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# Technology education challenges for the 21st century: how to prepare students for realities that do not yet exist

João Emílio Almeida
Assistent Professor at ISTEC
*Researcher at LIACC - Laboratório de Inteligência Artificial e Ciências da Computação*

**Abstract:** *The ongoing technological revolution, with the automation of many of the tasks traditionally performed by humans, in particular with the advent of Artificial Intelligence, will eliminate some jobs; however, will create others, nonexistent currently. The challenge facing higher education professors is to know what tools they should provide for students to prepare them for the future. Students now attending higher education, particularly those in the technological sector, will be confronted with new professions that do not yet exist. The question is, how do you prepare today's students to meet future technological challenges? In this article, a brief introduction to the theme is presented, highlighting the challenges that are posed to those in charge of educational training and some of the possible solutions to overcome them, in order to equip students with the necessary resources to face future challenges which, currently, we do not know what they will be.*

***Keywords:*** *education, higher education, skills and knowledge.*

## I. Employment in the 21st century

In this second decade of the 21st century, we witnessed a deep crisis that affected the most industrialized countries of the "first world". The instability that characterizes the current times, still recovering from the financial crisis of the "sub-prime", the bankruptcy of many banks and companies, originated a wave of unemployment that deeply affected our world and particularly our country, Portugal. Other events, such as Brexit, frequente changes in fiscal policy and even climate change, have created a world of instability and fear of the future (Marçano, 2017). Unemployment in technology, arising from the elimination of some jobs that became automated, or simply ceased to be needed, is at the stem of long-term unemployment due to under-qualification, mostly in new technologies. Tech illiteracy repels many of those unemployed from new jobs created daily by innovation.

In the US in 2015, the air force lacked enough technicians to operate drones, which led to a crisis in their uncrewed aerial vehicle fleet management (Brannen, 2015). Despite UAVs emergence eliminating some air force pilots' jobs, it created opportunities for other highly qualified professionals: each Predator drone required 30 technicians and more than 80 analysts to process the huge amount of data they gather. However, a factory worker, a salesman who loses their job to a robot or online direct to consumer sales, will hardly ever get a job as a drone operator or big data analyst, simlpy for lacking the necessary skill set. Thus, in the not too distant future, we may well have a large amount of unemployment rates and an equally large shortage of highly skilled workers (Harari, 2018, p. 53).

## II. The fourth industrial revolution and the factors of change

The fourth industrial revolution, characterized by advanced artificial intelligence, robotics, nanotechnology, biotechnology, communications, among other developments, is creating new challenges, at a pace never seen before (World Economic Forum, 2016). Por um

lado, trás novos e fantásticos avanços tecnológicos; por outro lado, apresenta complexos reptos, entre os quais, determinar quais serão as qualificações necessárias para desempenhar as novas funções laborais que são criadas todos os dias (Elliot, 2016). A crescente penetração das Tecnologias de Comunicação da Informação (TIC) na indústria está a transformar o ambiente industrial, apresentando uma combinação e coordenação entre os elementos computacionais e físicos, incluindo sua representação digital (virtual), por exemplo, na nuvem, resultando na formação dos chamados Sistemas Ciber-Físicos Industriais (ICPS) (Colombo, A. W., Karnouskos, S., Kaynak, O., Shi, Y., & Yin, S., 2017).

De acordo com um estudo publicado pelo World Economic Forum em 2016, os principais fatores de mudança no paradigma do trabalho, considerando os aspetos demográficos e socioeconómicos, são:

- Changing nature of work, flexible – 44%;
- Middle class in emerging markets – 23%;
- Climate change, natural resource use restrictions, transition to a green eceonomy – 23%;
- Increasing geopolitical instability – 21%;
- Consumers aware of ethical and moral values – 16%;
- Longevity, ageing societies – 14%;
- Young demographics in emerging markets – 13%;
- Women's economic power, aspirations – 12%;
- Rapid urbanization – 8%.

As for technological evolution, the factors of change are as follows:

- Mobile Internet, cloud technology – 34%;
- Processing power, Big Data – 26%;
- New energy supplies and technologies – 22%;
- Internet of Things (IoT) – 14%;
- Sharing economy, crowdsourcing – 12%;
- Robotics, autonomous transport– 9%;
- Artificial intelligence – 7%;
- Advanced manufacturing, 3D printing – 6%;
- Advanced materials, biotechnology – 6%.

Figure 1 shows these factors of change. These become amplified when they are present together. Smart systems (homes, factories, cities) will help to solve modern problems, from manufacturing to transport to climate change. In contrast, socioeconomic factors have broader implications, from demographics to politics.

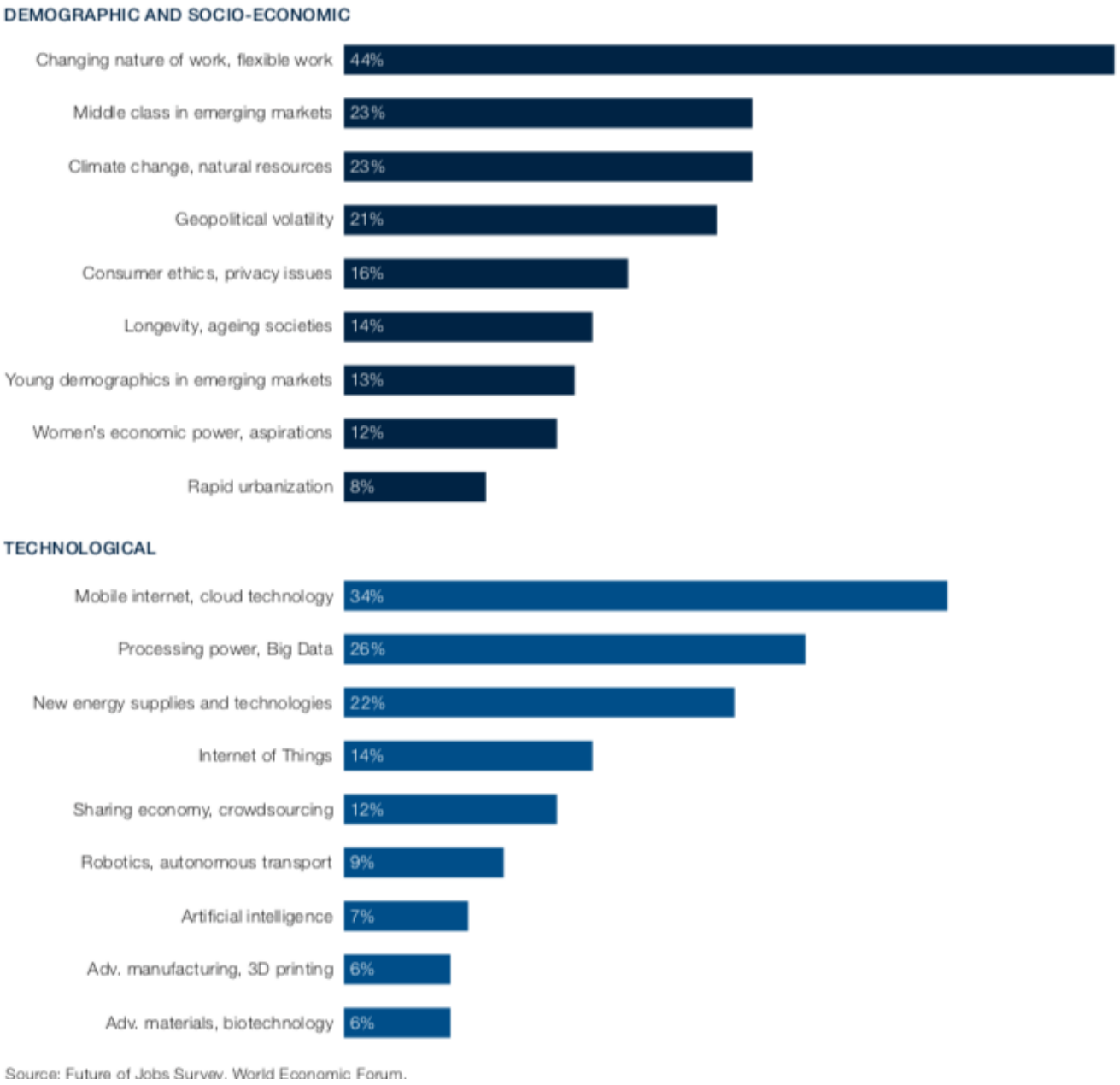


*Figura 1.* Fatores de mudança na indústria; fatores socioeconómicos e tecnológicos - *Future of Jobs Survey*, World Economic Forum, 2016.

## III. New jobs and those that will disappear

Growing productivity is essential for Portugal to sustain the growth in GDP that has happened in the last 20 years (McKinsey, 2019). Between 1996-2016, GDP growth (percentagewise) was 1,1%, where productivity improved 0,9%, but employment only 0,1%. For 2016-2030 the study made by McKinsey Global Institute and Nova SBE for Confederação Empresarial de Portugal (CIP), estimates a GDP growth of 0,5%, productivity to improve 0,9%, and for employment to decrease 0,4% (figure 2). There will be, then, a loss of jobs in the next few years.

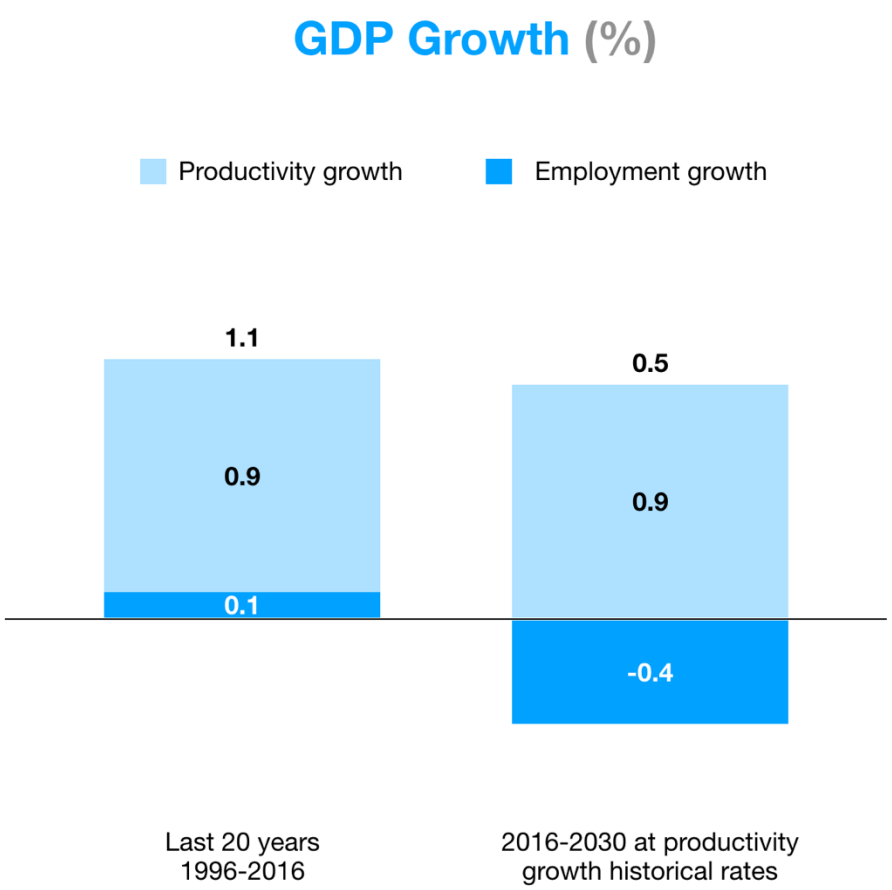


*Figure 2.* Growth in GDP, productivity and employment between 1996-2016 and 2016-2030. McKinsey Global Institute, 2019.

The same study mentions that until 2030 many of today's jobs will be possible to automate, rendering 1.1 million jobs redundant, mostly in manufacturing and sales (figure 3).

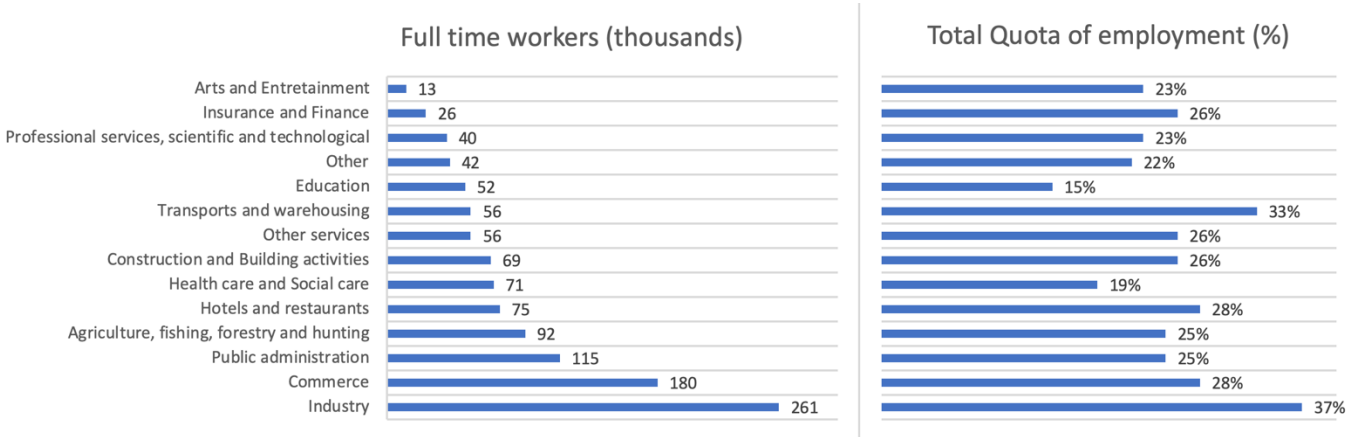


*Figure 3.* Jobs that will disappear through automation, until 2030. McKinsey Global Institute, 2019.

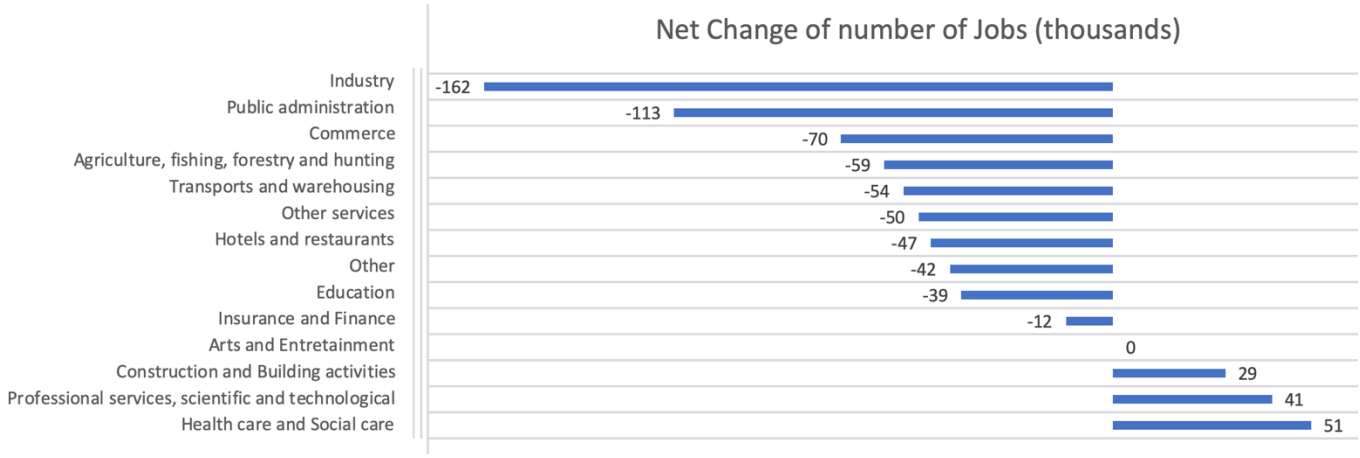


*Figure 4.* Jobs per sector, in 2016 and 2030, changes due to automation. Study by McKinsey Global Institute, 2019.

This reduction in jobs will arise from increasing productivity due to automation. However, it will be compensated by changes in other sectors and new, previously inexistant, jobs. The areas where there will be the most growth are:

- Healthcare and social workers;
- Professional scientific and technical services;
- Building.

The sectors where the largest losses of jobs are expected:

- Manufacturing;
- Public servants and government;
- Sales;
- Agriculture, woods, fishing and hunting;
- Transport and storage.

Thus, the employment mix will have profound changes, as evidenced in figure 4.

## IV. Technical and professional education in the 21st century

After the revolution of April 1974 in Portugal, technical and professional education was deprecated, due to profound and significant changes in the teaching, political and cultural paradigm, for teaching aimed at promoting equal opportunities, acquisition of new skills, preferably in higher education, through the acquisition of degrees or postgraduate courses, which allow the acquisition of competitive skills in the increasingly demanding world of work (Correia, J. A., Stoleroff, A. D., & Stoer, S. R., 2011). The idea behind this thinking, was that technical and professional education is limiting students' future choices, in case they want to pursue higher education. Thus, education focused on humanities and hard sciences, as opposed to technicals and "know-how". The class clashes of the 20th century, which opposed factory workers to urban jobs focused on services was at the origin of this change.

At the beginning of the 21th century, we notice there is a shortage of professional education of workers. A larger bet on technical education ensued, with internal and international support, which was now considered essential for societal development (Pinto, A. P., 2017). This movement is taking place not only in Portugal but also abroad, such as in Mozambique where the investment in this type of technical-professional education aims to help workers skills meet economical and societal development challenges. This example can be transcribed to Portugal, where development needs in technical and manufacturing areas also are applicable, even if there is a time delay when compared to the most industrialized countries of northern europe.

The study by McKinsey (2019) shows the need of a coordinated response from three key stakeholders to improve workers qualifications so they can face the upcoming challenges:

government, employers e educators. The latter must focus on the following actions:

- To inform about opportunities and improve access to education/qualification;
- To integrate practical learning / industry experience and reform curricula;
- To adopt new course structures and increase education based on broad ability rather than specific tasks.

Investing in human capital must rely on life-long learning. The old paradigm of studying to obtain a degree and get a life-long job is changed from last century. Near-constant scientific and technological evolution requires that workers are constantly investing in their own education. Only those most prepared will be able to overcome successfully the labour challenges and workplace transformations coming for them in the following years.
The main competencies every profesional should be concerned about are:

- Basics:
  - oral and written communication;
  - information technologies use;
  - qualification proactivity;
  - emotional intelligence;
  - social and human skills;
- Technical and scientific:
  - cognitive flexibility;
  - creativity;
  - logical thinking;
  - mathematical thinking;
  - complex problem solving.

## V. Conclusion

At the beginning of this century, the acceleration of technological changes is such that it is already consensual to be labeled the fourth industrial revolution. Artificial intelligence, robotics, nanotechnology, biotechnology, are areas in deep evolution that will revolutionize the job market. The study that CIP commissioned McKinsey, published in January 2019, estimates that about 1.1 million jobs will disappear in Portugal by 2030. Other jobs will replace these; but they will require new skills, which workers will have to acquire. For this, the importance of training is crucial. The paradigm of studying until reaching a certain level of schooling and from there working until retirement, is exhausted. In the 21st century, professional training and qualification will have to be permanent, otherwise the worker will be unemployed for a long time. The alternative is constant training, the acquisition of new skills, preferably in higher education, through the acquisition of degrees or post-graduations, which allow the acquisition of competitive skills in the increasingly demanding world of work.

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