European Journal of Engineering Education

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ceee20

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To cite this article: Ariadna Llorens, Joana Prat & Katarina Pažur Aničić (2023): What Spanish ICT employers want: before and a decade after the introduction of the EHEA, European Journal of Engineering Education, DOI: 10.1080/03043797.2022.2162861

To link to this article: https://doi.org/10.1080/03043797.2022.2162861

EUROPEAN JOURNAL OF ENGINEERING EDUCATION
https://doi.org/10.1080/03043797.2022.2162861

What Spanish ICT employers want: before and a decade after the introduction of the EHEA*

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ABSTRACT

This paper analyses the effect that the fulfilment of the European Higher Education Area (EHEA) has got among engineers in the information and communication technologies (ICT) sector. The focus is on Spain, and the comparison of the technical and managerial knowledge and skills most demanded by the sector in 2008 and 2018, coinciding with the first decade of the EHEA. The study also examines whether the professional skills acquired by university students are consistent with those required in the job market. The following question is answered: Are ICT students adequately trained a decade after the introduction of the EHEA? An empirical study was carried out on the basis of a cross-section of Spanish ICT sector enterprises. The results reveal a gap between employer expectations and the skills acquired by students. Policy and practice performance is also discussed.

ARTICLE HISTORY
Received 27 October 2020
Accepted 22 July 2022

KEYWORDS
ICT; engineering education; curriculum design; management; employability; EHEA

I. Introduction

It has been ten years since the European Higher Education Area (EHEA) was established in Europe and Spain.[1] This change of educational paradigm, also known as the Bologna process, has meant a revision of educational parameters (González and Wagenaar 2008). From its starts, one of the main aims of EHEA was to provide quality higher education, to strength mobility and to increase graduate employability (EHEA 2012). In the context of the Bologna process, employability makes it possible to strengthen the relevance of graduates' opportunities to start their professional life on the basis of their higher education. The discussion was based on transferability, i.e. on subject-specific and generic competences including individual processes through lifelong learning. In 1999, the Bologna declaration[2] defined as a goal, literally 'to promote European citizens employability and the international competitiveness of the European higher education system'.

Quality teaching, which has a positive return and stimulates in-depth student learning (Trigwell, Prosser and Waterhouse 1999), starts with the definition of a curriculum. To validate university curricula, this article will try to show whether there are training deficiencies in recent ICT engineering graduates relative to the needs of ICT employers. This paper intends to evaluate the technical (hard) and managerial (soft) skills most demanded by the Spanish ICT sector from the employer's viewpoint. This will enable the performance of Spanish technological universities to be evaluated

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*ICT engineer learning gap in Spain after the Bologna Process.

from the perspective of the ICT sector – an especially volatile sector that is subject to constant change (Fixson, Khachatryan, and Lee 2017).

Finally, this study compares the situation before and after the execution of the EHEA in Spain. It will identify variations and commonalities in recent training of ICT graduates a decade after the enter of the Bologna process (Llorens et al. 2013). The end of the first decade is an appropriate moment to clarify ICT employers' expectations regarding the main educational parameters.

This research follows the working philosophy of initiatives such as the European Commission's European Skills Agenda (European Commission 2016), which sets out the strategic importance of knowledge acquisition for obtaining employment, growth and competitiveness – and highlights the role of universities in ensuring that this is achieved and updated. Moreover, the 'right skills for jobs' are one of the 12 actions included within the recently published European skills agenda, which indicates the relevance of this topic nowadays (European Commission 2020). Moreover, the duty of universities in the teaching of ICT engineers is especially important (Davenport and Patil 2012), and their success in training future technology leaders will have a decisive influence on the operating of the new economy (McAfee and Brynjolfsson 2012; Gordon 2017).

II. The ICT sector and the curricular profile of the ICT professional

II.A. The Spanish ICT sector and the European perspective

It is essential to contextualise this work within the years the empirical results were produced. To validate how the macroeconomic context has changed when compared to 2008, the starting year for comparison, data for this year can be found in Llorens, Llinas-Audet, and Ras (2011). Data from key economic indicators for 2018 show that the economic recovery is happening. The latest provisional data published by Eurostat[3] (2019) show a 3.5% increase in Spain's gross domestic product (GDP) in 2018, and this represents a consolidation in economic growth. Spain's GDP grew more than the average for neighbouring European countries (3.2%), with a higher growth rate than nations such as Germany (3.1%), the United Kingdom (2.4%), France (2.5%) and Italy (1.7%).

According to the Annual Report onthe ICT and Content Sector in Spain2019 (Observatorio Nacional de las Telecomunicaciones y de la Sociedad de la Información 2019), the positive growth trendin the ICT sector in 2018 has been consolidated, with growth observed in almost all the measures used in the study. In 2018, the sector consisted of 25,065 companies, up 3.5% on the preceding year. The number of employees in the ICT sector grew by 8.3%. The ICT sector in Spain employed 423,541 people in 2018, 8.3% more than in the preceding year. The vast majority of persons working in this sector, specifically 96.4% (408,294 in total) are in companies selling ICT services, whereas 3.6% (15,247 in total) of these professionals work in the manufacturing of ICT products. The direct contribution of the ICT sector increased in 2018 and reached 3.1% of GDP. Moreover, the prospects for the Spanish ICT sector are of continuing but modest growth. According to the IDATE[4] DigiWorld Yearbook 2017 (Pouillot 2017), the ICT sector is growing worldwide and becoming more dynamic and secure among the rest of the economic sectors. Additionally, the growth prospects are optimistic, and this highlights the lack of ICT engineering graduates (Gareis et al. 2014). All of these data indicate the importance of ICT graduates for economic development and how the sector is distributed in Spain. It is interesting to notice the ICET sector in Spain is mainly based in selling and the manufacturing portion is just a 3% of the total. The implications of this in terms of needs for technical and managerial skills are remarkable.

Following the OECD[5] Principals of Corporate Governance, Eurostat defines, literally ' ICT specialists as workers who have the ability to develop, operate and maintain ICT systems, and for whom ICTconstitutesthe main part of their job' (Eurostat 2019, 2020). According to their classification, ICT university degree holders include engineers and audiovisual-multimedia specialists, electronics specialists and computer and telecommunication engineers. In 2016, 61.8% of all ICT specialists in the EU-28 had finished university courses, while in Spain, this proportion increases very significantly, with almost 80% of ICT professionals having a university degree (Pouillot 2017).

II.B. Skills requirements for future ICT professionals

The skills mastery of ICT engineers has been a matter of concern both in professional and scientific discourse for years. A comprehensive review of the literature on ICT graduate professional development by K. Pažur Aničić, Divjak, and Arbanas (2017) included over 7,000 research articles published between 1960 and 2014 and revealed a rise in the number of publications related to ICT professionals' education and career development over time. Moreover, the study detected that the importance of both technical and soft skills of ICT professionals is among the main aspects studied among research papers.

The concept of professional competence refers to the body of knowledge, skills and character that each individual possesses in relation to his or her professional activity, as is it said by Llorens et al. (Llorens-Garcia, Llinas-Audet, and Sabate 2009). Industry needs ICT professionals who base their ability to work on technical know-how and generic skills (Lee, Trauth, and Farwell 1995). Although the ICT industry is very propulsive and exposed to constant changes, a certain systematisation of the body of knowledge (BOK) exists due to efforts from professional organisations, such as the Association for Computing Machinery (ACM) and the Institute of Electrical and Electronics Engineers (IEEE).[6] Several BOKs and their updates have been produced over the years for certain ICT areas, providing insight into the most important technical knowledge and skills for universities and other interested parties.

When it comes to soft skills, the situation is not that clear. First, bundles of names are used, including soft, business, transferable, managerial or generic skills and competences. For the objective of this paper, we will use the term *managerial skills*. The question without a unique answer is *Which managerial skills are the most relevant for ICT specialists*? It is probably impossible to answer this and to detect the most relevant managerial skills. I.e. Hamilton et al. (2015) identified communication skills, teamwork, flexibility and willingness to learn, business acumen and confidence as the most desirable generic skills of ICT graduates from the perspective of employersin Australia, and Llorens, Prat, and Berbegal-Mirabent (2019) found teamwork, the ability to communicate, being problem-solving oriented and possessing the ability to plan to be the most important skills of ICT graduates from employers' viewpoint in Spain, while employers in Croatia consider the following skills to be the most attractive in ICT graduates: the ability to rapidly acquire new knowledge, the capacity to identify and solve problems and the capacity to apply knowledge in practical situations (Pažur Aničić and Bušelić 2021). However, certain similarities and patterns can be found when analysing the generic skills for certain study fields from the employer's point of view.

The challenge for higher education institutions (HEIs) is how to incorporate managerial skills into their curricula. Engineering curricula have traditionally focused on scientific content (White and Davis 2013). However, we can assume that aspects from other fields present in these curricula, including managerial skills such as communication, management or ethics, have a positive effect in terms of job opportunities for the future professional (White and Irons 2009; Clement and Murugavel 2015). According to Winberg et al. (2020), aligning subject content with the implementation of professional skills is useful for enhancing engineering education and increasing the employability of future graduates. In Europe, generic competences found a prominent place in the Bologna reformation of European higher education. The Tuning project (Tuning Educational Structures in Europe 2008) identified 17 different generic student competences, but it is up to educational institutions to take care of their development through reformed curricula as a component of learning outcomes (Badcock, Pattison, and Harris 2010). However, some authors Valentine et al. 2019) recognise that soft skills are generally not present in computer science courses. Valentine et al. (2019) detected that creativity, an important managerial skill, is only explicitly articulated in around 2% of compulsory electrical engineering courses. Evidence linking future professional practice and its associated training needs to curriculum design has usually been supported by the preparation of final degree projects in university ICT engineering curricula (Ríos Carmenado, Rodríguez López, and Pérez García 2015), but this may be insufficient. Based on research that included perspectives of Croatian

students, teachers and employers in the ICT study area, the authors concluded that more institutional effort should beput into mapping generic skills with the exploration of learning outcomes and to work closely with employers who can contribute to the development of students' generic skills (Pažur Aničić and Bušelić 2021).

It should be elaborated *why* generic skills are that important in the context of engineering education. Based on the results of a systematic literature review, Winberg et al. (2020) found that adequate combining of technical knowledge and professional skills in engineering education is crucial for their employability. One of the reasons is in the nature of engineering jobs – to be able to solve complex real-world problems and work with other in different context, engineers' needs to soft skills that enable them to use their theoretical engineering knowledge in practice. Except the ability to perform in the diversity of workplace, Collet, Hine, and du Plessis (2015) recognised the importance of graduate generic skills in knowledge-intensive industry for their organisational fit and success – organisation's structure, strategy and culture. The same can be concluded from the research on competence mismatch of engineering graduates in China (Peng, Zhang, and Gu 2016) – generic skills are essential from students in performing their jobs and to adapt to a work environment that differs from the academic one.

First, if we evaluate the role of engineering in society and the missions of technological universities, we identify the ability to transfer scientific knowledge to practical applications as a priority (Jamison, Kolmos, and Holgaard 2014). Second, engineering can be considered from an economic point of view and third, engineering can be perceived as a service to society (Jamison, Kolmos, and Holgaard 2014). But according to Monteiro, Leite, and Rocha (2019), the clearly predominant perspective is the second one – the engineer as an agent of economic development and a business creator. The high number of ICT specialists with university degrees indicates the importance of higher education in terms of providing high-quality and industry-relevant study programmes in ICT. According to Miah, Solomonides and Gammack (2020), too few engineering curricula analyse the market to determine the technical and managerial aspects demanded. Moreover, managerial skills are very important for the advancement of careers from junior positions to managerial ones (Nittala and Jesiek 2020). Therefore, it is noteworthy that universities are increasingly developing interdisciplinary programmes for the improved incorporation of engineers into the labour market (Harrison, Ewen Macpherson, and Williams 2007).

This study will show whether the Bologna process has modified the shortcomings regarding the technical and managerial skills of ICT professionals in the case of Spanish ICT engineering graduates.

III. Methodology

III.A. Objectives and research questions

This work, that is an extension of paper (Llorens, Prat, and Berbegal-Mirabent 2019), will determine the key technical and management skills of recent Spanish graduates in ICT engineering (that is, engineers in audiovisual-multimedia, electronics, computing and telecommunications) relative to the needs of ICT employers a decade after the implementation of Bologna. This study also assesses the role of universities in the training of ICT engineers, focusing on the technical and managerial knowledge that students acquire during their studies and that their professional activity requires.

This research originated in 2008 in the run-up to the implementation of the EHEA in Spanish universities (Llorens, Llinas-Audet, and Ras 2011). This represented a change in university teaching methods, and the results can be assessed a decade later in 2018. This comparative study is unique in Spain and enables us to compare the Spanish ICT sector's perception of the curricula prior to the implementation of the EHEA with its impression of the new curricula a decade later. The study answers the research question: Are ICT students adequately trained a decade after the implementation of the EHEA?

III.B. Instrument and participants

The complete questionnaire used in this research consists of five main parts: (1) Sectoral identification, (2) Cross-cutting skills, (3) Knowledge, (4) Academic preparation, (5) Role of professional associations. The key steps of the proceeding are the same as the previous one, realised 10 years ago, and they allowed a good comparison of the results, and permitted to work in parallel between both studies.

Therefore, the study evaluates the role of the university in the training of ICT engineers, both in technical and business aspects, emphasizing two key issues, what it considers most important and what is missing in the recent graduated curricula.

Specifically, the research question is answered by analysing responses to four survey items (these are almost the same as those used ten years previously):

> Q11. Regarding the technical knowledge of newly graduated ICT engineers, please indicate the two most important requirements that curricula should cover.
>
> Choose from the following: electronic design; programming and control; telecommunication networks; internet technologies; audiovisual and multimedia technologies; information processing; data analysis; energy; security; other (please specify).
>
> Q12. Regarding the technical knowledge of recently graduated ICT engineers, indicate the two most important deficiencies that you have detected.
>
> Choose from the following: electronic design; programming and control; telecommunication networks; internet technologies; audiovisual and multimedia technologies; information processing; data analysis; energy; security; other (please specify).
>
> Q13. Regarding the management skills of newly graduated ICT engineers, please indicate the two most important requirements that curricula should cover.
>
> Choose from the following: marketing-sales; management of work teams; project management; interpretation of legal norms; macroeconomic knowledge; accounting-financial economic management; logistics-production; entrepreneurship; other (please specify).
>
> Q14. Regarding the management skills of newly graduated ICT engineers, please indicate the two most important deficiencies that you have detected.
>
> Choose from the following: marketing-sales; management of work teams; project management; interpretation of legal norms; macroeconomic knowledge; accounting-financial economic management; logistics-production; entrepreneurship; other (please specify).

The survey details and analysis of general data are in paper Llorens, Prat, and Berbegal-Mirabent 2019 and in the Appendix.

IV. Results

Results of the 2018 survey regarding the technical (Q11) and management (Q13) proficiencies that the Spanish ICT sector believes a recent graduate in ICT engineering (basically, audiovisual-multimedia, electronics, computer and telecommunications engineers) should acquire at university are analysed. Additionally, the main shortcomings according to these areas from the employers' point of view are detected (Q12, Q14) – note that the QXX numeration is related to the number of the specific question posed in the study. Finally, the data obtained in the 2018 survey are compared with those obtained in the 2008 survey (Llorens et al. 2013), which provides a basis for the analysis of any changes a decade after the implementation of the EHEA in Spanish technological universities.

In other words, the conducted study enables the further analysis of changes in the technical and management skills of recent graduates in ICT engineering according to the perceptions of employers – from the period just before the implementation of the Bologna process to a point ten years after its

implementation. Changes in what the sector considers to be the most important technical or management requirements are also revealed.

IV.A. Technical skills

The most important requirements in terms of technical knowledge that, according to the ICT sector in Spain, a recently graduated ICT engineer should have in 2018 are the following (in order of importance): data analysis and internet technologies (18.6%), security (18.1%) and telecommunication networks (12.2%) (see Figure 1). The main shortcomings in terms of 'hard skills' or technical knowledge detected in the profiles of graduates are as follows: security (25.5%), data analysis (18.6%) and energy (13.3%) (see Figure 1).

If we compare the requirements and shortcomings, an important 'gap' can be seen in two specific areas, security and data analysis (as shown in Figure 1), since the proportions are similar – although the shortcomings are greater. The sector observes shortcomings of recent ICT engineering graduates in the acquisition of two technical skills considered to be among the most important: internet technologies and telecommunication networks.

Figures 2 and 3 show the change in the perception of the ICT sector (from the 2008 survey to the 2018 survey) regarding the main requirements and shortcomings in terms of the technical skills of recent Spanish graduates in ICT engineering.

During this decade, internet technology remained the most important requirement, while the topics of telecommunication networks and programming and control lost relevance (however, they continue to appear among the most important needs). Two emerging areas of knowledge that the sector considers as principal requirements for recent ICT graduates are data analysis and security, which are areas that did not appear among the main requirements a decade previously. Knowledge of design and audiovisual technologies remain important needs but in a more residual way, while energy appears as a new requirement.

As for the technical skills that the Spanish ICT sector finds lacking among ICT engineering graduates and compared to the perception ten years previously, we see that in general there is a clear

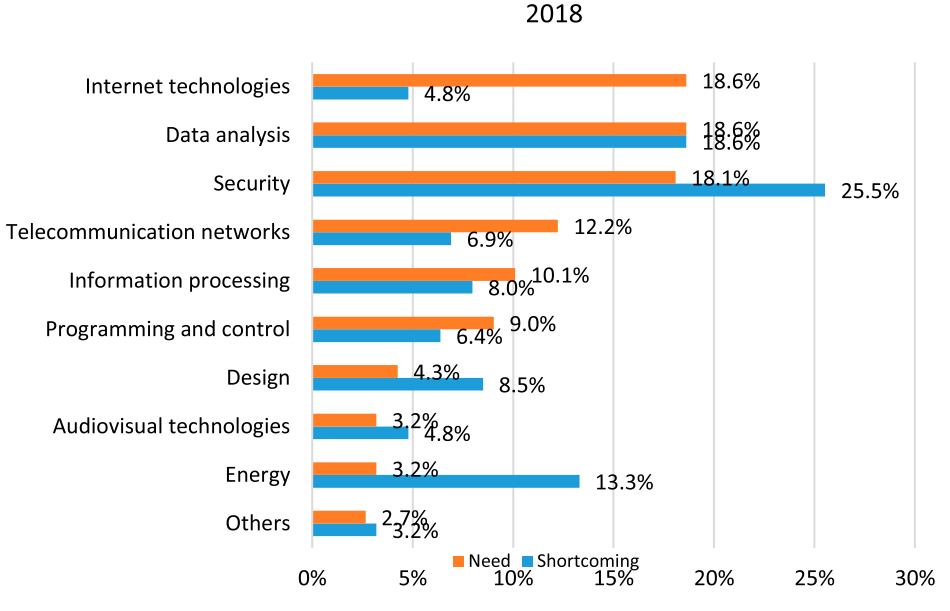

Figure 1. Results from the 2018 survey of the evaluation of the technical skills that recent ICT engineering graduates should have as well as their detected shortcomings given as percentages of the total answers.

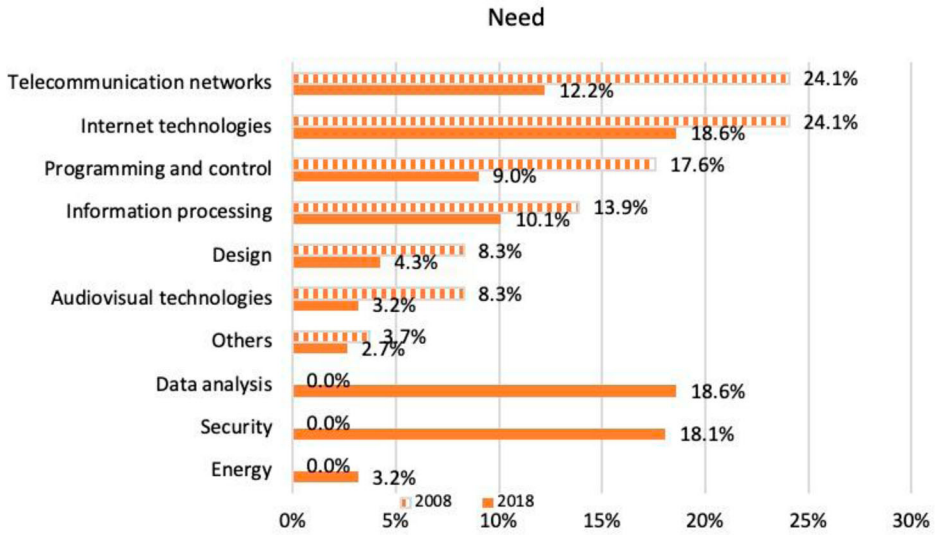

Figure 2. Comparison between the 2008 and 2018 surveys of the evaluation of needs regarding technical skills that recent ICT graduates should possess given as percentages of the total answers.

reduction in the level of shortcomings detected, with the exception of three areas: data analysis, security and energy.

IV.B. Management skills

This work also identified what the Spanish ICT sector believed were the most important management skills that a recent ICT engineering graduate should possess in 2018 (in order of importance): project management (30.3%), teamwork management (22.3%) and entrepreneurship (16.5%). While the three main shortcomings these employers detected in recent graduates were in the following areas: logistics-production (17.6%), marketing-sales (17.1%) and the interpretation of legal regulations (16.6%) (see Figure 4).

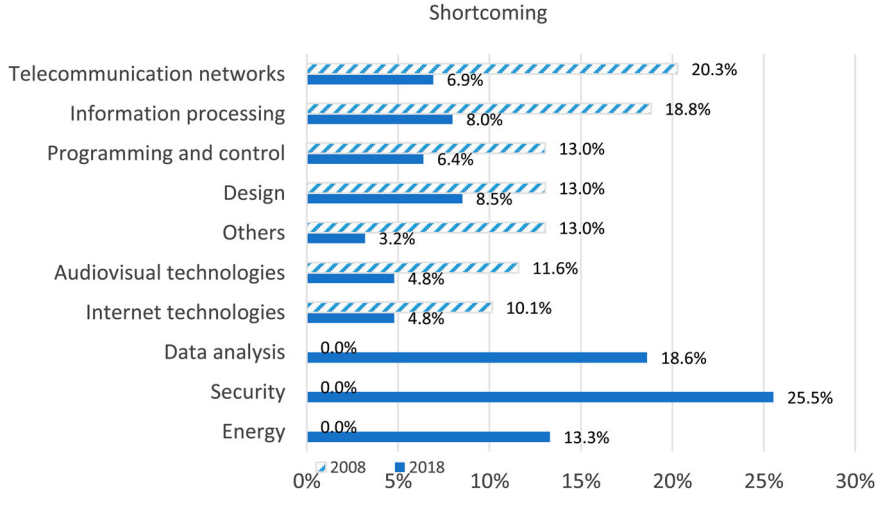

Figure 3. Comparison between the 2008 and 2018 surveys in terms of the evaluation of shortcomings regarding the technical skills of recent ICT graduates given as percentages of the total answers.

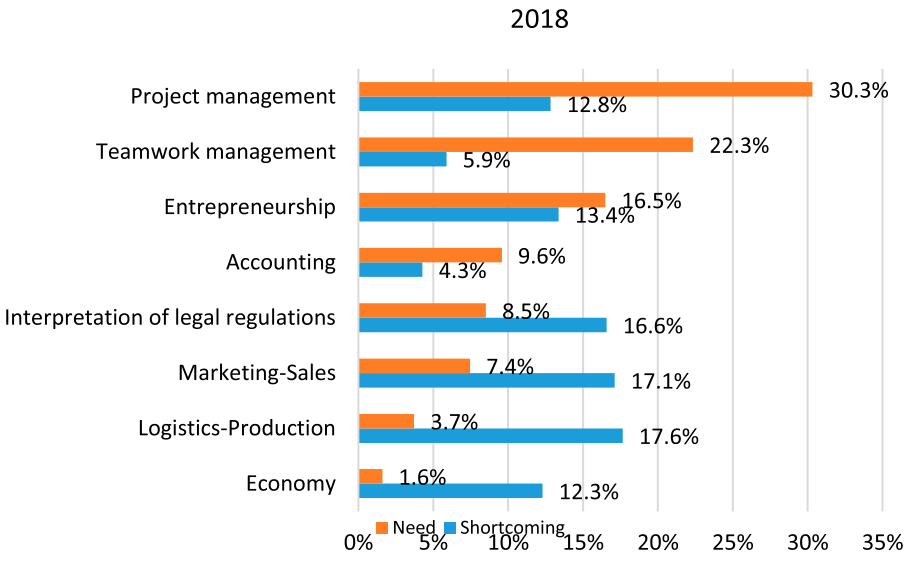

Figure 4. Results from the 2018 survey of the evaluation of the management skills that recently graduated ICT engineers should possess and their detected shortcomings given as percentages of the total answers.

Figures 5 and 6 show the ten-year change in the perception of the ICT sector before and after the implementation of the EHEA, that is, between the results of the 2008 survey and those of the 2018 one, in relation to the main requirements and shortcomings regarding the management skills of recent Spanish graduates in ICT engineering.

The management skills most needed in 2008 were ranked in order of importance (Figure 5): project management (35.9%), team management (19.8%), marketing-sales (18.9%) and business-management (13.2%). While in 2018, two new business topics appeared as the third and fourth most important requirements: entrepreneurship (16.5%) and accounting (9.6%).

Over the ten-year period, it is observed that for the ICT sector, the two themes of marketing-sales and business management continue to be regarded as necessary management skills, albeit to a

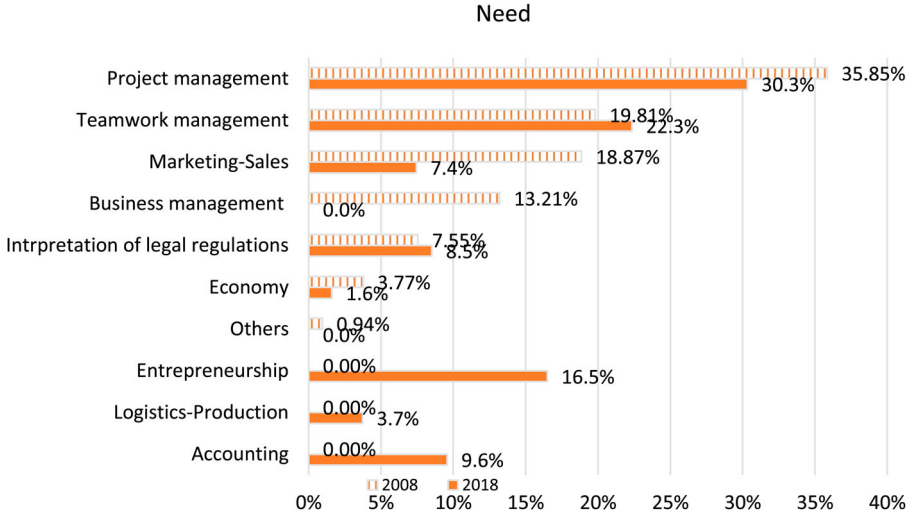

Figure 5. Comparison between the 2008 and 2018 surveys regarding the evaluation of management skills that recent ICT graduates should possess given as percentages of the total answers.

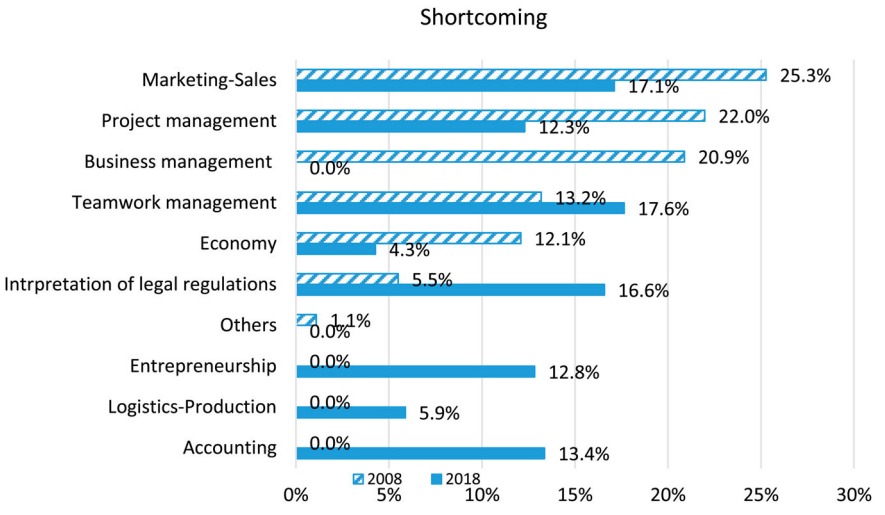

Figure 6. Comparison between the 2008 and 2018 surveys in terms of the evaluation of the needs regarding the management skills of recent ICT graduates given as percentages of the total answers.

lesser extent, while project management and teamwork management remain the most important management skills.

Regarding the management skills required by companies that the Spanish ICT sector finds lacking among ICT engineering graduates, we see that in 2008 the main deficiencies were as follows: marketing-sales (25.3%), project management (22.0%) and business management (20.9%) (see Figure 6).

Ten years after the modification of curricula and training programmes due to the introduction of the Bologna process, the training deficiencies in terms of management skills changed considerably according to employers. In 2018, deficiencies were detected in the areas of entrepreneurship, logistics-production and accounting, while deficiencies in the remaining subjects have generally decreased. Graduates were seen as less skilled in teamwork management in 2018 than in 2008, and there was also a greater level of deficiency in the interpretation of legal regulations.

V. Discussion

Although research regarding the technical and managerial skills of ICT graduates is not rare, this study provides a unique comparison of changes in the gaps between acquired and required skills over a ten-year period.

V.A. Technical skills

One of the most important findings is that some new technical skills appear on the list of the most required skills, namely data analysis and security. These 'new' skills are those most needed in the labour market and the skills that are found to be most lacking among current graduates. Employers consider security and data analysis to be important and perceive a considerable lack of such knowledge among future professionals. This finding is in line with the research from professional organisations – i.e. CompTIA recognised security and data, along with development and infrastructure, as four main pillars of IT functions; and cybersecurity analytics, data analytics, data visualisation and data science among top 22 skills to learn in 2022 (Kevkhishvili 2022). The IT leadership survey (Harvey Nash / KPMG 2017) found that big data/analytics is among top five most-demanded ICT skills, followed by Business analysis, Enterprise architecture, Technical architecture and Security and resilience. Moreover, this survey detected cyber security as a new business issue in 2016 that

IT should address. This goes in favour to the results of our research that recognises data analysis and security among skills 'new' skills most neededby the labour market. Finally, students themselves recognised Cyber security, Business and Data Science, and Data Specialists among top five favourites ICT roles to pursue after graduation (eSkills Malta Foundation 2021). Therefore, it is necessary to revise curricula to include more subjects on security and data analysis. The time path indicates that these topics will continue to gain importance in the employability of future ICT professionals – as has been the case in the first decade after the implementation of the EHEA. It is also relevant to identify that internet technology, telecommunication networks, information processing and programming and control (in order of importance) are still seen as important technical knowledge areas by the ICT sector and so must remain key elements in ICT engineering curricula. The acquisition of knowledge in these subject areas seems to have evolved positively since the implementation of Bologna, as employers detect a better understanding by recent graduates, and a positive trajectory is observed.

V.B. Management skills

As far as management skills are concerned, it can be concluded that project management and team management are still the most important requirements demanded by the sector. Entrepreneurship has gained importance as a new subject, and the EHEA has been unable to respond to this demand. Some HEIs have recognised the importance of entrepreneurship skills and incorporated them to their curricula. The implementation in the curricula of methodologies and thematic blocks that develop the capacity to create a company is advisable, given that there is a clear shortcoming identified in the profile of ICT engineers by the professional sector and that this subject has gained importance in recent years.

Team management is another important gap highlighted, since despite being an aspect of business management of great importance for the ICT sector, the survey identifies a low acquisition level of this skill ten years after the implementation of the EHEA. Therefore, reinforcing team management in ICT engineering curricula to improve the employability of future ICT professionals is another key recommendation. For years, teamwork skills appears to be consistently important for graduates in ICT (Hamilton et al. 2015; Llorens, Prat Farran, and Berbegal-Mirabent 2019; Pažur Aničić and Bušelić 2021).

The acquisition of skills in project management and marketing-sales has evolved positively with the implementation of Bologna. However, it is interesting to note that the ICT sector continues to identify shortcomings in key management skills, such as marketing-sales, the interpretation of legal regulations, accounting and logistics-production (from greater to lesser shortcomings). It would be plausible to conclude, given that these subjects form part of an intensification in the field of management skills, that employers in Spain generally detect a gap in terms of this for ICT engineering graduates. This shortcoming has not been corrected during the first decade of the implementation of the Bologna process, despite being identified from the beginning.

V.C. Policy level recommendations

As a result of this study, several recommendations can be provided at the policy level for improving the skill levels of future ICT professionals through higher education.

First, the continuous monitoring of trends in the ICT sector is a prerequisite for the provision of high-quality educational study programmes. Shortcomings in technical skills are most evident in relation with new skills (data analysis, security and energy). This indicates that HEIs are not successful in terms of monitoring trends in the ICT area and implementing these trends in study programmes. HEIs need to provide study programmes that meet current market needs, or they will lose their competitiveness compared to other forms of continuous education that are more flexible regarding labour market requirements.

Second, although the desire to harmonise study programmes with labour market needs exists, one limitation is that HEIs are not that flexible and cannot apply changes quickly. In this situation, gaps in skills and knowledge can be overcome by closer collaboration between academia and industry through innovative pedagogical approaches, such as work-based learning, work-integrated learning and various types of internships. These different approaches include industry involvement in curriculum provision in different forms, including the teaching that takes place both at HEIs and in companies.

Third, the proposed pedagogical approaches contribute to a great extent to the development of generic skills. Project teamwork in collaboration with industrial firms, with university lecturers as moderators, is evident in the literature related to engineering and computer science education and is one of the most successful approaches to developing technical and generic skills. This implies a need for the continuous education of academics regarding relevant professional skills and knowledge and the implementation of innovative teaching approaches in collaboration with industry.

Finally, collaboration between academia and industry appears to be a prevalent success factor in education for future ICT professionals. HEIs should have clear strategies regarding industry involvement in curriculum development and its provision. Moreover, it would be very helpful for HEIs to have a unit responsible for establishing and maintaining contacts with industry. In some HEIs, this role is covered by career centres that connect students and employers through various extracurricular activities and that support industry involvement in curriculum provision.

VI. Conclusions

This study is important not only with regard tounderstanding the lack of certain needed technical and managerial skills among young ICT professionals, but also in terms of rethinking the education of ICT professionals in general. ICT is a very dynamic and propulsive area, and the higher education system for ICT studies has multiple effects. Moreover, ICT labour markets and study programmes share common characteristics in most European countries, and therefore, the implications of this study are applicable to engineering education centres and computer science programmes in general.

One of the main conclusions offered by the analysis of the results is that various gaps exist between the expectations of the professional sector and the knowledge acquired by recent graduates in ICT engineering. Another important conclusion is that the demand for technical and managerial skills changes over time, and new skills appear on the list of the most needed skills. Concerning the period between 2008 and 2018, these newly demanded technical skills are data analysis, security and energy, and the newly demanded managerial skills are entrepreneurship, logistics-production and accounting.

Additionally, the analysis shows that HEIs should place more emphasis on management skills in ICT curricula as employers detect a marked general lack of acquisition of these skills in future professionals, and the arrival of the EHEA has not corrected this problem. This can be supported by innovative teaching pedagogies, such as work-based learning, project-based learning, problem-based learning and flipped classrooms. All these pedagogies put students at the centre of the learning process and, as such, enable the development of management and other generic skills. Moreover, such pedagogies often consider collaboration with employers, which makes the education even more valuable and connected to employers' needs.

One of the limitations of this study is its focus on one country (Spain). However, statistics show that the ICT sectors in many European countries share common characteristics, and therefore the results are applicable to a wider audience. Another limitation of this paper is that we have presented the results, but without a conceptually – or theoretically-analysis why these changes have occurred over time, nevertheless we think future studies might consider this as a future line of work.

This type of study can be useful as input for HEIs when (re)designing their curricula. Therefore, future research should be focused on involving more countries and updating research questionnaires with relevant skills related to the latest technology trends (i.e. distributed clouds, artificial intelligence engineering, cybersecurity mesh and businesses) (Gartner 2020). Due to very rapid changes in the ICT sector, another suggestion is to repeat such research more frequently than for a ten-year period.

Notes

1. The creation of a European Higher Education Area (EHEA) was initiated in the declarations of La Sorbonne (1998)[1] and Bologna (1999), and the process of convergence between national higher education systems began in 2008. It is also known as the Bologna process.
2. Bologna Declaration, where 29 countries expressed their willingness to commit to enhance the competitiveness of the European Higher Education Area http://www.ehea.info/page-ministerial-conference-bologna-1999
3. Eurostat is the statistical office of the European Union located in Luxembourg. It provides high quality statistics for Europe and promotes the following values: respect and trust, excellence, innovation, service orientation and professional independence.
4. DIGIWORLD. IDATE is a consortium of the largest companies in the ICT sector in Europe, and for the last eight years, it has published one of the most prestigious and complete reports on the state of the sector worldwide: the DIGIWORLD Yearbook.
5. The Organisation for Economic Co-operation and Development (OECD) is an international organisation that works to build better policies for better lives. Its goal is to shape policies that foster prosperity, equality, opportunity and well-being for all.
6. The Association for Computing Machinery (ACM) is the world's largest educational and scientific computing society, and the Institute of Electrical and Electronics Engineers (IEEE) is the world's largest technical professional organisation. In joining forces, the ACM and the IEEE produce and update curricula recommendations with regard to the landscape of computer technology.

Acknowledgements

The authors of this work are extremely grateful to the professional associations within the various ICT subsectors who have contributed time, resources, and precious feedback. Specifically, we owe our deepest gratitude to the Catalan Association of Telecommunications Engineers (ACET), the Official Association of Computer Engineering (COEINF), the Catalan Association of Telecommunication Technician Engineers (GrausTIC), and the members of the Spanish Association of ICT Professionals.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Appendix

Table A1. Detailed data (frequency and percentage) obtained regarding the technical knowledge of newly graduated ICT engineers.

			Need (Q11)		Shortcoming (Q12)	
Sample	Method	Technical skills	Freq.	%	Freq.	%
$N = 104$ ICT sector companies	Questionnaire	Others	5	2.7%	6	3.2%
		Energy	6	3.2%	25	13.3%
		Audiovisual technologies	6	3.2%	9	4.8%
		Design	8	4.3%	16	8.5%
		Programming and control	17	9.0%	12	6.4%
		Information processing	19	10.1%	15	8.0%
		Telecommunication networks	23	12.2%	13	6.9%
		Security	34	18.1%	48	25.5%
		Data analysis	35	18.6%	35	18.6%
		Internet technologies	35	18.6%	9	4.8%
		Total	188	100.0%	188	100.0%

Q11: indicate the two most important requirements that curricula should cover. Q12: indicate the two most important deficiencies that you have detected.

Table A2. Detailed data (frequency and percentage) obtained regarding the management skills of newly graduated ICT engineers.

			Need (Q13)		Shortcoming (Q14)	
Sample	Method	Management skills	Freq.	%	Freq.	%
$N = 104$ ICT sector companies	Questionnaire	Economy	3	1.6%	23	12.3%
		Logistics-Production	7	3.7%	33	17.6%
		Marketing-Sales	14	7.4%	32	17.1%
		Interpretation of legal regulations	16	8.5%	31	16.6%
		Accounting	18	9.6%	8	4.3%
		Entrepreneurship	31	16.5%	25	13.4%
		Teamwork management	42	22.3%	11	5.9%
		Project management	57	30.3%	24	12.8%
		Total	188	100.0%	187	100.0%

Q13: indicate the two most important requirements that curricula should cover. Q14: indicate the two most important deficiencies that you have detected.