineering education: developing a constructively aligned learning-by-doing pedagogical model for 21st century education", in *2017 IEEE Global Engineering Education Conference (EDUCON)* (IEEE, 2017), 1119-1124.

González, Julia, J., and Robert Wagenaar, Tuning Educational Structures in Europe II. La contribución de las universidades al proceso de Bolonia. (University of Deusto Press, 2006).

González-Alemán, Juan J., Salvatore Pascale, Jesús Gutierrez-Fernandez, Hiroyuki Murakami, Miguel A. Gaertner, and Gabriel A. Vecchi "Potential increase in hazard from Mediterranean hurricane activity with global warming," *Geophysical Research Letters 46,* no. 3 (February 2019): 1754-1764.

Hecklau Fabian, Mila Galeitzke, Sebastian Flachs, and Holger Kohl, "Holistic approach for human resource management in Industry 4.0," *Procedia CIRP* 54 (2016): 1-6.

Horváth, Ildikó, Innovative engineering education in the cooperative VR environment. In 2016 7th IEEE International Conference on Cognitive Infocommunications (CogInfoCom) (pp. 000359-000364), IEEE (2016).

Humburg, Martin, and Rolf van der Velden, "Skills and the graduate recruitment process: evidence from two discrete choice experiments," *Economics of Education Review*, 49 (December 2015): 24-41.

İlhak, Mehmet İlhan, Selahaddin Orhan Akansu, Nafiz Kahraman, Sebahattin Ünalan, "Experimental study on an SI engine fuelled by gasoline/acetylene mixtures," *Energy* 151 (May 2018): 707-714.

Kassens-Noor Eva, "Twitter as a teaching practice to enhance active and informal learning in higher education: The case of sustainable tweets", *Active Learning in Higher Education* 13, no. 1 (February 2012): 9-21.

Kaunonen, Marja, Mary Gobbi, Katharine Meier, Birte Østergaard, Dorthe Susanne Nielsen, Ian McCready, "Tuning educational structures in Europe: Guidelines and reference points for the design and delivery of degree programmes in nursing. Tuning educational structures in Europe" (University of Groningen, 2018).

Kosa, Mehmet, Murat Yilmaz, Rory V. O'Connor, and Paul M. Clarke, "Software engineering education and games: a systematic literature review," *Journal of Universal Computer Science* 22, no. 12 (2016): 1558-1574.

Kouwenaar, Kees, "Changing paradigms: towards competency-assessment in admission to master's programmes in Europe: a review," *Tuning Journal for Higher Education* 3, no. 1 (May 2015): 99-135.

Lean, Jonathan, Jonathan Moizer, Michael Towler, and Caroline Abbey, "Simulations and games: Use and barriers in higher education," *Active Learning in Higher Education 7*, no. 3 (2006): 227-242.

Lee, Jay, Behrad Bagheri, and Hung-An Kao, "A cyber-physical systems architecture for industry 4.0-based manufacturing systems," *Manufacturing Letters 3* (January 2015): 18-23.

Lorenz, Markus, Michael Ruessmann, Rainer Strack, Knud Lasse Lueth, Moritz Bolle, *Man and machine in industry 4.0*. (The Boston Consulting Group, 2015).

Maderer, J., "Artificial intelligence course creates AI teaching assistant", *Georgia Tech News Center*, 9 May 2016, http://www.news.gatech.edu/2016/05/09/artificial-intelligence-course-creates-ai-teaching-assistant. Accessed 28 Aug 2017.

Marnewick, Carl, and Annlizé L. Marnewick, "The Demands of Industry 4.0 on Project Teams," *IEEE Transactions on Engineering Management* 67, no. 3 (August 2020): 941 - 949.

McCrindle, Mark, M., and Emily Wolfinger, *The ABC of XYZ: Understanding the global generations* (University of New South Wales, 2009).

Nicholas, Arlene J., Preferred Learning Methods of *Generation Z*, Northeast Business and Economics Association 46th Annual Conference (2019).

OECD, 2017. The Next Production Revolution: Implications for Government and Business. OECD Publishing, Paris.

Pejic-Bach, Mirjana, Tine Bertoncel, Maja Meško, and Živko Krstić, "Text mining of industry 4.0 job advertisements," *International Journal of Information Management* 50 (February 2020): 416-431.

Peña Miguel, Noemi, Javier Corral Lage, and Ana Mata Galindez "Assessment of the Development of Professional Skills in University Students: Sustainability and Serious Games," *Sustainability* 12 no. 3 (March 2020), 1014

Pinzone, Marta, Paola Fantini, Stefano Perini, Stefano Garavaglia, Marco Taisch, Giovanni Miragliotta, *Jobs and skills in Industry 4.0: an exploratory research*, in: "IFIP International Conference on Advances in Production Management Systems" (Cham: Springer, 2017), 282-288.

Prenksy, Marc, "Digital natives, digital immigrants," *On the Horizon 9*, no. 5 (2001): 1–6.

Raj, Alok, Gourav Dwivedi, Ankit Sharma, Ana Beatriz Lopes de Sousa Jabbour, and Sonu Rajake, "Barriers to the adoption of industry 4.0 technologies in the manufacturing sector: An inter-country comparative perspective," *International Journal of Production Economics* 224 (June 2020): 107546.

Rodrigues, Helena, Filomena Almeida, Vanessa Figueiredo, and Sara L. Lopes, "Tracking e-learning through published papers: A systematic review," *Computers & Education 136* (2019): 87-98.

Ronchetti, Marco, "Using video lectures to make teaching more interactive", *International Journal of Emerging Technologies in Learning* 5, no. 2 (June 2010): 45-48.

Rosch, Jonathan L., and Jennifer J. Vogel-Walcutt, "A review of eye-tracking applications as tools for training", *Cognition, Technology & Work 15*, no. 3 (2013): 313-327.

Sigala, Marianna, "Investigating the role and impact of geovisualisation and geocollaborative portals on collaborative e-learning in tourism education," *Journal of Hospitality, Leisure, Sport & Tourism Education* 11, no. 1 (April 2012): 50-66.

Strauss, William and Neil Howe, *Generations: The History of America's Future, 1584 to 2069* (New York: William Morrow & Company, 1991).

Subramanian, K. R., "The generation gap and employee relationship", *International Journal of Engineering and Management Research* 7, no. 6 (November-December 2017): 59-67.

Succi, Chiara, and Magali Canovi, "Soft skills to enhance graduate employability: comparing students and employers' perceptions," *Studies in Higher Education* 45, no. 9 (September 2019): 1-14.

Suleman, Fátima, "The employability skills of higher education graduates: insights into conceptual frameworks and methodological options," *Higher Education* 76, no. 2 (2018): 263-278.

Sylos Labini, Francesco and Stefano Zapperi, *I ricercatori non crescono sugli alberi* (Gius. Laterza & Figli Spa., 2011).

Teijeiro, Mercedes, Paolo Rungo, and Mª Jesús Freire, "Graduate competencies and employability: the impact of matching firms' needs and personal attainments," *Economics of Education Review*, 34 (June 2013): 286-295.

Tijdens, Kea, Miroslav Beblavý, and Anna Thum-Thysen, "Skill mismatch comparing educational requirements vs attainments by occupation," *International Journal of Manpower* 39, no. 8 (August 2018): 996-1009.

Tinoco-Giraldo, Harold, Eva María Torrecilla Sánchez, and Francisco José García-Peñalvo, "E-Mentoring in Higher Education: A Structured Literature Review and Implications for Future Research," *Sustainability* 12, no. 11 (November 2020): 4344.

United Nations, *World population Prospects 2019* (United Nations Department of Economic and Social Affairs, 2019), https://population.un.org/wpp/Publications/Files/WPP2019_Highlights.pdf.

van Laar, Ester, Alexander J.A.M. van Deursen, Jan A.G.M. van Dijk, and Jos de Haan, "The relation between 21st-century skills and digital skills: A systematic literature review," *Computers in human behavior 72* (July 2017): 577-588.

Verbert, Katrien, Erik Duval, Joris Klerkx, Sten Govaerts, José Luis Santos, "Learning analytics dashboard applications," *American Behavioral Scientist* 57, no. 10 (2013): 1500-1509.

Westera Wim, "Competences in education: a confusion of tongues," *Journal of Curriculum Studies* 33, no. 1 (2001): 75-88.

World Economic Forum, *The Future of Jobs. Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution* (2016), http://www3.weforum.org/docs/WEF_Future_of_Jobs.pdf

Yousef, Ahmed Mohamed Fahmy, Mohamed Amine Chatti, and Ulrik Schroeder, "The state of video-based learning: A review and future perspectives," *International Journal on Advances in Life Sciences* 6, no. 3/4 (2014): 122-135.

Zarco-Tejada Pablo J., Neil Hubbard, and Philippe Loudjani, *Precision Agriculture: An Opportunity for EU Farmers—Potential Support with the CAP 2014-2020* (Joint Research Centre of the European Commission, 2014), http://www.europarl.europa.eu/RegData/etudes/note/join/2014/529049/IPOL-AGRI_NT%282014%29529049_EN.pdf

## About the authors

STEFANO CESCO (stefano.cesco@unibz.it) is Full Professor in Agricultural Chemistry at the Free University of Bozen-Bolzano (Italy) and President of the Italian Scientific Society of Agricultural Chemistry. He was Dean of the Faculty of Science and Technology of the Free University of Bolzano (Italy) and President of the National Conference on Education at the University level for the Area of AgriFood-Forestry Science (Conferenza di AGRARIA). He has been working in the field of plant nutrition and plant physiology since more than 30 years. His research interests are mainly focused on plant nutrition and the rhizosphere processes underlying nutrient mobilisation, uptake and allocation by applying chemical, biochemical, molecular and physiological approaches. His scientific production is documented by 152 papers on peer-reviewed international journal indexed in SCOPUS and more than 200 contributions to national and international conferences. He is Associate Editor of Frontiers in Plant Nutrition, Agronomy and Plant and Soil.

VINCENZO ZARA (vincenzo.zara@unisalento.it) is Full Professor of Biochemistry at the University of Salento (Lecce). He was Rector of the University of Salento and delegate of the Italian conference of rectors for teaching. His research has included the following topics: study of the import pathway of some proteins, in particular the metabolite carriers, into isolated mitochondria; study of the assembly reaction of the hydrophobic proteins in the inner mitochondrial membrane; study of spermatozoa energetic metabolism; effect of different hormonal and nutritional states on the hepatic fatty acid biosynthesis. Vincenzo Zara is the author of numerous scientific articles published in specialized international journals. He has participated as a speaker at various national and international conferences.

ALBERTO F. DE TONI (alberto.detoni@uniud.it) is Scientific Director of CUOA Business School and is Full Professor of "Operations Management" and "Management of Complex Systems" in the degree in Management Engineering at the University of Udine (Italy). He is also President of the Supervisory Board of CINECA, President of the Independent Performance Evaluation Body of the Istituto Superiore della Sanità and member of the Strategic Steering Committee of EUI - European University Institute. He was Rector of the University of Udine, President of the Foundation of the Conference of Italian University Rectors (Fondazione CRUI) and President of the Italian Association of Management Engineering.

PAOLO LUGLI (paolo.lugli@unibz.it) is Full Professor and Rector of the Free Univeristy of Bozen-Bolzano. He conducts research on nanoelectronics and molecular electronics. After completing his studies in physics at the University of Modena (Italy) in 1979, Professor Lugli moved to Colorado State University in Fort Collins (USA) where he received a Master of Science in 1982 and a PhD in 1985, both in electrical engineering. In 1985 he started working as an assistant in the Physics Department of the University of Modena (Italy). From 1988 to 1993 he was an associate professor of solid state physics in the Faculty of Engineering at the University of Rome II (University of Rome Tor Vergata) where he was appointed professor in 1993. From 2002 until 2016 Professor Lugli has held the Chair of Nanoelectronics at the Technische Universität München. He is the author of more than 350 scientific papers and since 2011 he's been a member of the Deutsche Akademie der Technikwissenschaften (AcaTech) and a fellow of IEEE.

ALEXANDER EVANS (alex.evans@ucd.ie) is the Dean of Agriculture and Head of the School of Agriculture & Food Science in University College Dublin (Ireland). Professor Evans has a BSc in Animal Science from Nottingham University (UK), a PhD from the University of Saskatchewan (Canada) and a DSc (Published work) from the National University of Ireland. Following a position as a postdoctoral fellow in Cornell University (USA) he joined the academic staff in University College Dublin, Ireland. His teaching is primarily in the area of Animal Physiology with an emphasis on animal reproduction and fertility. He has attracted over 15 million euros of research funding, has supervised over 30 graduate students, has published over 140 peer reviewed papers and served as Co-Editor-in-Chief of the international journal Animal Reproduction Science for 9 years. He is Past-Vice President of the Association for European Life Science Universities (ICA). Professor Evans has conducted research on a wide range of topics focusing on reproduction and fertility in cattle and sheep. These areas include the regulation of puberty, oestrus synchronisation, ovarian follicle development, oocyte and embryo development, uterine health and function, and management and physiological factors affecting fertility in cattle and sheep.

GUIDO ORZES (guido.orzes@unibz.it) is Associate Professor in Management Engineering at the Free University of Bozen-Bolzano (Italy) and Member of the Scientific Committee of the CUOA Business School. He has been Honorary Research Fellow at the University of Exeter Business School (UK) and Visiting Scholar at the Worcester Polytechnic Institute (USA). He has published more than 100 scientific works in leading operations management and international business journals (e.g., International Journal of Operations and Production Management, International Journal of Production Economics, International Business Review, and Journal of Purchasing and Supply Management) as well as in conference proceedings and books. He is involved in various EU-funded research projects on global operations management and Industry 4.0, including SME 4.0 – Industry 4.0 for SME (Marie Skłodowska-Curie RISE), European Monitor on Reshoring (funded by the EU agency Eurofound), and A21Digital Tyrol Veneto (Interreg V-A Italia-Austria). He is Associate Editor of the Journal of Purchasing and Supply Management and member of the board of the European division of the Decision Sciences Institute.


**Tuning Journal for Higher Education**
© University of Deusto • p-ISSN: 2340-8170 • e-ISSN: 2386-3137 • Volume 8, Issue No. 2, May 2021, 85-117 •
doi: http://dx.doi.org/10.18543/tjhe-8(2)-2021pp85-117 • http://www.tuningjournal.org/

# The future challenges of scientific and technical higher education

Stefano Cesco, Vincenzo Zara, Alberto F. De Toni,
Paolo Lugli, Alexander Evans, and Guido Orzes

doi: http://dx.doi.org/10.18543/tjhe-8(2)-2021pp85-117