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Artificial Intelligence:
Impact on Job Market and Society

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Abstract (English version)

One of the trends that most impact our world today is represented by artificial intelligence. The influence of this technology will redefine the business world: it will reshape the way of working itself, and the skills that current and especially future jobs will require. Looking beyond, many scholars are analyzing the impacts that this disruption will have on our society, and how the latter could adapt to take advantage of the new opportunities that artificial intelligence offers.

These issues, which are extremely topical nowadays, are however shrouded in uncertainty: no one can predict which jobs will be destroyed and which will be created, what skills will be required in the future, or what kind of structure our society will adopt. For this reason, I decided to pair a literature analysis with a survey that can express ideas on these topics from young university students. The future that artificial intelligence will form belongs to them, and it is necessary on one hand that they are aware of the implications of this revolution, and at the same time that their principles and values will contribute to build the most desirable future society.

Almost a hundred engineering students belonging to the Politecnico di Milano and the Institut Catholique d'Arts et Métiers (Toulouse, France) responded to the survey which allowed me to identify some interesting insights about different topics. First, I analyzed their relationship and knowledge about artificial intelligence and understand from which sources they draw information. Secondly, I investigated how ready they are for the revolution that AI will bring to the world of work: are they working on the skills that will be important in the future? Are they aware of the disruption that the technology will have in the coming years? Finally, I concluded my work with a more ideological part that investigates which of the possible government plans they consider most desirable to adapt our society to the challenges and opportunities that artificial intelligence brings with it.

Abstract (Italian version)

Una delle tendenze che oggigiorno sta maggiormente impattando il nostro mondo è rappresentato dall'intelligenza artificiale. L'impatto di questa tecnologia ridefinirà il mondo business: il suo contributo riguarda il modo stesso di lavorare, e le competenze che i lavori odierni e ancora di più quelli futuri richiederanno. Guardando oltre, molti studiosi stanno analizzando gli impatti che questa rivoluzione avrà sulla nostra società, e come essa dovrà o potrà evolversi per sfruttare le nuove opportunità che l'intelligenza artificiale offrirà.

Questi temi, al giorno d'oggi estremamente attuali, sono però avvolti nell'incertezza: nessuno può prevedere quali lavori verranno distrutti e quali creati, quali skills saranno richieste in futuro, o che tipo di assetto la nostra società adotterà a seguito dei cambiamenti futuri. Per questa ragione, ho deciso di accoppiare un'analisi di letteratura con un sondaggio che possa esprimere le idee su tali argomenti da parte di giovani studenti universitari. Il futuro che l'intelligenza artificiale formerà appartiene proprio a loro, ed è necessario da un lato che loro conoscano le implicazioni di tale rivoluzione, e allo stesso tempo che i lori principi e valori contribuiscano a fondare una società futura quanto migliore possibile.

Quasi un centinaio di studenti di ingegneria appartenenti al Politecnico di Milano e all' Institut Catholique d'Arts et Métiers (Toulouse, Francia) hanno risposto al sondaggio che mi ha permesso di individuare alcune interessanti conclusioni circa diversi temi. Innanzitutto, analizzare il loro rapporto e la loro conoscenza circa l'intelligenza artificiale, e capire da quali fonti traggono informazioni. In secondo luogo, capire quanto sono pronti per la rivoluzione che l'AI porterà nel mondo del lavoro: stanno lavorando sulle skills che saranno importanti in futuro? Hanno chiaro il tipo di impatto che la tecnologia avrà nei prossimi anni? Infine, ho concluso il mio lavoro con una parte più ideologica che indaghi quali dei possibili piani governativi reputano più auspicabile per adattare la nostra società alle sfide e opportunità che l'intelligenza artificiale porta con sé.

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1. INTRODUCTION

In 1982, the Nobel Prize winner, Wassily Leontief wrote "The role of human beings as the main factor of production was doomed to diminish" (article “The distribution of work and income” (Leontief, 1982)). As an analogy, he took the example of horses, which within a few decades at the beginning of the twentieth century went from being indispensable to human activities to substantially useless, following the invention of machines, trains, wagons for plowing fields and other innovations. The reason why in basically every developed country from the 1970s to the first decade of the twenty-first-century wages had remained stagnant was that most jobs, although increasingly productive, became less and less scarce: technological progress put people from all over the world in direct competition with each other, and often even against robots. If, however, at the end of the last millennium technological progress, automation in the first place, continued to create more jobs than destroy and to keep increasing productivity at work, at the beginning of the twenty-first century there was what is called "the great decoupling." This phenomenon brought greater productivity and innovation paired with higher unemployment and lower wages. Part of the responsibility can be traced back to the machines, which as a result of continuous innovations are swallowing up more and more jobs. In addition, the technological revolution is helping to fuel a centuries-old problem, the polarization of jobs, for which more jobs become high or low skill.

What humanity invented robots for (a word that comes from the Czech language and means effort) is actually working: they are taking away the burdensome jobs of human beings, simplifying their lives. What is needed, therefore, is a redistributive system, so that every citizen can enjoy the value created by technological progress. For a couple of centuries, this system was the labor market, as progress has continued to create new jobs and make others

more productive, allowing an increase in wages and living conditions. However, the trend seems to be coming to an end: many people are struggling to adapt their skills and be complementary to machines, and income inequality seems to be spreading.

To adapt to the previous revolution of the machines at the beginning of '800, society pushed for education and social security; similarly, the AI revolution today requires drastic measures: a shorter working week and universal income are among the most esteemed proposals. What should be rejected is the capitalist dogma of "working for a living": to create a better society, redistribution is necessary. Redistribution of money (UBI), time (minimum income), taxes on capital and not on labor and robots.

In this short paragraph, I summarized the topics my thesis is going to cover in the next chapters, from a broad introduction to AI technology to the change the job market will probably go through, to the different skills people need to obtain to compete and rise the disruption, to finally, an analysis of the main measures governments could take into consideration in the following years to cope with this disruptive revolution.

In parallel with this bibliographic analysis, for each theoretical macro-topic, I intend to couple practical considerations. For this reason, I created a survey that I tested both students at the French university ICAM (Institut Catholique d'Arts et Métiers), where I carried out my Erasmus and worked on my thesis, and the students of my Italian university, Politecnico di Milano. The survey is inspired in structure and meaning by the one from the scholars Carl Benedikt Frey and Michael A. Osborne about the future of employment (“The future of employment” (Frey & Osborne, 2013)), and has a dual purpose. First, to analyze how much young engineering students know about the world of artificial intelligence and are aware of the challenges that await them and how it will drastically change our society and the world of work. The other scope is to analyze possible differences in training and mentality between the

two sample classes belonging to two different universities. Although the number of participants is not remarkably high (61 for the French university and 31 for the Italian one) due to the length of the survey, I still believe it has a good statistical value since the two samples are extremely homogeneous within themselves (only engineering students, same age and similar background) and comparable with each other.

For each chapter of my thesis, I will therefore alternate a first theoretical analysis on a specific subject, followed by practical considerations derived from the survey concerning those issues.

2. WHAT IS ARTIFICIAL INTELLIGENCE

2.1 A definition of artificial intelligence

Artificial intelligence is a scientific discipline that aims to define and develop programs and/or machines that exhibit behavior that would be called intelligent if performed by a human being. This result can be obtained by creating a suite of appropriate software that gives "smart" instructions to the physical structure called hardware.

To understand how AI has evolved, it is important to define what is meant by intelligence. To do this, it is useful to think first about human intelligence and analyze its differences from an artificial one. Our intelligence can be defined as a set of many components that interact with each other to help us make decisions, solve problems and achieve goals. A very interesting theory for analyzing human intelligence is the one proposed by the Nobel prize Daniel Kahneman, who claimed that our mental activities can be divided into two categories: slow thinking and fast thinking (from the book "Thinking, fast and slow" (Kahneman, 2011)). Fast thinking comes into play for immediate decisions based on intuition, emotions or reflexes. Some examples can be actions such as recognizing a face, grasping a state of mind and perceiving a relative distance; for all these activities we do not use logic or complex thinking, but we act almost automatically. Differently, with slow thinking we make more rational and reflective decisions to come up with a thoughtful decision (ex: listening to a voice in a large environment, comparing two products to decide which one to buy, looking for an object among many with certain characteristics). According to Kahneman, most of our actions are guided by fast thinking, and those that require slow thinking still need numerous inputs provided by the other type. The two types of thought interact, help each other and sometimes conflict (for this reason we are not perfectly logical and rational beings).

Similarly, even considering AI, we can distinguish between slow and fast thinking. All AI techniques that follow logical and symbolic reasoning and offer a correct solution are the basis of AI's slow thinking, while those that solve undefined problems and do not ensure the optimality of the solution are the basis of AI's fast thinking. What changes between humans and machines is that the latter is equipped with incredible memory and computing speed, so they excel at solving well-defined and logical problems and analyzing substantial amounts of data. The two intelligences are, therefore, at least for now, complementary in tackling complex problems.

Defining the concept of artificial intelligence is therefore a very complex challenge that has been addressed since the birth of AI as a discipline. One of the founding fathers of AI is Alan Turin, who in 1950 wrote an article ("Computing machinery and intelligence" (Turing & Haugeland, 1950)) in which he proposed a practical way to assess the level of intelligence of an AI system. His approach was to put a C computer in one room and a P1 person in another; a second P2 person interacts with both through text messages. P2 can ask anything on any topic and must understand if the one who responds to his messages is C or P1. If P2 cannot distinguish between the two, then the C system is called intelligent. This test was first passed in 2012 by software designed to reproduce the answers of a Ukrainian teenager with a low level of English. Although it respects Turin's conditions, that software would not have been able to solve any other class of problems typical of human life.

A new and broader perspective is offered in the book "Artificial intelligence: a modern approach" (Russell & Norvig, 1994). The book is based on the concept of rational agent, which is a system able to understand what the best decisions are to arrive at the solution of a problem, or to achieve a goal. A rational agent uses logic, leverages on available data, and assesses the impact of its decisions on the context around it. Moreover, it should be able to learn from its mistakes, thus improving its decision-making process. The emphasis on

rationality led to the development of the so-called weak/narrow AI. In this case, starting from a specific problem, an AI system is designed to address it in the best viable way by exploiting some of the various techniques available (scheduling, logic, uncertainty treatment, learning, optimization, etc.). In addition to this kind of AI, other researchers have focused on developing a strong/general AI, which aims to achieve a virtual intelligence capable of performing the same activities as a person, with the same flexibility and adaptability to unfamiliar problems. This wider and more ambitious branch is still in its dawn and sees in some companies like Deep Mind its current pioneers.

Regardless of whether it is weak or strong AI, the prevailing approach of many researchers and companies is to conceive AI as an enhancement of human intelligence, rather than something that one day will completely replace humans. MIT (Massachusetts Institute of Technology), one of the most quoted universities in the field of technology, refers to AI with the name “Extended Intelligence”, highlighting the vision of machines that increase our skills (for example such as augmented intelligence systems in the medical field which analyze data of a patient and propose diagnoses, which will be evaluated by a human doctor) (article “Using artificial intelligence to set information free” (Hoffman, 2016)). In 2016 the results of a study (“Swarm intelligence approach for breast cancer diagnosis” (Zamani & Nadimi-Shahraki, 2016))regarding the correctness of the diagnosis of breast cancer was published: on average, doctors were wrong 3.5% of the time while AI systems 7.5%. Instead, combining the work of doctors and the support from AI systems only 0.5% of the diagnoses were wrong. This study demonstrated the complementarity of human operators and artificial intelligence systems: only with the collaboration of both we can reach the best outcome.

2.2 AI History

The history of AI is relatively short compared to other scientific disciplines, but it is very dense with innovations. The term artificial intelligence was coined in 1955 by John McCarthy during a two-month convention in the United States (Dartmouth, NH) centered in the discussion of how to develop intelligent algorithms (one of the challenges that the group of scientists considered was whether an AI system would have been able to prove mathematical theorems not yet defined or proven by other mathematicians) (article “A Proposal for the Dartmouth Summer Research Project on Artificial Intelligence” (McCarthy et al., 1955)). Over the past 60 years since then, AI has experienced alternating phases with periods of great promise and enthusiasm, the so-called summers of AI, followed by periods of disappointment, the winters of AI, where funding and the development of new applications were greatly reduced. The hardest winter in the history of AI was in the 80s, following the disappointment of the application of the so-called "Expert Systems," systems that tried to model the knowledge of any professional job, but failed in large part because of overly ambitious promises. Although in the following decades the funding for AI were significantly reduced, many researchers carried out studies which lead to incredible successes, also thanks to the exponential increase in computational power in computers and greater availability of data.

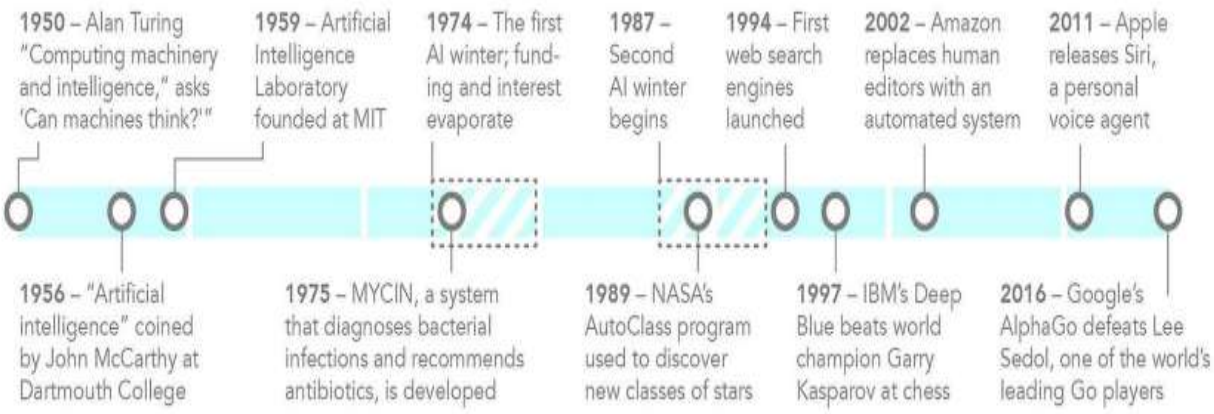


Figure 1: History of AI

Some of the biggest milestones in the history of AI concern games, which, although they do not represent daily life situations, can offer a simplified testing environment with clear rules and well-defined outputs. Some of the biggest successes are:

- In 1997 an IBM developer created Deep Blue; a program capable of playing chess. Surprising the world, the program managed to win against the world champion, Garry Kasparov. The key to DB's victory was, however, the immense computing power of the computer, which allowed it to consider every opponent's move in advance, and therefore being able to choose the best move decision relying on a lot of information. Although good intuition and intelligence are universally recognized as necessary for the game of chess, this is true just for humans who lack computing capacity ("Man versus machine: Kasparov versus deep blue" (Goodman & Keene, 1997)).
- In 2005, the Stanley car won an autonomous driving competition organized by the U.S. Department of Defense (article "Stanford racing team's entry in the 2005 DARPA grand challenge" (Team, 2005)). The car represented an incredible combination of applications that used AI: a video camera to probe the ground, GPS

for the position, LDR (light-dependent resistors) systems to determine the distance of objects, accelerometer gyroscopes to provide data predefining the speed and direction of the car. After winning the competition, the group leader Sebastian Thrun (director of a Department at Stanford), decided to join Google to carry out the research. Google pioneered the search and manufacture of self-driving cars, followed by Testa, Uber, Nvidia and others. Self-driving cars are a notable example of an AI system: they must perceive moving and stationary objects on the street, predict the actions of pedestrians and other cars (massive use of planning techniques and probability), and decide how to reach a goal of autonomy.

- In 2011, AI played Jeopardy, a popular quiz game that proceeds by clues, each one representing a notion of general culture (article "Computer wins on 'Jeopardy!': Trivial, it's not" (Markoff, 2011)). Competitors must guess the question that could have been asked by analyzing the clues provided (the answers). Whenever a competitor provides the correct answer, he/she accumulates money as reward; subsequently, the player can bet part of the prize on the next question. Watson, an IBM program, won against the world champions. To do this, one of the cornerstones of the program was the software's ability to self-assess its knowledge on a topic, and consistently bet the right amount each round. Here the computational ability resulted only in a faster answer compared with the human players, while the challenging tasks the IBM team tackled were the interpretation of the problem in human language, the search for the right answer and the statistical evaluation of the probability of correct answer in the next question. After the victory, Watson was broken down into sub-systems, each of them re-adapted to specific areas (including the medical, financial and transport sectors).

- In 2016 the AlphaGo program, created by the company DeepMind, won against Lee Sedol, one of the best go players in the world (article “The evolution of computing: AlphaGo” (Chen, 2016)). The match took place in South Korea, the home of Go. Without going into technicalities, the game vaguely resembles chess, but the board is considerably larger (19x19), making it much more difficult to predict all the moves with pure computing power. The number of possible configurations in the game is higher than the number of atoms in the universe, thus making the brute solution for AI impossible, and it is very complex to understand who is winning during the game. Against the predictions of most, the algorithm won the game, exploiting multiple AI techniques.
- Chess and Go are both full information games: both players always know the number of pieces of the opponent and their positions on the chessboard. Otherwise, card games are partial information, since you do not know the hand of the opponents, making the solution of the game more complex, and more oriented to a probabilistic approach. In 2017 the Libratus program won against 4 of the best poker players in the world for 20 consecutive days (an approach that effectively eliminates the luck of one hand or a few games). At the end of the period, Libratus had significantly more money than human players (article “Libratus: The Superhuman AI for No-Limit Poker.” (Brown et al., 2017)).

2.3 Machines learning

Until a few years ago, translation systems like Google's offered a less than optimal performance. They were based on a procedural algorithm, which provided step-by-step indications to the program on how to translate a sentence (identify words, group them into elements according to the grammar of the input language, translate the words into output

language, reconstruct the sentence with the words translated according to the output language). This approach, which reflects Kahneman's slow thinking, is incapable of grasping the ambiguities of human language and the various exceptions of different languages. The solution that brought a clear improvement started from a change of approach: modern automatic translators receive in input many examples of translations and sentences that contain the same words but in different contexts, and let the algorithm learn by itself the best way to translate a specific word/sentence. This second method, more effective, reflects the fast-thinking discipline.

This approach is called machine learning: you offer a lot of input data to a computer, which will independently extract its rules and understand the problem by abstraction. These examples serve as training for the AI system (in supervised learning, the participation of a human is required, who provides the right input data and verifies the correctness of the learning process). Eventually the system will be tested to verify the effectiveness of the process; if the test is successful, the system will be ready to apply the same reasoning and abstractions even to new cases. The conceptual structure used by machine learning techniques is called neural network, following the strong inspiration from the network of neurons in our brain. Our brain is indeed built of many different components, each of them knows how to solve a quite simple problem. The various neurons are linked to each other by connections, at first random. The same schema can be transposed for a machine learning system. Through training, the connections between parts are refined and the system optimizes itself to solve the problem. This second approach has recently become viable thanks to two technological innovations: an increase in computing capacity that allows us to quickly analyze a lot of data and the incredible amount of data nowadays available thanks to the internet (which today has 4 billion users ready to share and send photos, texts and data in general). To clarify how much external conditions have changed, more data has been

produced in the last two years than in the rest of human history. What has counterbalanced this phenomenon is the exponential growth, theorized by Moore's law (in the paper "Cramming more components onto integrated circuits" (Moore, 1965), of the internal components of a computer (transistor), which corresponds to an equal increase in speed / computational capacity. Today this trend has decreased slightly, and every year there is a growth of "only" twice the number of transistors.

The other machine learning technique that has been developing in recent years is reinforcement learning: the system solves a problem many times, initially almost randomly, and at each solution it receives a reward that indicates the quality of the solution obtained. To maximize the reinforcement signal, over time it tries to improve the solution proposed.

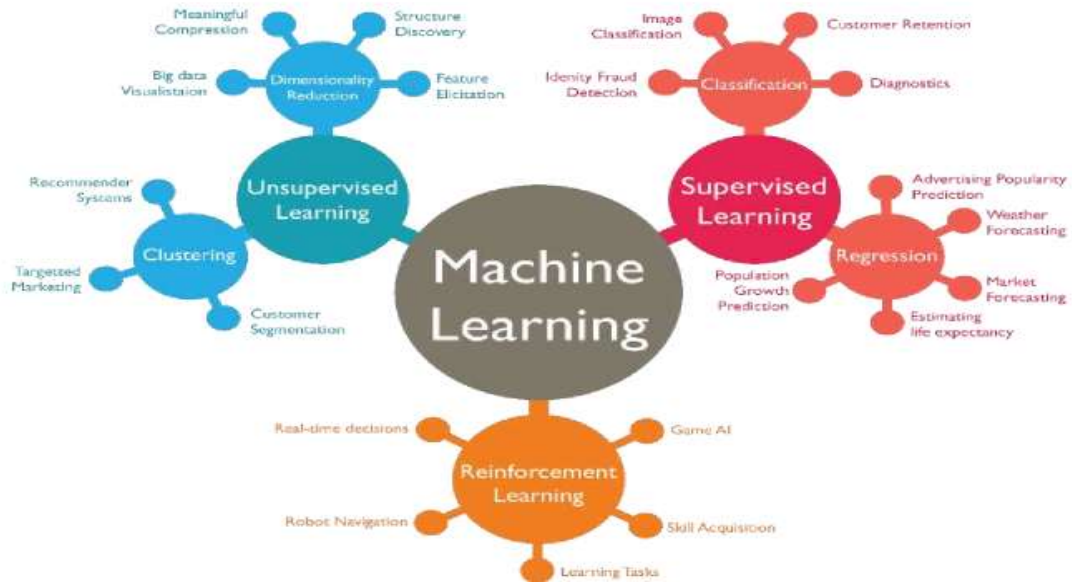


Figure 2: 3 techniques for machine learning

This technique is widespread in online automatic suggestion systems that recommend the purchase of products; the reward is the click on the advertising in this case. Depending on our answers (click or no click), the system learns what interests us and improves its offer. This second approach has the advantage of not requiring a vast number of input data.

It is also worth analyzing the difference between machine learning and deep learning: the second one is a type of ML based on a neural network architecture. Machine learning is about computers being able to perform tasks without being explicitly programmed, but they still think and act like machines. Their ability to perform some complex tasks still falls far short of what humans are capable of. Deep learning models introduce an extremely sophisticated approach to machine learning and are set to tackle these challenges because they have been specifically modeled after the human brain. Complex, multi-layered "deep neural networks" are built to allow data to be passed between nodes (like neurons) in highly connected ways. The result is a non-linear transformation of the data that is increasingly abstract. Comparing general machine learning with deep learning we can identify 5 differences:

1) Machine learning requires more human intervention
2) Deep learning systems are extremely complex and require powerful hardware and resources to run
3) The setup for deep learning systems can take longer, but the results are more accurate
4) Machine learning typically needs more structured data and applies traditional algorithms, whereas deep learning works with large volumes of unstructured data employing neural networks
5) Deep learning enables more complex and autonomous programs (like self-driving cars)

Obviously not for all problems it is necessary to apply advanced AI techniques: when the problems are well defined, there is no uncertainty about I/O and the number of cases is not huge the procedural algorithms (such as the navigator program that selects a path from point A to point B according to our requests (time, cost etc.)) are well suited and always offer correct solutions, especially in optimizing problems (as long as the programmer's instructions are correct). On the other hand, machine learning techniques are strongly based on an

abstraction of a statistical nature; because it proceeds according to estimates and probabilities this kind of AI is much more flexible and adaptable to unfamiliar problems, but this, of course, involves a higher risk of error. A key parameter to evaluate a machine learning algorithm is therefore accuracy, which is the measurement of the errors. The most advanced algorithms in this area, such as image recognition, are able to reach a 5% accuracy (a particularly interesting value when compared with the average human error in this task, which varies from 5-10%).

2.4 Limits of AI

After introducing the potential of AI, it is interesting to analyze now what the current limits of artificial intelligence are and which of these can be solved:

- Learning errors, typical of applications with machine learning techniques. To minimize this error, it is central to provide quality data in the training phase, as well as to program the algorithm correctly. The nature of this error, however, is intrinsic to this system, and can never be driven down to 0; for this reason, each ML system always accompanies a response/solution with the percentage of accuracy.
- ML systems adopt their own rules, and sometimes offer answers that are completely absurd to us. Famous is the case of recognition in photos of a panda: two photos with only a few modified pixels led a machine to correctly recognize the first with 56% accuracy, while the second was matched with a gibbon with 99% accuracy. To the human eye the two photos were the same, and it would not be difficult for any person to recognize the animal. These random bizarre behaviors can lead to serious problems in the near future, considering for example an autonomous car that fails to recognize pedestrians on the street. Faced with binary choice problems, errors can be either false

positives or true negatives, and depending on the situation there can be more or less grave consequences.

- The most advanced applications (translation of languages, reproduction of sounds) may seem at first glance highly intelligent, but in reality, they do not understand the meaning of what they are doing, nor abstract general considerations (learn) from the association of I/O. For example, an image recognition system will be able to answer almost perfectly to questions in that area, but it will not be able to respond to descriptive questions (what is it?); this problem highlights how many applications are currently restricted to a very precise scope. Another example is the poor understanding of the text from modern AI applications, which currently manage to sustain a mere question and answer with a human user, since they are not able to interpret the meaning of the words (a famous example is the test in the Winograd schema challenge: to the sentence “the trophy does not fit in the suitcase because it is too small/large", only in 60% of cases the solution proposed managed to answer the banal question "what is too small or too big?").
- It needs powerful computers, since compared to our brain, AI is not very efficient in the use of resources: the most advanced AI systems require about 15 Megawatts against only 20 Watts of the human brain and carry out less operation per second. The development of AI can therefore go through the study of the human brain.

2.5 Concerns and trust

For some years now, artificial intelligence has been more and more a topic covered by the media, which often exacerbates possible negative scenarios by riding a dystopian / sci-fi wave that is very unlikely and, in any case, remote. Many people are frightened by the idea

that the progressive developments of artificial intelligence will end up making human work obsolete, others by the uncertainty about how our lives will change in relation to AI.

One of the most serious problems is the biases that AI that characterize some AI systems, which are generated by the database on which they train (“Managing bias in AI” (Roselli et al., 2019)). If the database is not perfectly representative, the system will learn with a distortion and will discriminate against some subjects or favor others. One example is the automatic translation from Turkish to Italian (convenient example because Turkish has a neutral gender, so translating into Italian the AI program must choose a sex) of the phrase "he is a nurse" and "she is a doctor": the first will be translated as "he is a doctor", while the second will become "she is a nurse". This gender discrimination is due to a difference in the database analyzed, which evidently contained many more men doctors and women nurses. A more serious system is represented by the AI Compass system, an algorithm that evaluates the probability of a criminal to recommit a crime used by some judges in the US. This system suggested the possibility of releasing the prisoner earlier if the possibility of committing a new crime is low. In 2016 a strong bias was discovered that disadvantaged people of color, even though the reality was quite different and there was any evidence to discriminate based on the color of skin (article “Ethical implications of bias in machine learning” (Yapo & Weiss, 2018)).

Another theme is the ethics of AI (book “AI ethics” (Coeckelbergh, 2020)). A doctor is required to follow the Hippocratic oath, so it would be appropriate for an AI system to have moral and ethical values to guide its decisions, and that these should be communicated to the operators who interact with the system. When developing the algorithm, it is necessary to declare every constraint that we want the system to respect. For example, asking a future self-driving car to take us home as quickly as possible, it must be well specified in the code that it respects the rules of the road, maintains a comfortable ride for passengers etc. This problem

is critical in machine learning systems, where we do not specify every constraint and leave the system a certain freedom and flexibility to tackle a problem. This freedom makes AI creative and allows it to make decisions that humans would never have thought (AlphaGo won against the world champion of Go with numerous bizarre moves), but this can also generate unpleasant scenarios.

The third challenge is to explain how AI comes to a particular decision. This issue is particularly felt in Europe, where since 2018 a law (after the GDPR's document "The impact of the General Data Protection Regulation (GDPR) on artificial intelligence" (GDPR, 2018)) allows every person to ask the reason for the decisions made by an algorithm if a decision had an impact on his life (for example denying the request for a mortgage). Analyzing the reason for certain decisions is important in every area, especially scientific and medical, because it is necessary to assign the right responsibilities on the decisions made. The problem is that machine learning systems are black boxes, and do not provide a description of the logical steps to arrive at the proposed solution. This characteristic is particularly tricky because it discourages people from relying on technology that they do not understand and cannot explain their decisions in a logical way.

A final aspect is the management of personal data: the infinite amount of data to train ML systems is directly coming from us. The content we publish is used to train commercial algorithms that want to sell us their products for example. What must be protected (also part of the European GDPR) is personal data, for which explicit consent is required. In the rest of the world this law does not exist, but companies are required to declare for what purpose they are using the data they collect. An exemplary case concerns Facebook and Cambridge Analytica, where millions of data was used for political purposes (for which no consent was given, and which certainly pose a huge ethical problem).

2.6 The impact on the world of work

Economists have different views on how AI will impact the world of work. One of the prevailing interpretations is that the current period in which we find ourselves is a transitional phase, in analogy with what happened at the turn of the eighteenth-sixteenth century: the industrial revolution actually destroyed many conventional jobs, but simultaneously created others different from the previous ones. An example of this phenomenon is the introduction of the ATM, which replaced the work of cashiers in the bank, but at the same time made the cost of running a branch much lower, thus allowing the opening of many other banks overall increasing the total number of employees. In the transformation that took place about 200 years ago, the role of education was key to correctly training a new generation of employees to the new needs of the respective sector. And this point is what worries the part of economists with a more negative view: the revolution driven by artificial intelligence is taking place at an incredibly faster speed than the industrial one, and it will not be as easy to adapt the skills of the population to the new opportunities offered by change. The radicality of the change makes it difficult to hypothesize whether eventually the balance of the works will once again be positive and therefore the contribution to society will be improving, or if unemployment will increase. What is certain is that virtually every job will be modified by this revolution, especially those tasks that are repetitive or that require massive data analysis. Governments and companies will play a key role in the process of reskilling workers, teaching them how to best interact with recent technologies and integrate them into their work.

A long-term problem, which at the moment worries researchers more than ordinary people, is the "singularity" (otherwise defined as super intelligence): it is the moment when the first artificial intelligence system will become smarter than a human being (strong / general AI)

(article “Robots and AI at work: the prospects for singularity” (Upchurch, 2018)). Beyond this point, an exponential increase in the capabilities of AI is expected, and at the same time the partial or total loss of control over the system by humans. Although apocalyptic scenarios resembling the movie "Terminator" belong more to science fiction than to the near future, the loss of control is an extraordinarily complex problem, and numerous working groups of researchers, such as the Future of Life Institute, are currently working to try to mitigate it.

2.7 An ethics for machines

One of the most significant events in defining an ethics for machines was the conference in Asilomar, California, in 2017 (article “AI4People—An ethical framework for a good AI society: Opportunities, risks, principles, and recommendations” (Floridi et al., 2018)). The place of the conference was incredibly significant, since the same resort was the location where the principles for the development and use of DNA combination techniques were defined in 1975 to limit the possible negative effects on society. Similarly, 40 years later a group of about 250 participants, including leading AI-related science leaders, sociologists, psychologists, philosophers, and entrepreneurs (such as Google co-founder Larry Page and Elon Musk), sifted through over 100 possible principles to regulate AI applications and research. At the end of the conference, 23 principles were selected, with almost unanimous consensus, which can serve as an ethical basis for the future of AI. These principles were subsequently published on the web and signed by numerous institutes and universities, and recently by the state of California. These principles deal with issues such as privacy, responsibility, social impact, collaboration between researchers, entrepreneurs and politicians, alignment with human values, prosperity, control. These principles serve as a

guideline to align future developments and research in artificial intelligence towards a better future for all.

Another key ethical event was a conference held in 2016 at NY University. Here, Demis Hassabis, head of Deep Mind (recently acquired by Google), proposed to create an organization where companies that develop AI could collaborate to share common principles and methods to develop a better technology for our society. This group, later called partnership on AI (PAI), was joined by giants such as Microsoft, Google, Amazon, Apple and IBM. The San Francisco-based PAI shares principles including open and non-competitive discussion about issues such as collaboration between people and AI, the impact of AI on work and society, transparency, and the elimination of bias. From a few initial partners, today PAI boasts more than 100 partners including private companies, scientific associations, research centers, organizations that protect human and consumer rights.

Another relevant theme is to define a long-term vision of what we would like our society to look like, which can guide technical development in the right direction. In this sense, we can adopt as founding objectives the 17 principles of sustainable development defined by the UN (article “Sustainable development goals and inclusive development” (Gupta & Vegelin, 2016)), concerning issues such as eradicating poverty, education, work, health, equality between the sexes, sustainable cities, climate, peace and justice. To understand how to use AI to pursue these objectives, in 2017 the "AI for good" initiative was born, to coordinate UN agencies (those who identify the problems to be solved) with AI experts (who will be the main drivers of AI development and will be able to propose solutions to the problems identified). Since then, 3 conferences have been organized in Geneva, with a substantial increase in international interest with each iteration.

If the AI for Good program aims to guide the high-level development of technologies useful for society, in 2016 the IEEE association (Institute of Electrical and electronics Engineers, which includes over 400,000 engineers worldwide) decided to define a manual called "Ethical aligned designed" written by over 250 experts from various disciplines with the aim of proposing general principles and analyzing various common development problems, sharing best practices to approach them, and defining technological standards about ethical problems.

One other theme about the ethics of AI is to reflect on what the role of politics should be. At the European level, the European Commission in 2018 appointed a group of AI experts made up of 52 people with the request to write the ethical guidelines for AI in Europe and outline the policies of allocation of resources to AI. A year later, the group published a document ("The EU approach to ethics guidelines for trustworthy artificial intelligence" (Smuha, 2019)) identifying the main features of the AI of the future starting from the fundamental rights of European citizens. The idea that emerged was defined as "trustworthy AI", that is a vision based on people and their rights, and that has all the characteristics to deserve the trust of citizens (impartiality, respect for human dignity, few errors, explain decisions). A few months later, the group also published recommendations for policies and investments for this type of AI. The hope is that more and more countries will adopt the vision outlined by the group and allocate funds to pursue research in this regard and support it with the means at their disposal. In addition to international recommendations, governments can use other tools such as international standards, regulatory agencies, laws, etc. to pursue maximum beneficial impact on society, without slowing down innovation and disturbing competitiveness.

The final consideration I want to focus on is the incredible geographical inhomogeneity of ethical guidelines in the world.

Figure 3: Number of ethical guidelines per country

As the graph shows, only a limited part of the world, especially North America, Europe and some Asian countries, is actively working to create ethical guidelines to protect its citizens. This situation is even more impressive if we consider that almost 90% of those have been written after 2016. One country that definitely stands out is China, one of the world's largest AI players, where at the same time there are virtually no regulations concerning AI (which is tidily linked to abuses of power by the Chinese government). Creating more guidelines and making sure that are worldwide spread will definitely be an important mission in the next decade.

2.8 Trends in the artificial intelligence field

To analyse the main trends in the artificial intelligence sector, I will rely on 2018 research provided to me by the Observatory on Artificial Intelligence of the Politecnico of Milan ("Artificial Intelligence: on your marks!" (Perego, Tubaro, 2019)). Part of the research is aimed at analyzing over a thousand companies, many of which were of an international

nature, and analysing what type of AI they were exploiting. To conduct this analysis, the researchers first defined 8 possible solutions that an AI system can propose:

1) Autonomous robot: Robots that can move themselves, or some parts (e.g., arms), to manipulate objects and execute actions of diverse types, without human intervention, taking information from their surroundings and adapting themselves to events that were not foreseen or programmed.
2) Autonomous vehicles: Autonomous means of transport used to transport people, animals or things, either driving on the roads (vehicle) or navigating in the sea, lakes or rivers (vessel), or even flying in our atmosphere or in space (aircraft), able to perceive the external environment and identify the correct maneuvers required to adapt to that environment.
3) Intelligent objects: Objects that are able to perform actions and make decisions without requesting human intervention, interacting with the surrounding environment using sensors (e.g., thermometers, cameras, microphones, etc.) and actuators (e.g., open/close door/window, switching on of domestic appliances or installations, etc.), learning from the habits and actions of the people that interact with them.
4) Virtual assistant/chatbot: Software agents able to perform actions or provide services to a human interlocutor, based on commands or requests received via natural language interaction (written or spoken).
5) Recommendation: Solutions aimed at showing the preferences, interests or general decisions taken by the user, based on information provided by the user, directly or indirectly. The output consists of personalized recommendations, that can appear at dissimilar stages of the customer journey, or more generally, of the decision-making process.

6) Language processing: Language processing solutions for various purposes from content comprehension to translation, to producing text autonomously based on data and documents supplied as input.
7) Computer vision: Solution for analysing images, individual or in sequence (video), for recognizing people, animals and objects in the image, biometric recognition (e.g., face, irises) and to generally extract information from the image.
8) Intelligent data processing: Solutions that use artificial intelligence algorithms on structured and non-structured data, for purposes related to extracting information from the data and to trigger consequent actions.

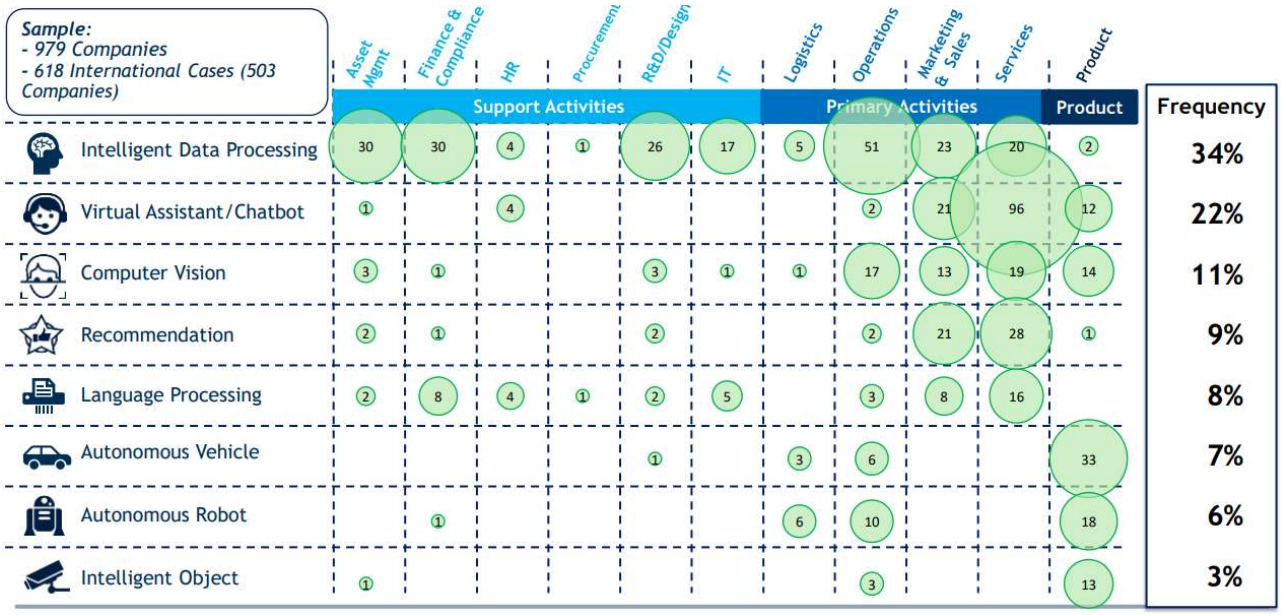


Figure 4: AI trends in the main sectors

We can extract different information from this analysis (summarized in the table above):

- The physical solutions (autonomous robots, vehicles and intelligent objects) occupy the last places in the frequency ranking, highlighting the dominance of software solutions.

- Software solutions play a leading role in support and primary activities whereas physical ones in the product industry.
- Intelligence data processing is the solutions with higher frequency and holds a monopoly for the support activities along with language processing
- Virtual assistant chatbot are by far the most common application and are very well known by consumers
- Industries such as service and marketing have played a pioneer role for the success of software solutions and nowadays heavily rely on those technologies

This analysis can be further enriched by considering only start-ups as base for the research. By their definition, start-ups represent the idea of innovation, and analysing which industries rely on which AI solutions can be useful to spot some trends in the market. In this case the sample is composed of almost 2000 firms.

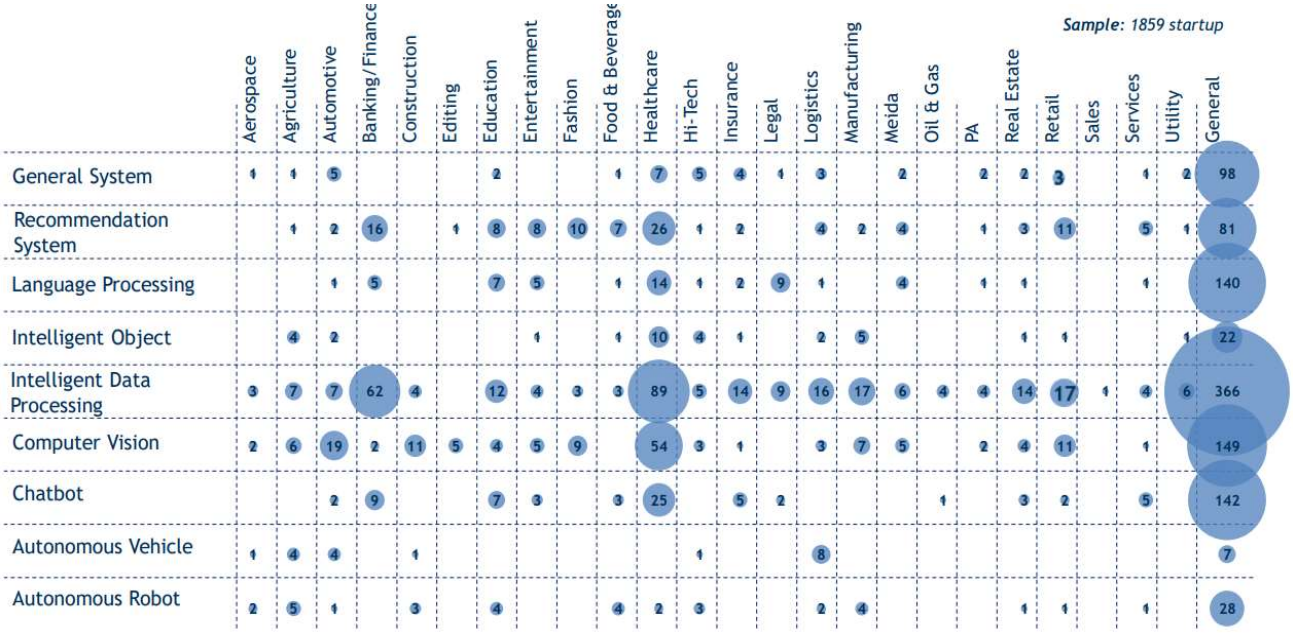


Figure 5: AI trends in the main sectors for start-ups

Once again, we can highlight some interesting point:

- The difference in frequency between physical and software solutions became even larger: 85% of solutions are software versus only 7% physical (the remaining 8% are about enabling technologies meaning database, computer architecture and hardware technology).
- Even in this case, intelligent data process solutions are the most popular, and play a role in almost every industry considered
- The healthcare system uses a broad variety of software solutions, especially concerning data analysis, computer vision and recommendation systems. In this field there is an incredible amount of data availability and it is a good fit with the current AI innovations.
- Growing sectors like automotive are investing in multiple applications to tackle a multifaceted innovation. In that car industry for example, you can find companies working on self-driving (recommendation systems), driver assistance systems (intelligent objects), voice and gesture interaction systems (computer vision) and so on. All this innovation will be used by the car of the future and are to some extent complementary interconnected.

2.9 The future of AI

More than 70 years passed since the invention of the Turing test, which, for a long time, had represented an ideal towards which the innovations in the field of artificial intelligence should have proceeded. However, this objective is limited and represents only a small part of the capabilities and ambitions that today's AI systems aspire to achieve. Looking at the future of AI I find remarkably interesting the article “Human-Level Artificial Intelligence? Be

Serious!" (Nils J. Nilsson, 2005) by Stanford professor Nils Nilsson. He proposes to monitor the percentage of jobs that can be performed by a machine as an indicator of progress in the field of artificial intelligence. Referring to this test as an "employment test," the author is well aware that he proposes more an ideal than a concrete goal (at least nowadays it's hard to think that some jobs will be fully automated) and at the same time is conscious of the fact that achieving a 100% in such test is not necessarily something desirable, both economically (there will always availability of men who can perform some jobs at a lower cost) than socially (people find meaning in work). Nevertheless, such a shift of perspective towards strong AI can be particularly useful to understand where we are in the development of intelligent applications and how fast we are progressing.

To develop systems that are able to progress in the employment testing, it is necessary, according to Nilsson, to move from the development of numerous systems that master a limited set of skills and can aspire to perform only specific jobs (in line with the idea of narrow AI that is still dominant today) to the development of more flexible systems oriented to the constant learning of new job skills, which he calls "habile systems." These systems should aim to completely tackle more and more human jobs, which however hide much more complexities and require skills that modern developments in the field are not able to address. What Nilsson proposed yet is interesting: instead of focusing on the development of a system that can replace a particular job, no matter how complex it is, we should try to progressively develop systems in an analogous way to how human beings start learning. In his idea researchers could start to develop a system that is able to pass a high school course, if too difficult they can go back to middle school or primary school. At the same time, you can program other features and programs that you consider useful, always with the idea of starting from a base that is considered simple enough and then continue to progress for successive layers. The idea to eventually achieve a hard AI is a development called "growing

onion.” If developing an external layer is complicated, you can try working at core level. Nilsson proposed in 2005 his version of the "child machine" that is the core part that every habile system should have. This idea is based on the following requirements/skills:

- Sensory-motor system, at the level of a human child. This level requires interacting with visual, tactic, audio and haptic sensory mechanism inputs. For these objectives will be central in the ability to recognize patterns and learn (key activities for each child)
- Perception of spatial attributes (above, inside, etc.) and motor actions (grasp, move forward, go back etc.) to enable the system some freedoms of movement
- Ability to predict future perceived states and plan ahead. The ability to break down a high-level goal into multiple actions needed and plan the steps to achieve that goal is critical for any advanced AI system
- learning, typically with a punishments and rewards system
- reasoning and representation about approximate and vague concepts
- language towards other AI systems, human or even to interact with documents

This approach is just one of the possible paths for the future development of artificial intelligence, and it could be integrated in the future with more vertical build-in solutions based on specific skills to get as close as possible to the idea of strong AI.

3. SURVEY: BASIC KNOWLEDGE AND PERCEPTION

The first part of the survey is focused to understand the level of knowledge and the approach that the two samples of students have in relationship with AI.

The first introductory question "*How much do you think to know about AI*?" has results terribly similar with a majority of students assessing their level as familiar or solid knowledge. This first finding was largely predictable, because the two samples are very similar in background (only engineer, strong industrial imprinting) and experiences of life. Just few of them have no knowledge on the subject, while none consider him/herself an expert.

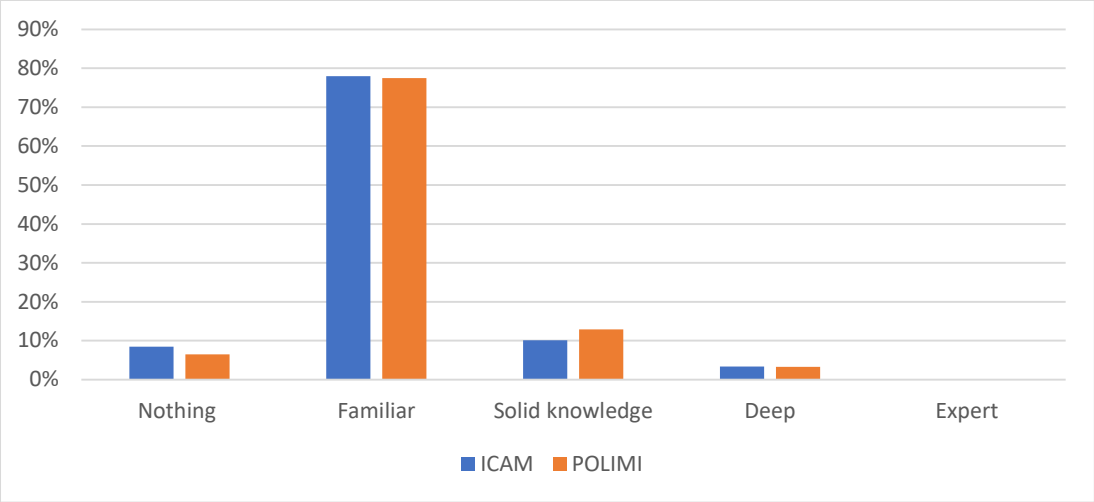


Figure 6: How much do you think to know about AI?

To go deeper in this analysis, it is interesting to evaluate the differences in the preferred channels of education between Italian and French students. Icam students take advantages of several tools independent from the classical university life, such as the strong usage of videos (around 90% of them, almost 40% more than the other group), but also didactic channels (book and courses). The only channel where a higher % of Polimi students replied to use is

conference/seminar. What it appears from this question is that French students are exposed to a more theoretical learning, whereas the Italian ones are more interested into applied expositions.

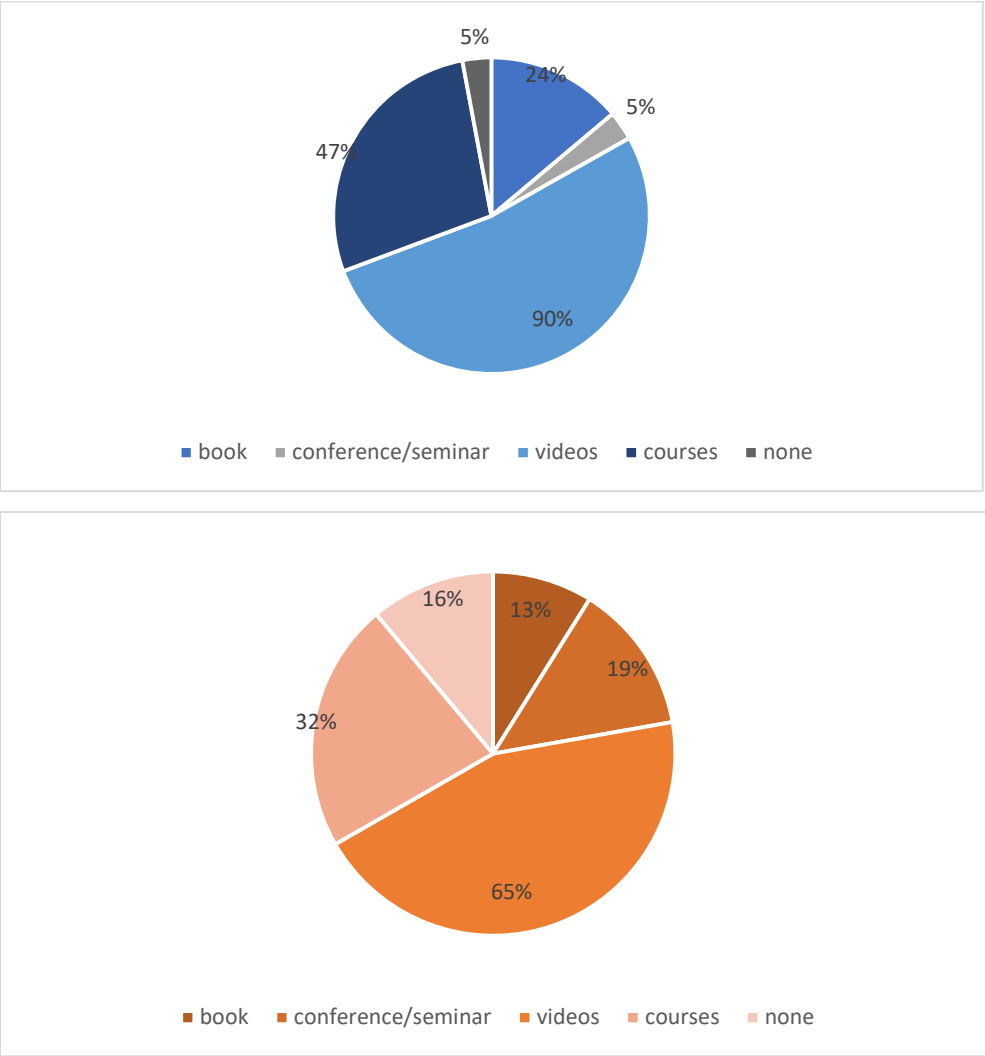


Figure 7: Educational channels (ICAM on top vs POLIMI on bottom)

The other question regarding the knowledge is more technical and aim to assess the level of confidence that the survey participants have in the discussion of terms such as machine learning and deep learning. The answers go from 1/4 equals to not confident to 4/4 greatly confident. French students' knowledge appears more grounded, with a majority of them replying to be moderately confident (56%) or pretty confident (22%), whereas most of the

Italian students reply to be not confident at all (45%) or just moderately (29%). This fist interesting result can be connected with the finding of previous question regarding the educational channel: a more traditional and theoretical education generate higher confidence in the ICAM sample.

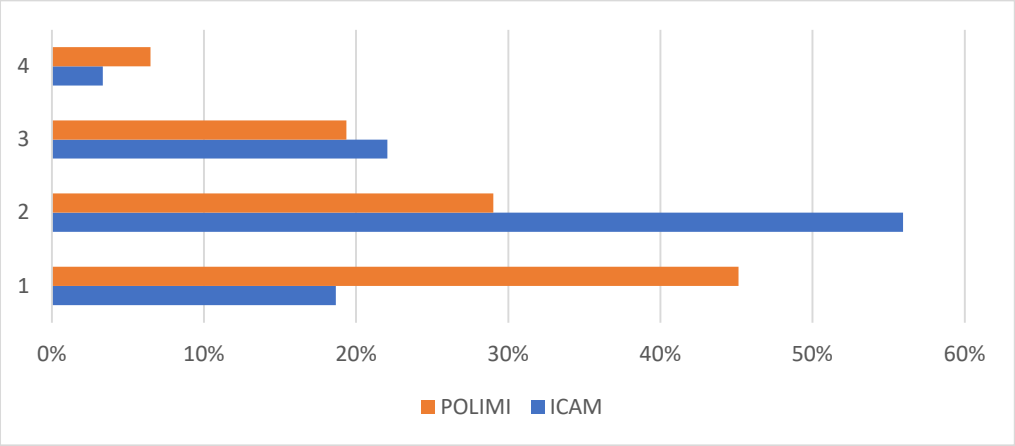


Figure 8: Confidence level in the discussion of AI

What is interesting is that this confidence does not foster a more favourable attitude toward AI/robot. Polimi students are strongly pro-technology (54%pro and 42% neutral), with basically just few respondents declaring to be afraid. From the other side, ICAM students' answers are strongly gaussian, with a majority of neutral answers but also a significant part of people afraid of AI (15%). This attitude will result into interesting considerations in the following chapters.

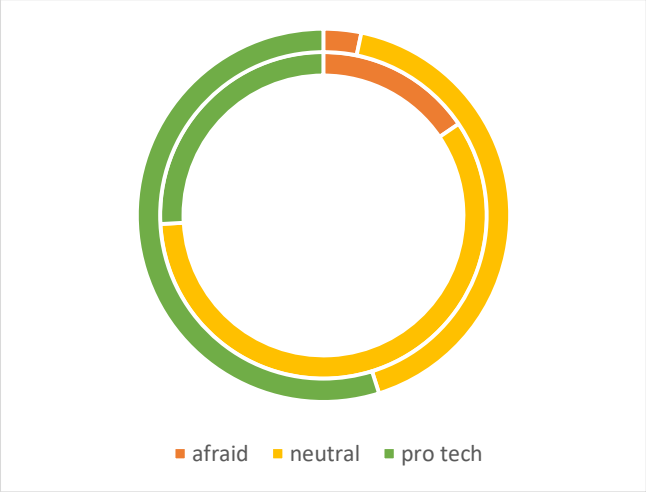


Figure 9: Relationship with AI/robot (external ring POLIMI, internal ring ICAM)

4. FUTURE OF WORK

As written in the book "*Human work in the age of smart machines*" (Merisotis, 2020), the work is changing in an unprecedented way, as technology and AI take over more of the tasks people used to do. It is not just machines doing tasks that people cannot or do not want to do, it is that they are doing things with people helping them to perform better. This sentence comes from Joe Luis, an old-time assembly line employee for a manufacturing company in the Indiana area, in the US. Unlike a lot of other colleagues and researchers, his opinion is not that robots will steal jobs from people, but they will allow human employees to perform only creative and high-level tasks, avoiding repetitive and dangerous ones (not ergonomic tasks, jobs that expose the operator to unhealthy chemicals, etc.). Luis and his colleagues refer to the new smart machines as collaborative robots (or Co-Bots), and the company's idea is to keep increasing the number of them to make their employees' life easier. In the last years, Luis and other colleagues have worked to train the machines to perform multiple tasks, and at the same time they went through several phases of training and retraining to learn how to operate along with the Co-Bots. Although some of the employees were initially scared of the change, Luis stated that eventually they were persuaded by the potential benefits and improvements of their life.

This success story seems in contrast with the mainstream narrative that foresees an incredible loss in a large part of human jobs and a significant reshape in the rest of them in the next few years. The speed of improvements in the AI sector keeps augmenting: for example, in 2019 Google reported a breakthrough in computer capacity using a quantum computer, which would likely boost the capacities of future robots using AI systems (Hu et al., 2019). Quantum technology is the latest example of how modern technology can re-shape the range and possibility in human work and life, as it happened in the past with each major

technological disruption. Klaus Schwab, a worldwide known economist, defined in the article "*the fourth industrial revolution*" (Schwab, 2017) the period we are entering is the 4th industrial revolution, and predicts that, as with every revolution that came before, it will disrupt work and employment for most of the people around the world. Moreover, because this AI change is about automating the act of thinking, arguably the most human activity, most of the researchers agree on an unprecedented social alteration. Some articles talk about half of the US jobs being eliminated; others forecast a 99% of jobs lost in the next decades demanding a universal basic income (UBI)-type of society. The reality is that the outcome of this revolution is fairly unknown, and it is reasonable to believe that this revolution will follow the same pattern of destruction-creation of jobs as the others. Therefore, more than focusing on how many jobs will be eliminated, it makes more sense to analyse which new skills can help people to take advantage of the new opportunities that inevitably will be created by AI. As explained in the article "Stop Saying Robots Are Destroying Jobs—They Aren't" (Robert D. Atkinson, 2013), when a machine replaces a worker, there is a second order effect (other than the first order, which is the direct loss of that job): the organization using the machine saves money and that money flows back into to the economy either through lower prices, higher wages for the remaining workers, or higher profits. In all three cases that money gets spent which stimulates demand that other companies respond to by hiring more workers. While some studies have found that productivity growth does have some short-term negative job impacts, all the studies find either no impacts or positive impacts on total jobs in the longer term.

An extensive Vanguard research study (*Vanguard-Research-Megatrends-Series-Future-of-Work*) analyses the underlining tasks used in the top 100 occupations in the US and classifies them as basics (requiring few skills and little or no training), repetitive, or uniquely human. This last cluster contains tasks that require an adaptability to situations that cannot be

codified; this kind of work cannot be (at least in a near future) substituted by machines, which can assist with but not take over. Jobs with a high concentration of repetitive tasks face the highest probability of automation. The analysis shows also that several occupations have changed their nature in the last years with an incredible speed. One notable example is the work of a photographer. 80% of the tasks of this job are different compared with the ones in early 2000: this change involves most of the repetitive technical skills, such as processing films, but also some human tasks, such as thinking creatively and establishing an interpersonal network. Across all the occupations, nowadays 50% of activities are uniquely human, compared with just 30% of 20 years ago. A projection of this trend forecasts that in 10 years around 80% of tasks will belong to the third cluster. At the same time, studies show how technologies are increasing the demand for people performing human work. As AI is becoming more and more able to replace simple and repetitive jobs, the human component is the real added value for work in the future. What is worrying in this scenario, is that a large share of people lacks the skills, knowledge and abilities to perform these more human intense jobs. In contrast with the past, it is no longer enough to look at the high-level vs low-level difference in jobs, arguing that only low level of skill jobs will be disrupted. What is more likely is that no matter the level of skill or knowledge a job requires, if its nature is repetitive, it will probably be automated in the next future, even if it is high-level. What AI really changes in the way we perceive work is that it extends the possibility of automation beyond manual tasks, threatening highly skilled professions (such lawyers, accountants, surgeons etc.) if their tasks are just applying their knowledge and skills (no matter how sophisticated) to common or consistent tasks. Whereas some low-skilled jobs, such as food servers, will probably survive for the opposite reason.

Those ideas suggest that the classic dichotomy between blue and white-collar jobs will no longer be relevant, and the traditional college/university path will no longer be enough to

guarantee a successful career. The work of the future will probably reward more people that own valuable skills, such as teamwork, communication, critical thinking etc., rather than a certain type of degree. Machines will take over well standardized jobs, while people will be employed where human work is necessary. Current AI systems struggle to deal with unpredictable environments, and human interactions generate exactly that type of environment: for this reason, a large part of human work involves interacting with people. One other area where human skills are required is innovation and creativity: coming up with innovative approaches to tackle problems is an increasing skill to own. The expanding capabilities of AI and new digital technologies are leading to new employment structures: empowering some jobs and displacing others. It is substantially impossible to guess which job will disappear and which will be created, but it's interesting to consider the macro- trend that is already going on: the enrichment of human tasks in every job and the loss of repetitive ones. This change will not only have an economic impact, but also a social one: people could enjoy their daily life more and have more satisfaction and meaning out of their work (no longer as a simple way to an end).

It is interesting to analyse the 2008 Great Recession, one of the events that boosted the pattern of destruction of low skilled jobs and the creation of high skilled ones. During the first 3 years of the crisis, several industries employing low skilled workers were wiped out and many people lost their jobs. At the end of 2010, the economy faced a loss of 7.4 million jobs, 5.6 million of those were for people with a high school education or less. During the following 10 years the economy recovered, and about 8 million jobs were added, but almost all of them for people with a college degree. About the 5.6 low skills jobs lost, only 800 thousand came back. This cycle is once again repeating with the Covid-19 disruption, which will speed up the trend even more.

According to a 2018 OECD survey (main findings in the article "*Skill for the 21st century*" (J. P. Martin, 2018)) regarding the job skills among more than 30 member countries, companies are increasing their demand for highly qualified personnel. Firms search for employees with good cognitive skills, complex problem solving, creativity, social intelligence, negotiation, and other valuable soft skills. According to the same research, 50% of the sample have at best a basic level of problem-solving using technology, highlighting the lack of one of the most valuable skills of our time. In US, the number of good jobs (intended at least 35k dollars per year plus retirement and healthcare plans) available for just high school diploma has fallen from 1/3 in 1991 to 1/5 today; meanwhile, the overall number of good jobs is growing, but they are all going to people with high credentials. The increasing demand for people with credentials is indeed the response for a shift to a talent-based job market in the so-called "knowledge" economy. This natural trend will only be accelerated by the developments of new technologies such as AI.

According to an analysis carried out by Nord East University, most people in the US (55%), Canada (54%) and UK (52%) claim to have solid understanding of AI, with even more confidence for younger people. Even thus, a supposed understanding doesn't foster confidence: most people in all the three countries think that AI will have a negative impact. More than 60% of people from Canada and the UK thinks that it will destroy more jobs than the ones it will create, more than 70% of Americans agree. The effect of AI and automation will be more disruptive in advanced countries: by the end of 2030 it is estimated that around 1/3 of workers in US and Germany and half of workers in Japan could be displaced. Despite this strong belief, only around 37% of workers in Canada, 34% in the UK and only 17% in the US are actually worried about losing their jobs due to AI, highlighting a significant dissonance between what is likely to happen and what they think.

One other major change in the structure of work is the shift from full time long-term employment in the past to more short-term jobs in our days. This new paradigm, the so-called "Gig" economy, can be well understood by considering that ¼ of Americans currently have an independent job (McKinsey research) and 1/9 of workers in the most advanced nations are working on a temporary contract (OECD research). According to both sources, the numbers of both types of workers are expected to grow, as the digital marketplace becomes more widespread and displaced workers use temporary contracts to re-enter in the job market. Worldwide, 84% of people agree that their career will be significantly different from their parents' one: young people are more willing to change their work multiple times and explore different paths. According to the book "*The design of business: Why design thinking is the next competitive advantage*" (R. Martin & Martin, 2009) from Roger Martin, a researcher from the University of Toronto, what is likely to happen in the future is a clear division between two class of workers: those belonging to the "talent economy", made by high skilled and knowledge workers that operate as independent contractor to maximize their income and opportunities, and those belonging to the "uber economy", where workers don't really offer any particular skill and compete on price rather than quality. For the first cluster of workers that possess the necessary knowledge, skill and abilities, this shift seems more attractive, and they can hope for an improvement in their quality of life, revenues and opportunities. The other group will probably experience the opposite effect, with a worsening of life expectancy and other major indicators of wellbeing. In the short term, talent will be directly proportional with the quality of life. A 2015 American paper (Krueger et al., 2015) shows the difference between mortality for despair between people with lower education (dropping school or low level of education) and people with higher education. Low-educated people are losing faith in social mobility and are cornered in the job market. One other significant explanation in the different rates of death between people with higher and lower education/social status is the

increasing stress due to the precarious and worsening social and economic situation that many people face. Their concerns are indeed well justified: as a 2020 study (Saez & Zucman, 2020) about growing inequality in US shows, the wealthiest 10% owns 70% of the total assets in 2018, against 61% in 1989; meanwhile the bottom 15% of Americans has no net worth at all, down from 4% of total in 1989 to 1% in our days. These trends are even more marked if we break the analysis down by race and ethnicity. Income and wealth inequality are intrinsically connected with a third inequality: education inequality. In 2018 in the US 48% of white people had at least a bachelor's degree, 32% for African Americans and just 25% of Latinos. Other relevant differences could be spotted analysing this by geographical areas.

Any discussion about the future of work should take into consideration all these distinct aspects, trends and problems of our society, and try to propose some solutions to offer equal opportunities to everyone. To offset the negative effects of the AI disruption it will be necessary, as it was during the industrial revolution, to implement a social help system and upgrade our educational programs to allow a smoother transition to the next phase of our society.

4.1 Human work

"*Human work is the work only human can do; it requires human traits such as compassion, empathy, personal communication etc. and use human capabilities such as critical analysis, judgment of quality, anticipation of what other might do*" (Merisotis, 2020). Human work brings together the things that give us meaning, and allow us to flourish (learning, earning money, serving others). Work in this sense is way more than a way to pay rent: it defines the position in the world, identity and sense of self-worth. Human work should serve a purpose or lead to a result, and that is intrinsically different from the mere definition of a job (only

goal is earning money). Applying these two definitions, the work of the future should be more than a job, and it should bring meaning to people's life.

More and more people in the future will not have an occupation that fits in the standard industrial-age categories of work, mastering only a single body of knowledge or a set of technical skills. Human work requires a wide range of abilities which should be applied to solve complex problems in dynamic settings. New opportunities requiring human work are emerging, while traditional jobs are shifting towards this type of employment. Nowadays, 4 kind of new occupations that embodied human work are emerging:

- Helpers: their jobs involve human interaction. In our economy, heavily based on services, these occupations are everywhere, and they mostly focus on providing the best customer experience. Consider for example the financial sector: as technologies took over some repetitive tasks that accountants and bankers used to do, their jobs became focused on understanding client's needs and responding to them. More and more companies have a customer centric business model, and therefore they need people capable of interacting, understanding and assisting their clients. One other industry where helper jobs are in high demand is healthcare: studies have shown how a patient centric system that interacts properly with the patient and makes him/her involved in the decision-making of the therapy, have an incredible outcome, and lower costs.
- Bridger: this concept of work "bridge" (bring together) solid technical skills and more soft people skills (such as communication and empathy). A fitting example of this category are information system experts, who should have a strong IT background and be able to interact with diverse types of people (not having the same level of knowledge in that field).

Another profession that represents this idea is the teacher job: it combines technical expertise with great social skills to help students grow and learn.

- Integrators: These people combine knowledge and skills from different fields and apply them in a highly personal way. Social workers are a very good example: they should master different fields of competence (psychology, nutrition, economic), understand the implications of emerging research and theory and integrate them in their work, constantly seek new way and theory to better meet their customers' needs; all these actions are done within a social and economic context, under constraints of law and regulations that also are changing. Integrators are also people that apply a strong knowledge/expertise out of the initial area of work.
- Creators: people with high technical skills and pure creativity. One of the fields that requires both these 2 ranges of skills is computer gaming: game developers should use technology as a means for expressing their ideas and creativity.

With all these changes in work one of the things that people need to learn is learning quickly and adapting skills in different fields. While it is still important to expand people's knowledge and abilities through traditional education and programs, the competences required by the market are constantly changing and it is impossible to prepare young people for the competence that will be necessary in just 10-20 years. Today, the world is way more chaotic and uncertain, and that is because of the incredible increase of knowledge. An interesting model to explain how fast our knowledge is increasing is the knowledge doubling curve (Model developed by Buckminster Fuller in 1982, well explained in the article "*The Philosophy of R. Buckminster Fuller*" (Kelly, 1982)). AI researcher Ray Kurzweil applied his findings to this model, estimating that from the beginning of human history to about xix hundred the human knowledge doubles approximately every 100 years, around 1950s every 25 years, by 2000 every year; now he claims (arguably and without strong evidence) the

doubling time will reach daily the span. As the amount of data and information keeps increasing in every field pushing human knowledge further and improving our life, it is also true that our knowledge and skills become obsolete at an increasing speed. The amount of time information is useful for us is shrinking increasingly. In such a world, there is no way to rely education on old models based on the proficiency in one set of vertical knowledge.

Researcher Rube Goldberg suggests that humans should adopt a complementary approach to learning, which he called wide learning. It is based on 3 key dimensions:

1) Time: human work should be paired with lifelong learning, to help people constantly adapt their skills.
2) Range of people: human work should serve everyone, no matter the race, gender, immigration factor, age or any other factors. We should all share the benefits of human work.
3) Content of learning: learning should be based on the skills complementary to AI and machines, those that cannot be replaced by an algorithm.

To embrace wide learning, people must focus on the so-called "higher" skills (higher than the mere technical ones), often referred to as soft skills. Even thus there are countless soft skills that can be useful for succeeding, the author of the book "Human work in the age of smart machines" (Merisotis, 2020) classifies 3 important groups that are necessary to ride the AI change:

1) People skills. Human work is centered around interaction with people, therefore this first set of skills seems obvious. One good example to understand the importance of these skills is the banking sector: once an ATM took the place of a cashier, then smartcards and smartphones became the common way to deal with money and people can move money and manage assets online, but still customers go to the bank. The

reason is that bank's employees offer more complex interactions that cannot be done online, and they offer a connection between clients and a full range of financial services that the bank offers. The skills this job requires of course includes technical knowledge, but mostly people skills: communication is pillar to understand customer's needs and explain what the bank can offer. Other relevant skills are teamwork, which is increasingly necessary to tackle complex and interdisciplinary problems, and empathy, which leads to the understanding of people and the creation of connections.

2) Problem solving: arguably the highest-level skill, problem solving is indeed a complex multistage process that combines different other skills and knowledge, as well as creative thinking to analyse a situation, its contents, and develop a solution.
3) Integrative skills: in the human work of the future, one of the most necessary skills will be the capacity to integrate and create synergies between technical (hard) and soft skills. The purest integrative skill is learning new things and integrating them with the other competences.

4.2 Preparing for the work of the future

Worldwide, our society is facing an economic trend that we could call "Global talent gap". Everywhere there is a global shortage of talent, creating challenges for the economy and society, but at the same time opportunities for the people with talents in demand. This gap between what the job market is searching for and what people can offer is going to increase even more, following the effects of the AI revolutions. The understanding of this gap is important to explain the growing unemployment rates of the developed countries, but at the same time disprove the idea that foresees extremely negative impacts of AI on the job market.

What is true is that AI and innovative technologies, other than destroying occupations, are creating new opportunities and jobs that people are struggling to adapt to, generating unemployment and economic stagnation. To find a better convergence between these two forces, classic education before entering in a career path is not enough: more people are understanding the importance of continuous learning and re-training throughout the whole life to stay update (59% of Americans agree on that, 64% in Canada and 70% in China).

As happened with the industrial revolution, the solution to this problem is adapting our educational systems around the idea of human work. But this is not enough: one other problem to tackle is the apparent but false dichotomy between training (which output is intended to be able to perform a task/job) and learning (usually associated with higher scope, like living a healthy life, have some ethical principles etc.). This dissonance is really crucial when it comes to university education: should a college/university maximize the short-term employment of its students, preparing them to their first job, or giving them the long-term tools for their lifelong career. The problem is that human work requires a wide learning, which is based on the development of people's talents. Those talents, such as curiosity, problem solving, people's skills etc. will not become obsolete after the first job, and they will last for all their life. To have a complete discussion, it is important to analyse both the current educational systems (I will consider the American system, in analogy with the main reference book of this chapter), to spot the main criticalities and the positive points.

Training center short-term programs aiming to provide the competences and skills to perform a job and requires just a few weeks/months to train or re-train an employee. Often, they proved to not be enough, as shown by an evaluation of a US program to re-train workers whose job went overseas, after 4 years only 37% of participants were still working in the industry they were trained for. Other than a shortage of budget, which affects the quality and efficiency of the training, the mistake was intrinsic with the courses. The main problem with

the training center is the disconnection, exacerbated by AI and new technologies, between the environment they were created for, and the one we live in. In fact, the large majority of these programs are designed with a pre-2008 crisis mindset, a period when most of the unemployed people were able to return at their old job, or in a similar company or industry. What happened with the Great recession, and what is happening right now with the Covid Crisis and the AI revolution, is a complete disruption of the market: some industries were wiped out and the new jobs were completely different from the ones before. Moreover, all the new jobs, and definitely all the good ones, required higher skills that a short-term program is not able to provide. One example is the integration skill (among technical and soft skills) that can be learned only if people have a solid background of knowledge, which takes time to be gained.

After exposing all the problems of short-term training programs, universities/colleges seem to be the key to providing people the right knowledge and skills they need to adapt to the changes in the job market. Considering the US market, community colleges in particular offer to millions of people an opportunity of social mobility thanks to a positive trade-off between a lower cost of education and length (compared with a bachelor path) with valuable assets to build a solid career. No matter the typology of college, either a community college or a bachelor's degree or finally graduate school, statistics show that around 70% of Americans are satisfied and recognize full value in their education. Data proves how entering a higher education program will increase the likelihood of earning higher salaries and most of the good jobs require those types of credentials. Overall, universities are important to prepare young people for their future career. What is missing in their offer is often a broader view, a desire to provide tools for preparing people not only for their career but in general in their life; in a few words, helping them to develop their more human skills and be ready for the future of job. We can identify some major problems that the higher educational system is failing to tackle and analyse how a new learning system should solve them.

1) More people need higher level learning. Work is changing in a way that requires higher skills, offered by this kind of education, and the speed of change requires a higher reskilling or up-skilling for employees. The traditional education system (one and done) is over. Education institutions need a radical transition to fit a wider range of needs: not only "traditional" student (after high school) ones, but also the ones of adult employees that need new skills and credentials for taking advantage of the opportunities created by digital technologies. Higher educational systems must become more flexible to different customers, for example offering online classes that allow students to work at the same time and offering flexible schedules for lessons. One other area of improvement is working along with governments and local institutions to offer all the economic and social help to eliminate barriers that potentially prevent students from being successful. The shift of perspective that this revolution requires from education systems is to understand that they are not only serving some customers (clients), but they are serving a community: providing all the help to make their students successful overtime should be their ultimate goal.
2) Developing skills required by human work. Higher education systems are not proving skills required by the future of work (exposed in the chapter before). Most of the universities focus on teaching technical skills and expect students to develop the soft ones. Human skills such as empathy, ethical behavior, social skills, morality, kindness are not only genetic traits that people are born with, but they should be cultivated through people's life, and education (at every level) plays a decisive role. More than any technical skills, these ones require a more practical approach: traditional lessons should be paired with more learning by doing a type of didactic.
3) The nature of traditional higher education and training systems: they are almost always segmented by specific disciplines, maximizing their offer to help students

succeeding in that field. But human work requires by its definition a multidisciplinary approach, which goes beyond a single field; moreover, because of the uncertainty in the future and the continuous changing of the market, people should receive all the background knowledge to be flexible and adapt to different jobs/industries. Creating synergies by the core discipline and other more general ones can be a key to solve this problem.

After considering both the traditional educational systems, we realize how any of those can be enough to face the change of the AI revolution. Training programs are not capable of providing the complex high-level skills required; moreover, they are not even widely adopted (around 4% of American adults hold a valid industrial credential that can be useful for their job) and especially do not reach the people who would need them the most: long-term unemployed. On the other hand, universities need to drastically change their structure, adapting to the new needs of people. The traditional one and done university system is over: people need constant learning throughout their life, and higher-level education systems should respond to this change. Moreover, their program should reflect the new skills required by human work and embrace a wide learning approach.

One other major issue to solve for the work of the future is the credential system. The key thematic is transparency: workers need to clearly understand the knowledge and skills the market requires. Credentials represent the proficiency in a certain body of knowledge and are nowadays necessary to start some kind of jobs and advance in certain career. One of the industries where credentials are more required is IT: 66% of US IT employees plan or are currently working to get a new credential. A continuous learning through credentials is something that could be quite common in every industry in the future of work, like it is already now in the IT sector. If this system is working well within the same country and same industry, by meaning for example that US IT workers know which knowledge they

should gain to access a different job in the same field, this does not apply for people coming from different industries (owning different credentials and knowledge) and countries. This is a problem right now, and it will be even more exacerbated by the massive deployment of works that AI will cause. One other issue is that even people with good credentials, like a college degree, often do not know what their true value is, what they can offer and therefore they struggle to fit a respectable job. It seems obvious that the problem with credentials is transparency, and in particular 3 aspects:

- It is not clear what credentials really represent in terms of knowledge and skills; even when this is clear, sometimes having the theoretical assets does not mean being able to fulfil a task. The credential system should be based more on what people learned throughout the course.
- Firms and educational institutions often do not talk the same language and mean different things for the same concepts (96% of higher education institutions think they are preparing graduates adequately, only 11% of business leaders agree on that). Skills such as problem solving and working on a team have a broad interpretation, and it will be necessary to improve the communication between these two different worlds to find a better match.
- Credentials are decently recognized only if acquired through traditional pathways (college, university masters etc.). One example is that it is difficult for veterans to find a job after their service, because their skills are not recognized in a different field other than the military one. In the future of work every learning should matter, and people should pursue every pathway they better desire.

4.3 Earning, learning and serving

In order to shift to a human work centered system, the most important revolution must be around the education system. The traditional school-college pathway is no longer enough to suit the needs of the upcoming class of workers because there is a clear division between learning and working. Even more progressive systems, based on the cyclical alternance between formation and working share the same problem, which is dividing the moments where people gain new skills and competences to the ones where they need to apply them. A human work ecosystem will require a system that fully integrates the acts of learning and working in just one long-life path. The new high-level skills must be learned in the meanwhile by applying them to the real world's challenges. Education (which for us is foundational learning) and training must be merged into one system.

What is just described as change in the future is actually happening right now. 2/3 American college students are employed while still in college, and 40% have a full-time job. Work offers not only the possibility for many students to be financially independent from their parents, but also provides valuable skills for young people. The problem is that in the considerable number of cases, student work is not connected with the major they chose, some of the skills they earned are not synergetic with the knowledge they are gaining. One possible solution to this problem is apprenticeship. This concept is gaining popularity these days, especially in the UK. Between 2017 and 2019 more than 300k British students enrolled in some kind of apprenticeships and earned money while working and learning. This is made possible by a strong connection between firms (which provided 50% of the funds for the program) and government (which provide the remaining half). Germany has been recognized per year as a gold in this more than half of the students (52%) has entered the job market through their apprenticeship. This kind of system merges skills, knowledge and practical

abilities that the human work needs; moreover, they offer a great transparency between what people learned and what they can do. This model of education is spreading worldwide, with Australia and Germany leading this innovation. To fully achieve the human work idea, it is not enough to pair learning and working, but the nature of the organization should change: at the very fundamentals, any organization should become a learning organization. As proved by research from Accenture, the cost of tuition for employees (usually a benefit for higher members of the organizations) was offset by the higher productivity and returns generated from the same members. What companies in the future should do is partially change their business model, including the learning and developing of employees' skills as a key investment to create competitive advantage. Investing in people's talents, as investing in physical assets, will generate returns over time. The shift of mentality from corporates should be considering these investments no longer as an expense but as a powerful tool to succeed. Other than helping firms to increase returns, embracing the very core virtual human work cycle of earning, learning and serving by investing in people's talent will create strong communities around businesses. One great way to serve a community, other than directly investing in learning opportunities for employees, is allowing the same workers to participate in social projects during company time: employees can serve as teachers, mentors or helping youth during internships and traineeships. Helping a community can be seen as a philanthropic purpose, but indeed it offers a very pragmatic return: attracting more talent, which is the very key element to succeed in a human work ecosystem.

4.4 Human work in a democratic society

Work affects human life way more than purely economically, but it brings meaning to life. People without a job can feel disconnected from their society, left out from their communities

and the life of the country. This idea is well proved by an analysis of psychological problems of US citizens: these ones are more than double (34% vs 16%) for long-term unemployed. This problem can be extended to the people working for the so called “bullshit jobs' ', which are jobs that do not bring any contribution to the society. AI and new technologies are pushing the trend of polarization of work: more and more people end up working in low pay-low value sectors, as well as high pay-high value. It will be necessary to find a way to re-qualify those lower-level jobs and help the people marginalized by the change. These personal and economic problems end up affecting the political decisions and public life: regions where the economy is thriving, thanks to the creation of new works and opportunities, are able to make investments that improve the quality of life of the community, resulting in even more attracting new people. This cycle works the opposite way when the economy is shrinking. Some studies support the idea of education as a primary explanation for these 2 trends. What is really connected with the results of these cycles is politics: extremisms ideas and a general polarization of the electors are one of the main problems of our societies.

The effect on jobs is just one of the ways that technologies like AI are affecting our society. AI is transforming the flows of information, re-shaping public opinions, changing the way people obtain and process information from the world around them. AI and similar technologies are as much as disruptive for the economy as for society. As for economy, they can lead to different outcome: positive, as creating new kind of social networks, democratizing access to data and information and mobilizing collective actions, but also negative as enabling people to self-isolate and allowing people to live in bubble (where they only face information and ideas that are consistent with their initial beliefs). What is happening now is that more people have a perception of the word shaped by some algorithms and have lost critical thinking (fake news is spreading). The combination of big data and social media allows powerful people to influence society with remarkable efficiency.

Whereas we live in a word full of information, the way that people manage and analyse the data is largely insufficient. AI and technologies tended to make people more passive concerning public life, consumer choices and in their communities.

From the other side, the same pillars of human work (as based on human interaction) can be an answer to burst those bubbles of beliefs. Skills typical of human working such as critical thinking and problem solving (frame and understand a problem, propose solutions etc.) are indeed the tools that our society needs to overcome the negative effects just mentioned, and communication can foster understanding between people and create a healthy social dialog. Along with those skills, it will be necessary to work to open students' minds and stimulate their sensibility for ethics, word issues and global literacy. The talent that human work requires is the same talent our society desperately needs to escape the negative trends we are facing. To protect our democracies, people must be active citizens, who recognize the importance of having an active role in their communities and the value of serving others.

5. SURVEY: CHANGES IN THE JOB MARKET

This second part of the survey aim to analyse the level of awareness of students toward the possible changes and disruptions that the job market will face due to AI, and if they are ready to adapt their skills and knowledge to ride these future challenges. The first part of the questions regards their perception about how much the job market and will evolve due to AI, and how this change will impact their future jobs.

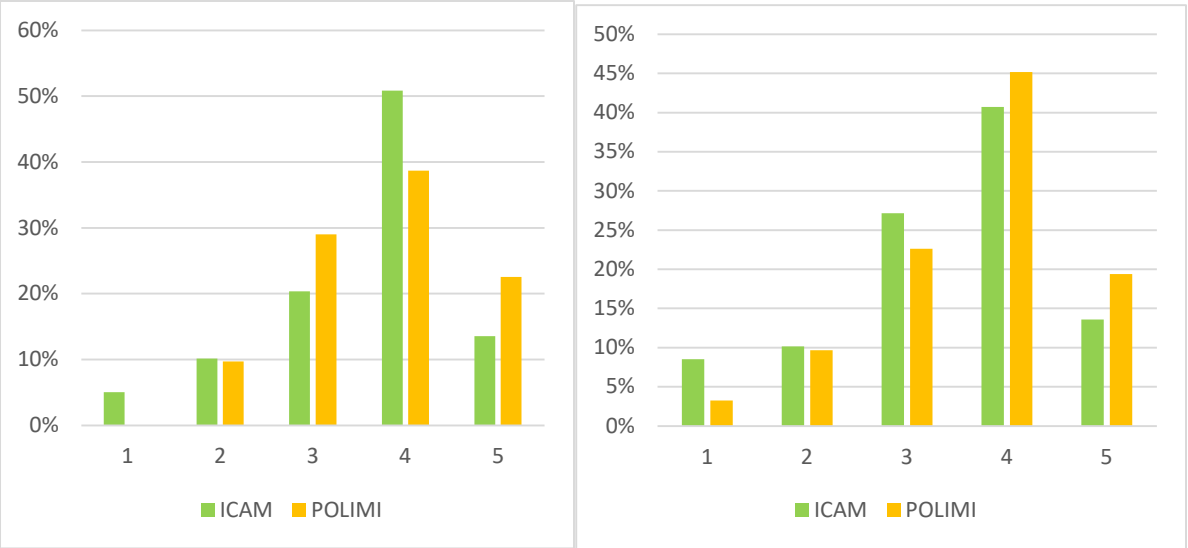


Figure 10: How much do you think AI will be relevant for your future job? (left) How much do you think AI will impact your sector? (right)

Both samples of students are pretty aware of the future impacts of AI on their sectors/jobs. the large majority of respondents forecast a high (4/5) or considerable (3/5) impact. One interesting detail is that in both answers POLIMI students are more optimistic in the evaluation of the impact, while French ones are slightly more prudent. The average answer is 4,5% and 8% higher for the Italian student.

To enlarge this first set of question, students replied to a question concerning the impact of AI for the number of jobs in their sector. As already explained in the theoretical part, assessing the future job creation-losses in the medium-long term is a virtually impossible problem, because nobody can really forecast how a strongly disruptive technology will re-shape an industry, especially people with few or zero practical experience in that field. What is interesting, however, is to analyse their attitude and faith in the artificial intelligence technology. The two distributions are centered around the same average but follow two radically different profiles: French answers are way more distributed in the tails than the

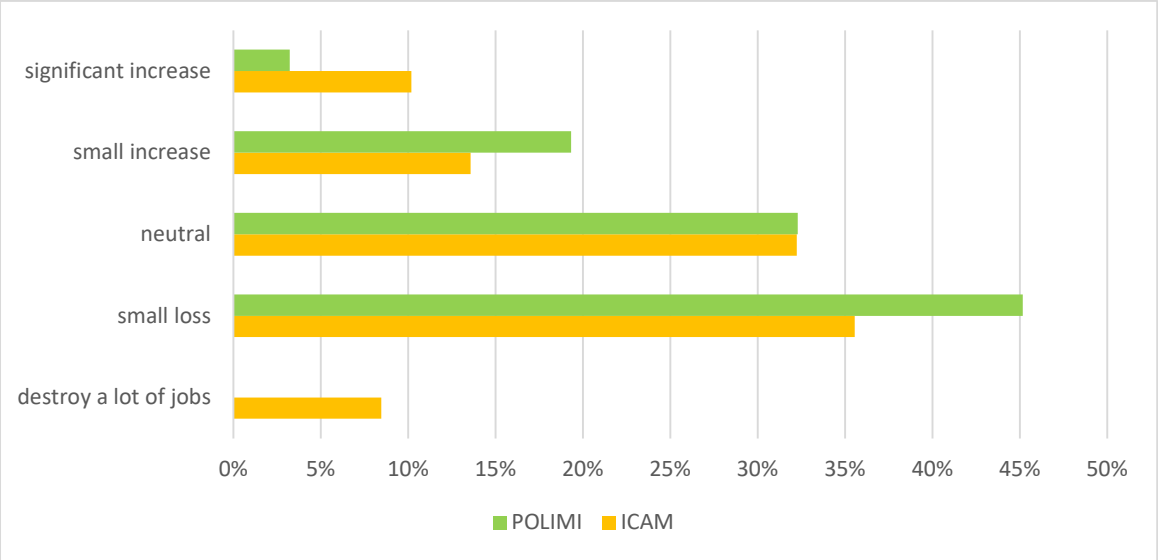


Figure 11: what do you think will be the impact of AI on the number of jobs?

Italian ones, which are well centered. This result is partially in conflict with the previous idea of POLIMI student being more pro-technology. There is a good % of French (10%) that are convinced of a significant increase in the number of jobs.

This contradiction could be explained by considering the structures of the samples, because the question regards the industry where the student would likely work into. ICAM student are

generally focus on a traditional industrial background, while POLIMI student come from very different branches of engineering.

Most of the students consider the probable impact of AI on the number of jobs as minor or neutral (Figure 11), but both samples agree that AI will disrupt their future jobs and sectors (Figure 10). This information shows a great understanding of the phenomena: researchers project that high-skilled jobs (like the ones most of them would likely end up in) will require different skills and will change in the nature, but there is no evidence to claim that the overall amount will drop.

One different aspect where the tendency of POLIMI students to be more pro tech stands out regards the possible de-personalization of human work that artificial intelligence could foster. Italian students are not concern at all (45%) or slightly concerned (48%), while a large part of French ones (22% vs 6%) foresee a really dangerous situation.

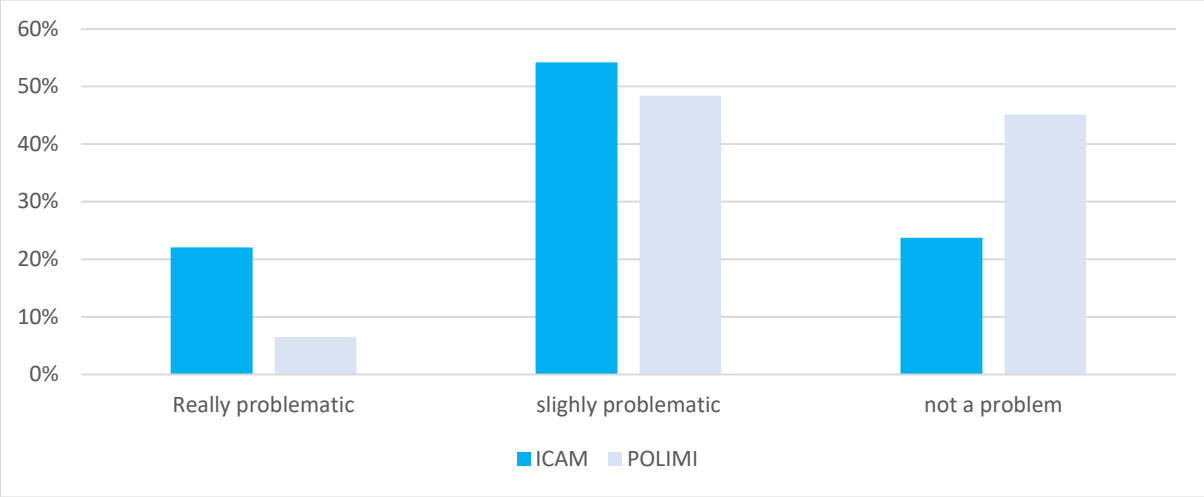


Figure 12: How do you perceive the possible de-personalization of human works due to AI in your sector?

To enrich the first high level question of this chapter (Impact of AI on your industry), it has been asked students to grade the effect of artificial intelligence (positive, neutral, negative or

unknown) over 5 critical dimensions for a company. Because long term effects are difficult to forecast and require experience, I tailored the question with a shorter time horizon (5-10 years).

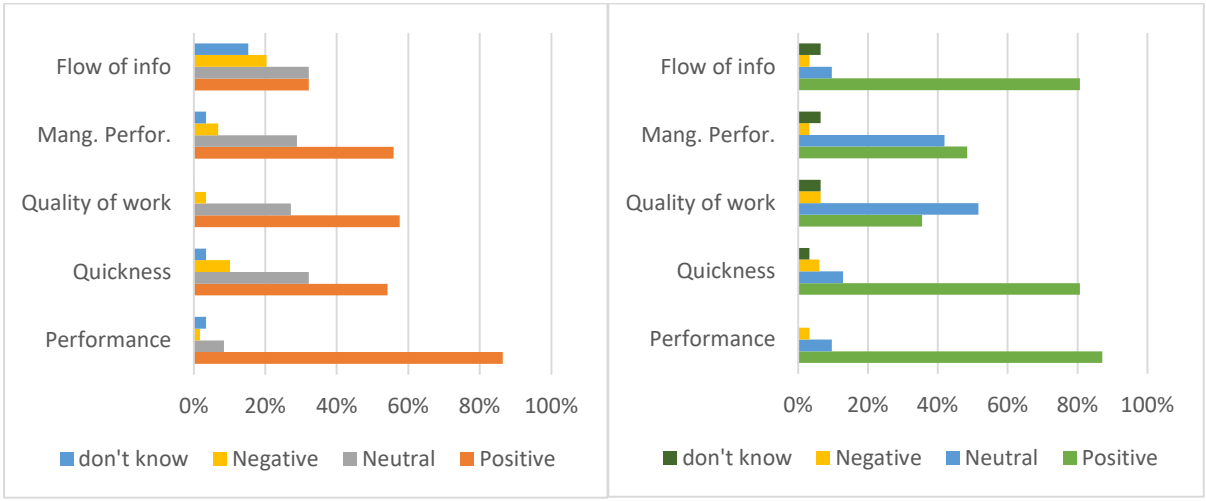


Figure 13: Within the next 5-10 years, how do you think AI will impact the following aspects in your field (ICAM on the left, POLIMI on the right)

Here are some considerations:

-both samples believe strongly in an augment of performances. This is the only dimension with a strong consensus (87% on average) from both ICAM and POLIMI student, and in general has a staunch support from researcher and mainstream market. The problem of whom will enjoy this increase of performances is postponed for the next chapter.

-Italian students believe that Ai will improve the quickness in industries' processes, whereas French ones are more conservative.

-Both the Quality of work and Managerial performances do not have dominant opinions for the Italian sample, and instead are pretty polarize for the other one (toward optimism). Something interesting is to note that quality of work is the only dimension in this survey

where the POLIMI sample has a higher % of neutral answers than positive ones, differently from French that still have a good majority (58% optimistic versus 27% neutral). French students appear greatly confident in the future benefits of AI on their work, which is an interesting insight.

-there is a substantial difference in the flow of information dimension: Italians are really optimistic (more than 80%), French way milder with a surprising 20% of participants answering for a negative impact (highest % of negative feedbacks in the question).

In general, both samples appear confident for future improvements in business dimension (performance, quickness and managerial performance), while there are contradicting opinions on more qualitative dimension. Both these last two pillar are based on social interactions, an area where the effect of AI is not forecasted as optimistic compared to the other dimensions from the survey participants.

To analyse more the effect that AI can have on jobs I designed a question that states something controversial, to analyse participants' reactions. The question is "Some people claim AI will eventually be an obstacle to many high skill jobs because it will take away part of the decision-making power. Do you agree with this sentence?" The looseness of the question is what make the answers interesting, because they reflect some prejudices that a sample have toward AI. A positive answer would have been ideal in case the question was framed on repetitive high-skilled jobs, which are threaten from AI as any repetitive jobs (no matter if high or low skill). But without the distinction between repetitive-human-kind jobs is difficult to build a question that can be answered with conscience.

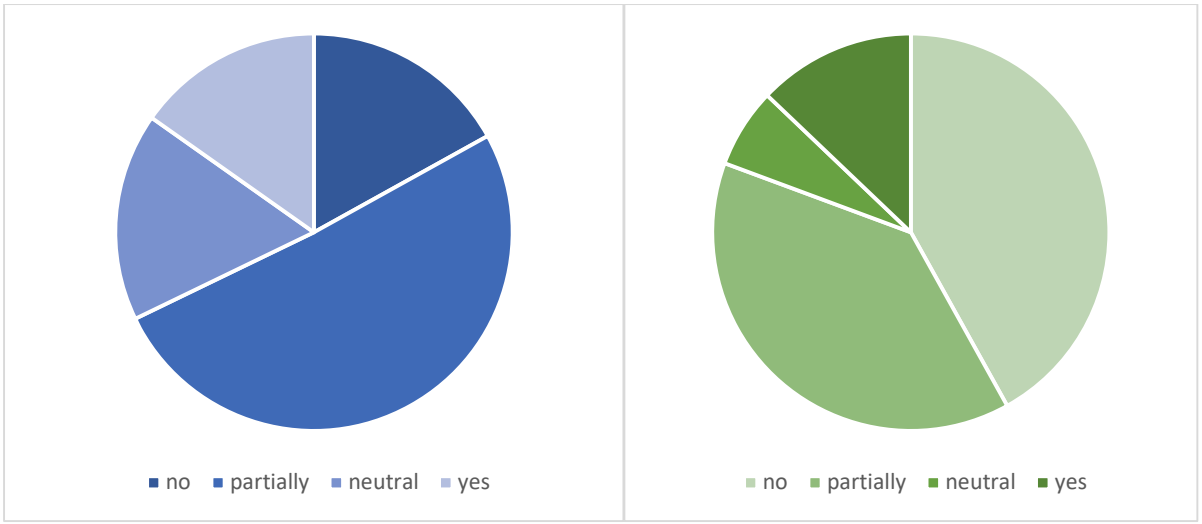


Figure 14: Will AI be eventually an obstacle to many high-skill jobs because it will take away part of the decision-making power? ICAM (on the left) vs POLIMI (on the right)

Most of the ICAM student partially or completely agree with the sentence, where POLIMI ones lean more toward no. This difference is consistent with the idea from chapter one that French students are more scared from AI.

The opposite principle applies in the next question concerning the problem of job polarization being amplified by AI. This idea has a strong consensus among researchers/scholars of AI, and there is a strong belief that artificial intelligence will escalate furthermore this issue. In this question French students show a better understand of the problem and once again a more prudent behavior concerning AI.

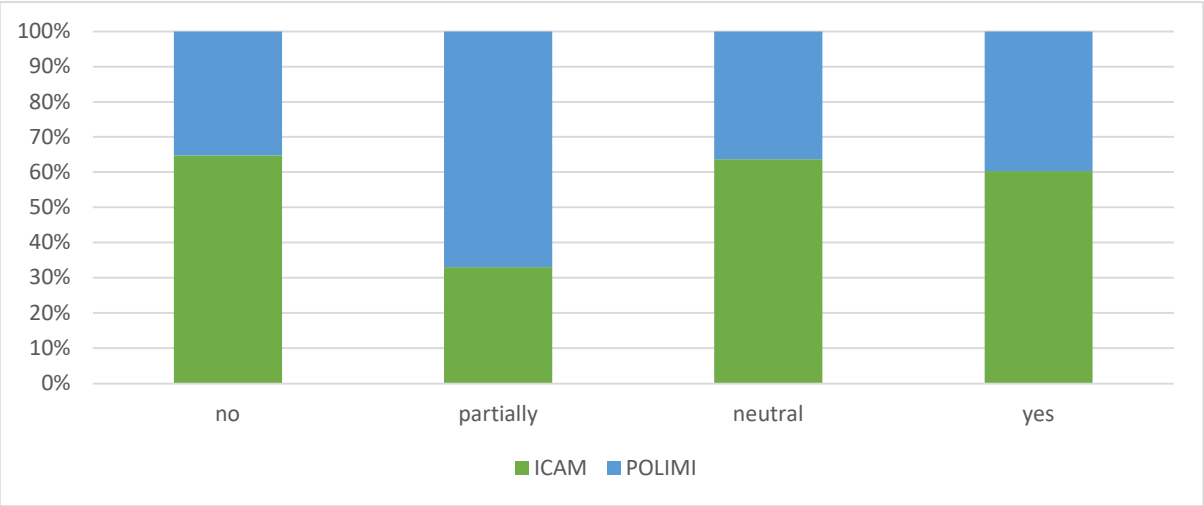


Figure 15: Researchers claim that future development of AI will escalate the issue of polarization in the job market. Do you agree?

This first part of the survey in chapter 2 concerned a broader analysis of the future impact in the job market due to AI, while the upcoming part will be focus on the skill that future engineer should master to ride the technological change.

Before going at the core of the problem, I designed two preliminary questions to approach the discussion from a general perspective to more detail aspects. The first one is about which kind of skill will be more relevant to face the changes due to AI, the second one on their coding/informational skill level. The French sample perceive as more important the soft skill, while the Italian one assess equal importance. Despite this difference, the results about the coding skill (one of the most critical hard skills that today market demands, especially in the AI field) shows very comparable results

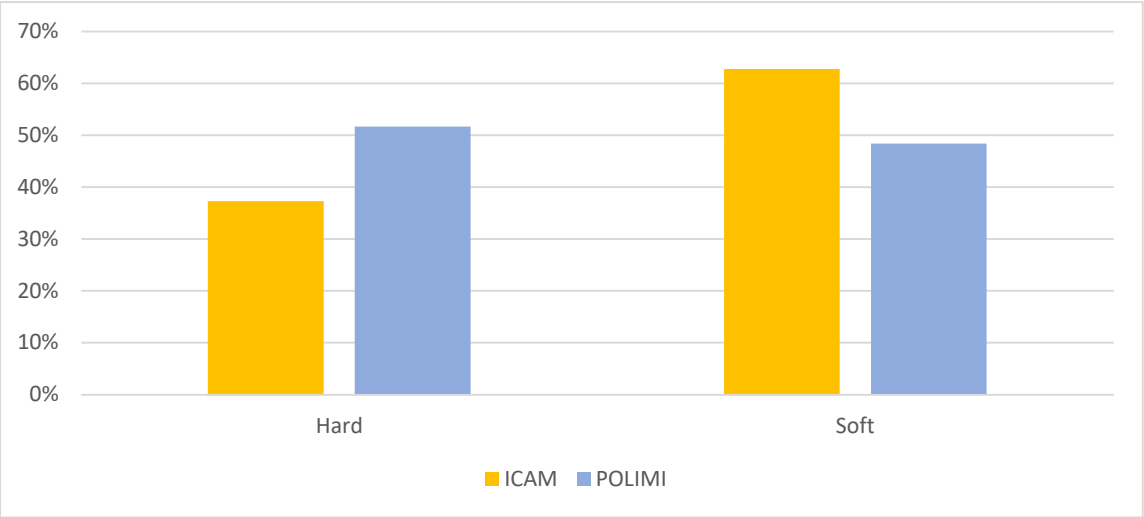


Figure 16: Which kind of skill will be more relevant to face the changes due to AI?

This set of questions highlight a higher coherence from the French sample, because the Italian one claimed before to strongly believe in the relevance of hard skills, but then it is averaging the same levels of coding skills (the most desirable for working/ interacting with AI) as the other sample.

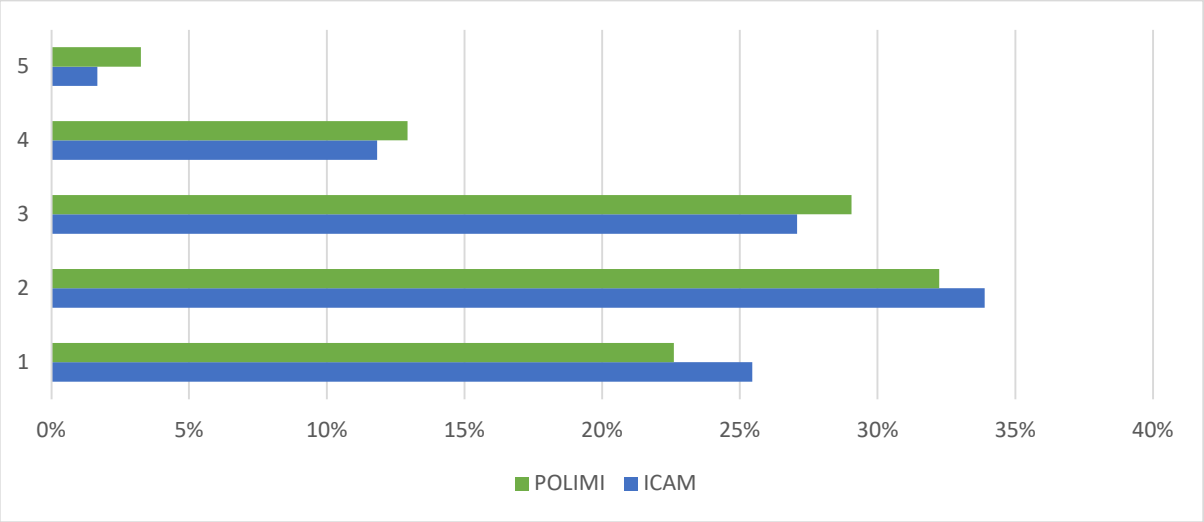
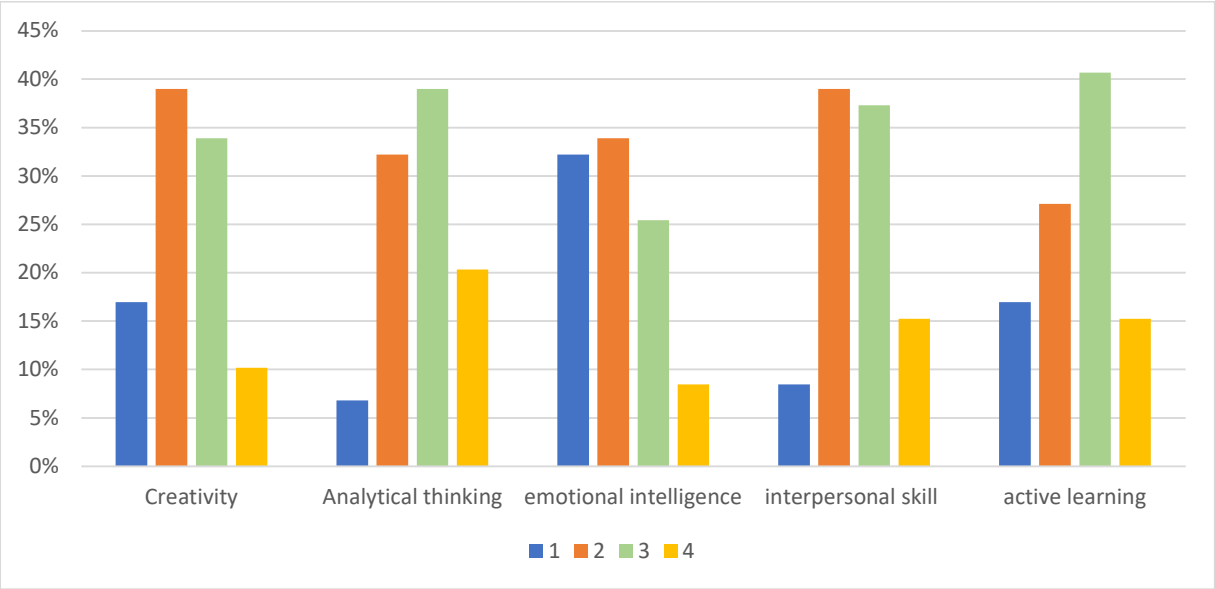


Figure 17: How would you assess your knowledge about coding/informational skills?

While researchers still value the importance of building hard skills to thrive in a specific industry, the unanimous idea is that the key for ride the change from artificial intelligence is

to master a good set of soft skill, the ones that embodied the more the values of human work (4.1 Human work). To dig deeper into this subject, I created 3 set of questions analysing 5 dimensions that I think represent the core of human work. Compared with the theoretical definitions of Cp.4 (3 main skills: People skills, Integrative skills and Problem-solving skills) I reframed slightly the group of skills to make the questions clearer and more straightforward to a broad audience. This set of questions is also inspired by the book "*In the ai era soft skills are the new hard skills. Artificial Intelligence and its Impact on Business*" (Dolev and Itzkovich 2020).



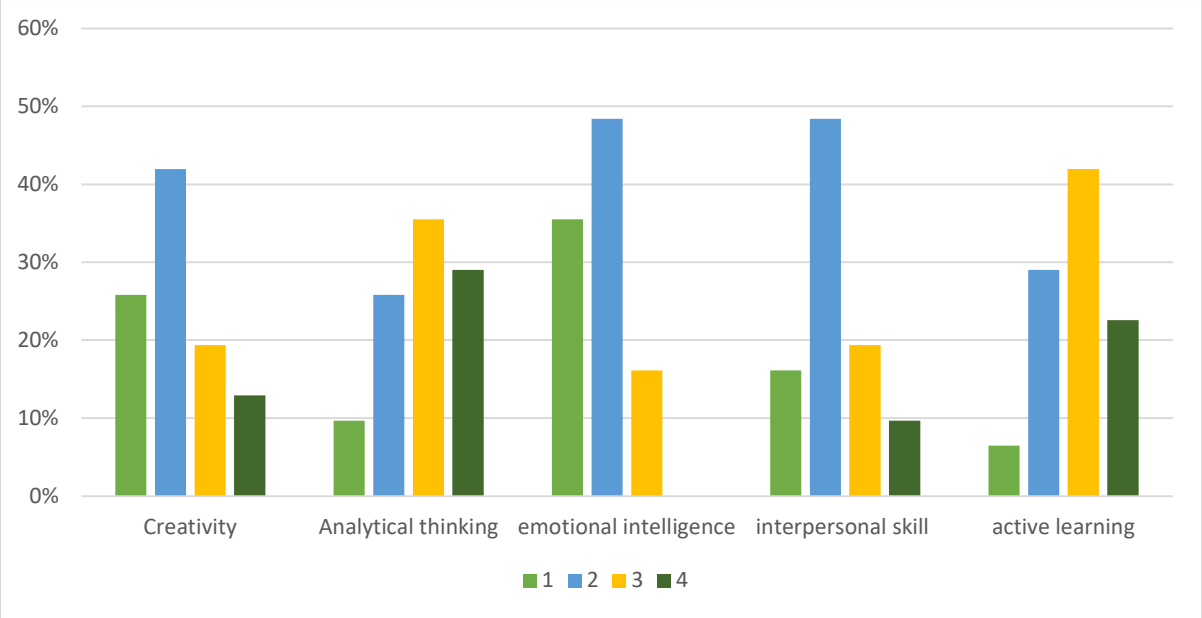
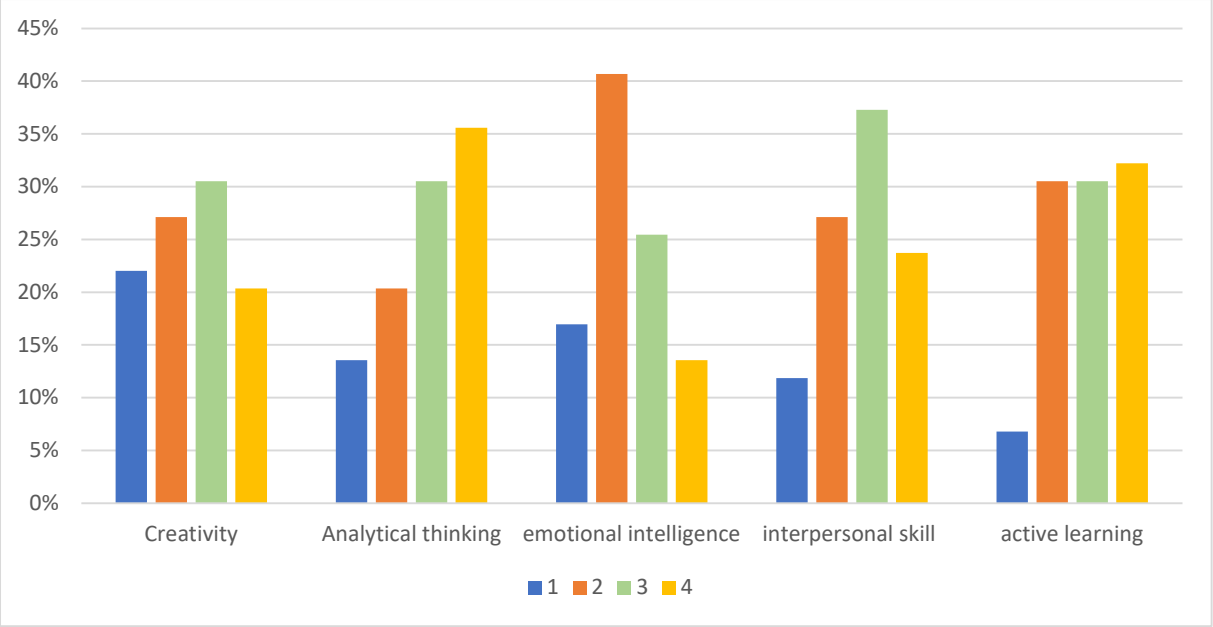


Figure 18: Looking forward, do you think your university is helping you to develop the right set of soft skills for embracing the change from AI? (ICAM above, POLIMI below)

The first question of this group concerns how much the two universities are focused to develop some kind of soft skills. The results are considerably similar: both samples answered that the skill their universities are helping them to develop the most is analytical thinking, the one they are helping lest is emotional intelligence. Moreover, Italian students gave credit to the Politecnico to strongly encourage them to improve their active learning, while creativity is more recognized at ICAM. The skill with the highest difference between the two differences is the people/interpersonal relationship (average point of 2,6 for ICAM versus 2,1 for POLIMI).



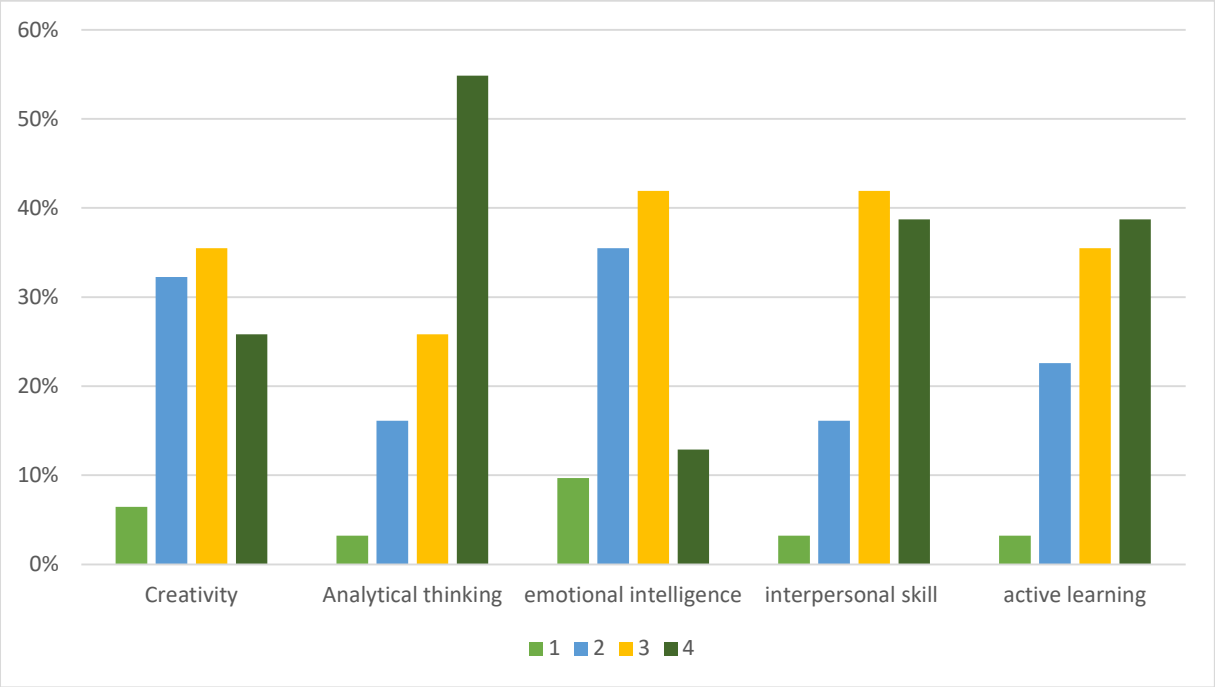
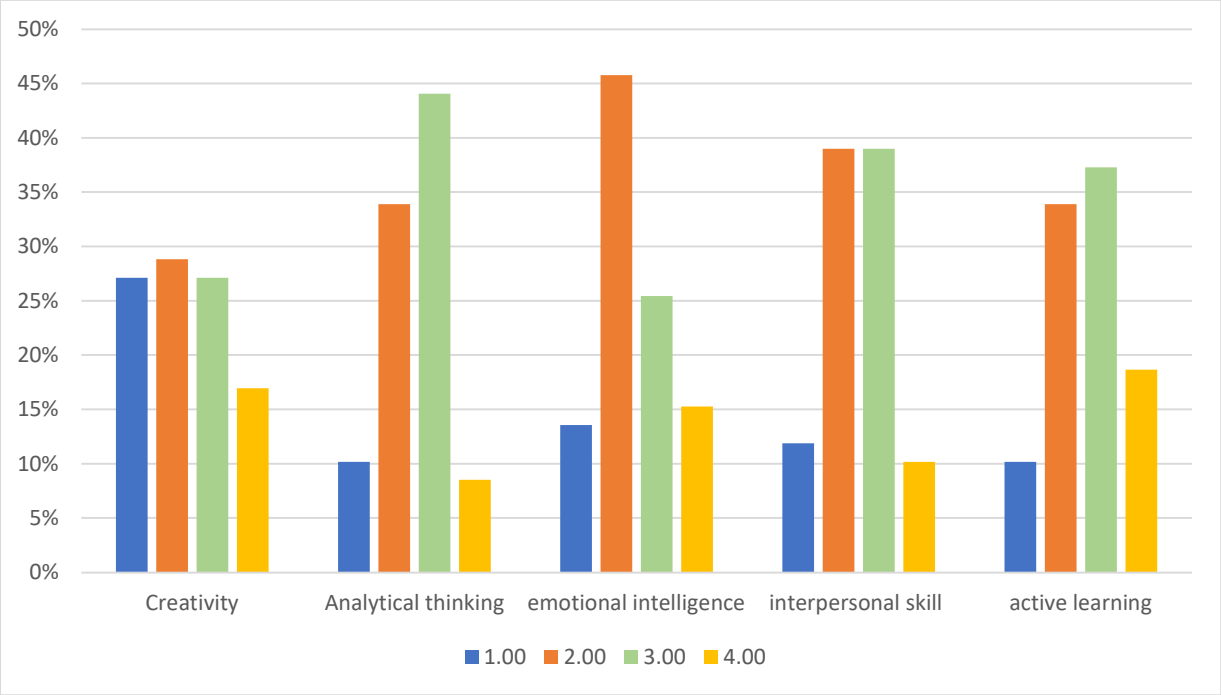


Figure 19: How critical will they be for your job? (ICAM above, POLIMI below)

The results of question 19 concerning how critical these soft skills will be for future engineering jobs are really coherent with the previous one (how much universities are investing in those skills). In fact, participants of both sample value the most analytical

thinking and the least emotional intelligence. ICAM students also strongly believe in the importance of active learning, a field where their university is not overperforming. Same principle applies for the POLIMI student that consider important the interpersonal skills, but receive less incentives from their university to work on that. Considering both questions we can make a first relevant observation: there is a slight misalignment between what universities and what students think is important to ride the AI changes, but both agree on the most and least important skill.



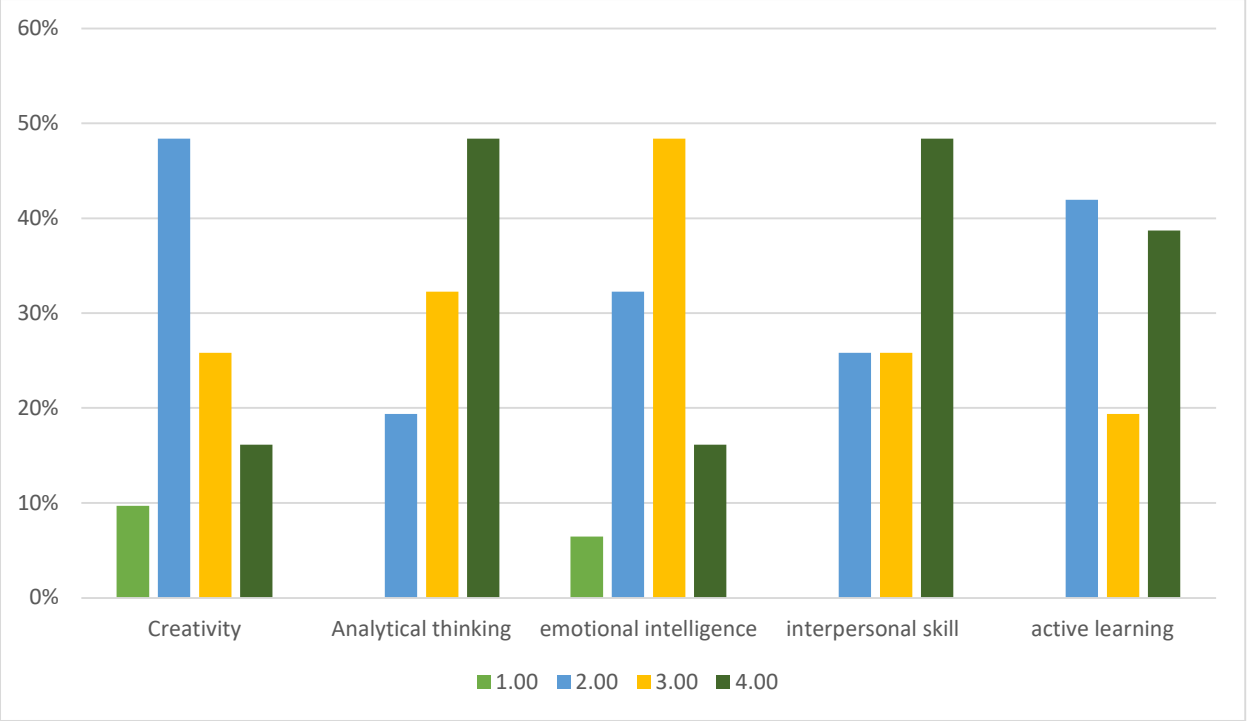


Figure 20: How much are you currently working to develop your soft skills? (ICAM above, POLIMI below)

This last question completes the analysis about human work, and concerns how much students are currently working to improve the 5 softs skills. This problem generates some coherences, such as the high level of value and current commitment for analytical thinking and interpersonal skills (POLIMI) and active learning (ICAM). From the other side there are also several inconsistencies: both samples are working the least on creativity, even though none of them think is the least relevant and ICAM student value highly analytical thinking but are not working as hard as in other skills and finally.

The results of these three questions are really depending on the sample chosen: because every participant is attending engineering courses it is more likely that skills like analytical thinking are more appreciated (it is more rooted in the nature of the education) compared with others like creativity. However, what scholars like Dolev and Itzkovich are telling us is that no

matter your future jobs each of these soft skills will be necessary to embrace the changes in the future job market and take the opportunities that AI will generate. Among all the question of my survey, these set of 3 are the ones I will be more interested to extend to other samples of student (non-engineer).

To end this part of analysis I designed 3 final question that investigate how participants think their future jobs will be reshaped by AI. The first one is about the relationship that they will have (as engineer and future decision-taker) with recommendation from AI system. Results are similar for both samples, with a slightly more optimistic view from the Italian sample. The idea that emerges is that there is a strong uncertainty is how we will deal with recommendation, even if the weak majority for an active relationship.

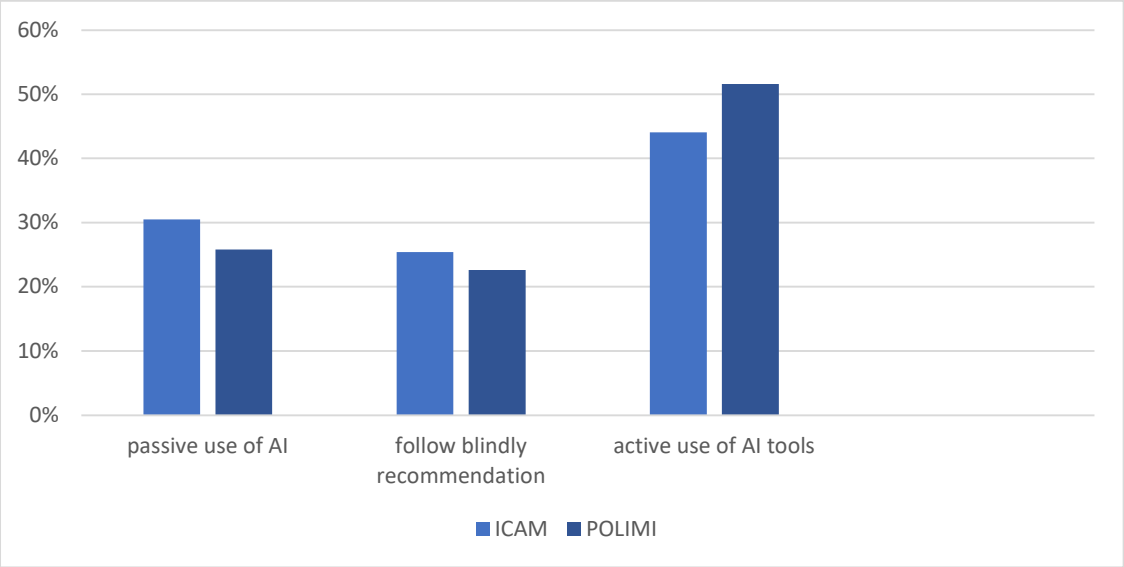


Figure 21: How do you think managers will deal with recommendation from AI?

The second question investigates what the added value of AI technologies to their future jobs could potentially be. French students think the most value from AI tool will be the large number of resources we will be able to access, followed by be able to complete more tasks. Italian ones instead value more a deeper understanding of problems, and after the more

resources. It is certain that both of the 3 benefits could be enhanced by AI, but it is difficult that it will happened at the same time: accessing more resources will not necessarily make easier to understand a problem and understanding a problem deeper will not easily translate into more tasks accomplished. It will be important for each job use an AI-based technology that enhance the aspects more in demand for that occupation.

Figure 22: Looking at the future, what is the added value that AI tools can have for your work?

The last question concerns the belief/fear that within 50 years most of human jobs will be automated. We can see remarkably comparable results, centered around 50% forecasted probability. Italian results are less variable and more centered, while French ones for example have a double probability in a likely scenario (80-100%) compared with Italian ones.

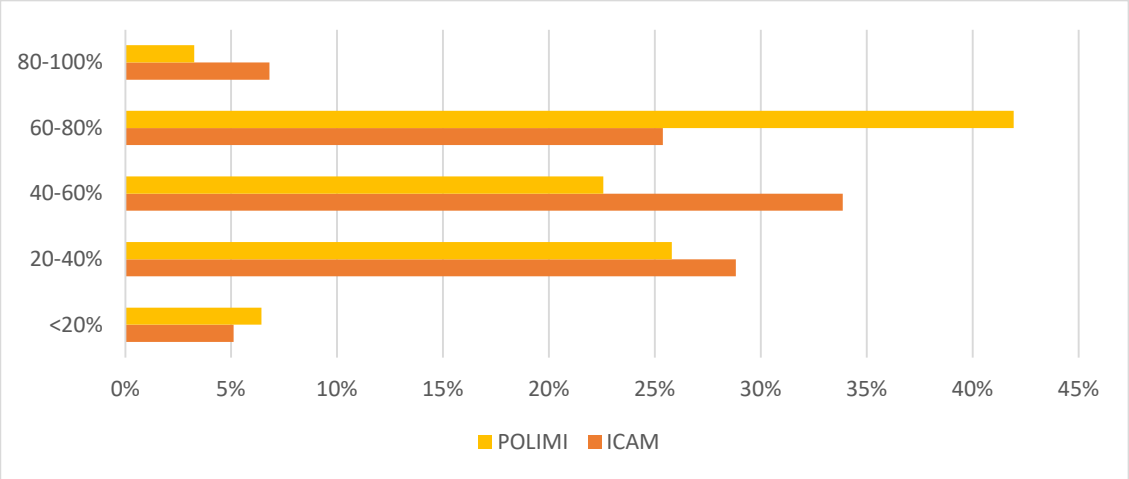


Figure 23: In the next 50 years, which is the likelihood that computers and machines will do much of the work currently done by humans? (Orange ICAM, yellow POLIMI)

6. SOCIETAL TRANSFORMATIONS TO COPE WITH AI DISRUPTION

6.1 Why do we need a utopia?

Looking back on the last centuries, scientific progress has not gone hand in hand with an improvement in people's income, and therefore in their quality of life. After hundreds of years of stagnation, in the last 150-200 years there has been an exponential growth in the economic conditions of the population: in a few decades, the percentage of population below the line of poverty had moved from 80% to 20%. We can argue that today's Europe represents the medieval utopia, embodied by the ideal city of Cuccagna, where everyone has access to food and medicines, where there are no wars and everyone can enjoy an education.

Quoting the book “Utopia for Realists”(Bregman, 2017), the progress itself is transforming utopias into history. The utopias of the past, simple and naïve, corresponding to the lack of basic needs (food, health, etc.), are nowadays becoming standard for a large part of the world. What 50 years ago was perceived as fiction is now science (self-driving cars, stem cells, human-shaped robots).

So, what is missing today? Why do people struggle to be happy in a world that ensures them the highest expectancy of life, economic wealth and opportunities? One problem could be the lack of new dreams, the difficulty to imagine a better world, the impoverishment of ideals in politics and in life. For this reason, utopias like Moro’s one can be valuable for our society because they help people to open their minds and ask the right questions (why do we work harder if we are richer? Why does 60% of your income depend on the country you were born in? etc...).

6.2 Universal basic income (UBI)

6.2.1 Why should we give money to everyone?

One of the first experiments (reported in the article “The case for a universal basic income” (By Godfrey Moase, Carina Garland and Shirley Jackson, 2016)) we can look at to answer the question “Why should we give money to everyone?” was held in London in 1935: 13 homeless people received £ 3000 per month without asking for anything in return, except to answer the question: what do you need? After a year, 9/13 of them were able to acquire a house; all 13 progressed in their personal life (reduction of drugs and alcohol) and financial lives (they took courses in educational subjects, gardening, cooking etc..). The project not only radically improved their lives but also reduced the social costs that it would have been necessary to face to help them with the traditional assistance programs.

One of the assumptions this experiment, and many others in the past 100 years, questioned is that money makes people lazy. Another good example is the story of Bernard Omondi (“Has the time finally come for universal basic income?” (Rutger Bregman, 2020)), a miner in Kenya for his whole life, after receiving $500 in his bank account (1 year's salary for him). With that money he decided to finance some reconstruction works in the village and start a small business as a taxi driver. The program behind this gift is called” Give Directly”, an organization that donates money directly to people without asking anything in return. According to their data, people have managed to increase their salary by an average of 38% compared to the value before the donation, proving that the poor people probably know how to better spend money than external organizations that help them through assistance plans. Similar conclusions can be drawn after the 2008 Uganda experiment (“Universal basic income in the developing world” (Banerjee et al., 2019)), where about 12k citizens received

$400, with the only request being to present a Business Plan summing up how they would like to spend the amount; 5 years later, we can see a 50% increase in their incomes.

Many other anti-poverty programs in Africa support the idea that the most effective way to spend public funds is to donate them directly to people. Brazil, India, Mexico, South Africa and many other countries in the southern part of the world are adopting similar programs. In 2010, 110 million people in over 45 countries were involved in similar programs. In each country, these programs generated better results than traditional care systems' ones, significantly increased people's consumption (they have more money) which supported local economies, reduced the use of alcohol and tobacco in 82% of cases and overall proving that donating money directly to people can be the best way to support them.

The idea to forward basic economic support to every citizen in a country, other than only poor people, is actually older than every of these experiments. The first version of what we call today, "universal basic income" was introduced by philosopher Thomas Moore in the book Utopia (1516) and has been carried on from both right and left politicians and economics in the last 5 centuries.

One of the most significant large-scale experiment to test the validity of UBI was held in Canada in 1973 ("The Answer to Poverty: A Universal Basic Income in Canada" (Clark, 2021)): $84 million were distributed among the inhabitants of the small town of Dauphin to ensure that everyone has an income higher than the definition of poverty. The experiment was going smoothly for 4 years, when a change in the government led to a cut of funds and a rapid loss of interest in the experiment. International spotlights return in 2009 when a researcher found the Dauphin's dossiers and compared them with the data from neighboring cities, highlighting impressive results as a lower birth rate and stable amount of worked hours (one of the main assumptions back then was that people with free money would have been

more lazy, less productive, would have stayed at home more and have more children), better academic results, more school longevity for women, 8.5% drop in hospital patients, less domestic violence, less mental health problems and higher earnings for the next generation.

The other 4 major social experiments of UBI were conducted in the USA. In 1964 the government tried to create a solid social welfare network in the war against poverty called by President Lindon B Jonson ("Utopia for realist"). The experiment consisted of providing a minimum income to around 8,500 Americans from different states (New Jersey, Pennsylvania, Iowa, North Caroline, Seattle and Denver), then comparing the experiment groups with the control ones. The main scope was analyzing 3 topics:

1) Will UBI lead to a decrease in working time?
2) Is it too expensive?
3) Is it politically impossible to adopt?

According to the results of the experiment, there was no significant decrease in the amount of work, and the little gap was justified by the fact that many citizens start following new courses to learn new skills and eventually improve their working condition. Regarding the cost, it is estimated that completely eradicating poverty in the US would require 175 $ billion, which accounts for 1% of the national PIL, or an even more astonishing 25% on the yearly military expense. Therefore, even if considerable, the economic side is not an insurmountable problem for most of the western developed countries. Thus, the only real problem that prevented the success of the experiment was the political side. Shortly after the beginning of the experiment, on the wings of enthusiasm, an article written by 5 renowned economists and signed by over 1,200 colleagues was published in the NY Times, calling for a minimum income equal to the definition of poverty for every citizen. Moreover, President Nixon tried to introduce a plan (family assistance plan, FAP) to extend the financial aid to every US

citizen ($1600 per family of 4, equivalent to $10k in 2010). In 1970 the job was almost done, but the FAP was rejected in the Senate, particularly by Democrats who demanded more funds. Once again, the next year Nixon tried to present a latest version of the plan, which failed again. In 1978 the program was definitely sunk, after the curious discovery (later proved to be false) that the rate of divorces in the group population went up by 50%, implying too much freedom for women. In a few years, everyone's enthusiasm was extinguished, and the public debate lost interest. This story proved the complexity of approving social plans that considerably help a small minority, without a return for the other citizens.

6.2.2 Are poor people lazy?

There is another curious anecdote, other than the alleged increase of divorces, which hampered the ’69 Nixon's dream of basic income. In those days Nixon received a document about the Speenhamland experiment, in the early 18th century in England, where an attempt was made to implement a prototype of basic income. The president was shocked by the results, which demonstrated the loss of citizens' willingness to work and the damage to the creation of a liberal market. He tried to adjust his proposal by introducing work obligations and making his initial ultra-liberal plan more conservative. The lack of opportunity to overthrow a system and rewrite society was lost because of 150 years old “poor lazy” myth, based on the results of the experiment.

But what really happened? At the end of '700 in England there was a great discontent and a desire for social revolution, on the echoes of that French one. Therefore, the city of Speenhamland created a new program of public support: every needy man was entitled to a minimum support; this approach was later widely adopted all over southern England,

improving the social bad temper. The experiment was paired with a survey around the 30s, one of the first large-scale social analyses, aimed to support future social policies. The output highlights several problems of that system, like the steep increase in the number of children, an average wage reduction, more immoral behavior of people and a general degradation of the English working class. The paper written from the survey was used by many scholars of the social sciences, as for example Marx in his theories in the "Capital." The experiment was relegated as a failure and played a key role in the creation of the "lazy poor" myth. 150 years later, however, analyzing the documents, it is noted that the analysis was completely wrong: the paper was written before receiving data, only a small part of the population was interviewed (and most of them were rich people from the church), and almost no one received the subsidies. The evidence, completely distorted, served as a proof to promote a different Poor Law (which incredibly lowered the wages and treated the poor people like prisoners in forced labor, without any civil rights).

In the head of Nixon this story, completely distorted, weighed more than the rigorous experiments in the 60s and 70s in the USA and Canada. Re-analyzing the Speenhamland data, some scholars noted how in reality the population growth was explained by the numerous working kids recognized in the society, the revolts were connected with the approval of another law (the Golden Law) against the poor class and industrialization (especially in agriculture field, where the new machines produced more food than ever, but the poor people couldn't afford it because they worked less and less) and finally the lower wages because the social plan was applied in the poorest neighborhoods.

6.2.3 Principle of scarcity

Jane Costello, a British author and reporter, has analyzed the relationship between poverty and psychiatric disorders since the 90s, trying to understand the nature of the correlation (as explained in the paper "Cultural and community determinants of subjective social status among Cherokee and White youth" (Brown et al., 2008)). In the early years of the 20th century, she found the perfect case study, since 25% of her research sample (poor children) belonged to a tribe of Native Americans, the Cherokee, who in those years made a fortune of money creating a mega casino on their lands in North Carolina. After the casino opened, half of the children who lived below the poverty line were no longer in that condition, and it was possible to observe a 40% decrease in social problems, bringing the average value in line with the rest of American wealthy children. Along with that, there was a significant improvement in school outcomes, decreased crime, and a diminish of alcohol and drug consumption. In particular, the younger the children were at the moment that their life changed, the better the results she found; among the youngest children the results were even better than those in the control group. Costello concluded that mental problems depend on both genetic factors and poverty, but only the second one can be eradicated.

Why do poor people tend to make worse decisions? (Crime, smoking, worst diet, attitude etc.). In many countries, especially English-speaking countries, the basic idea is that poverty must be fought individually. The reason why they make worst decisions can be explained by the principle of scarcity, which focuses the attention of poor people to solve short term serious problems related to economic privation, blurring their judgment in multiple other problems/aspects of life because all their energy converge every day in the thought of their deprivation, and how to escape it. The context in which they live and the economic conditions broadly justify their bad decisions. It is estimated that being poor results in around 13-14 IQ points less (the same as not sleeping for a whole night or being an alcoholic).

Another interesting experiment was conducted by Eldar Shafir ("A behavioral-economics view of poverty" (Bertrand et al., 2004)) on a group of Indian farmers who receive almost all their profit in a certain part of the year: their IQ scores are worse in the time of year when they are poorer, and vice versa.

The main takeaway is that poverty narrows the mental band, bringing people to make worse decisions, as evidenced by the Cherokee casino experiment. In that case, the cost of financing the casino generated a higher reduction in the costs related with crime, school delays, use of care facilities and other social issues in just a few years. The idea is that financing poverty assistance programs generate returns in society, savings in welfare, more revenue generated (therefore taxes) by the people who managed to change their life for good. The fight against poverty on children, according to the theory of a British study, would be completely repaid at the middle of the citizen's life.

This principle of scarcity does not apply only to poor people and can be useful to explain why more individuals are unhappy even if wealthy. The growing social inequality in the western societies in recent decades increased citizens' perception of scarcity, which is shaped from what they see and perceive around, lowering the social bandwidth. Social studies proved that money by itself is necessary to happiness only below a certain threshold, around $5000 per year; as soon as people have enough food, medicine and health, being richer does not necessarily generate more happiness. Social equality instead has a decisive impact, as proved by the example of Portugal: it has the same level of social problems as the USA, which has twice the GDP per capita. The more you have, the less the increase in your income impacts your well-being. If we consider the disparity between the incomes of citizens, almost the same for the USA and Portugal, we are able to explain the similar numbers of social problems (depression, drugs, obesity, political absenteeism etc.). A certain level of inequality

is necessary to motivate people to work, compete and excel, but today in most of the countries, inequality is spreading and generates higher unhappiness, even among the rich.

UBI would be an incredible tool to solve the problems of poor people related with economic scarcity, and would definitely make our society more equal, improving everyone happiness.

6.2.4 Will UBI boost or depress people's participation in the job market?

One of the most recent experiments of UBI has been held in Finland between January 1^{sts} 2017 and December 31st 2018, as reported by the papers "Basic income: Finland's final verdict" (Van Parijs, 2020) and "The Rise (and Fall) of the Basic Income Experiment in Finland" (De Wispelaere et al., 2018). More than 2,000 long aged unemployed citizens between 25 and 58 years old received an unconditional minimum-income benefit of 560€ a month. The main aim of this experiment was to analyze the impact of this plan on their participation in the job market. In the first year of the experiment the difference in working days was slightly positive compared with a control group, but not statistically significant. Instead, during the second year, the gap in the working days increase to up to 6 more days of work per year, despite the application of a right-wing reform that was supposed to stimulate more the control group's work (this program, called 'activation model', concerned 2/3 of the control group and only half of the experimental group). Researchers safely conjectured that without the activation reform, the gap of work would be even higher. Whereas this experiment does actually prove how the application of an unconditional basic income increased the participation of beneficiaries in the job market, it is impossible to answer questions regarding the long-term economical sustainability of a similar version of UBI or the structural effect on health, skill and motivation. What it is interesting to discuss instead is the higher number of hours worked by immigrants (13 days more versus 3.6 days more), by

people living in rural areas (7.8 days more vs 1.8 days in big city like Helsinki) and households with children (13.7 days more vs the 1.6 days of childless households). On top of all this data, a significant difference in favor of basic-income recipients emerged in their subjective perceptions of health and stress and their trust in other people and institutions.

Another interesting program which reinforces the assumptions just set out was held in Stockton, California, in 2019, as described by the paper "Stockton's Basic-Income Experiment Pays Off" (Daly, 2022). Around 125 randomly selected citizens with an income lower than the city median received $500 a month, without any request or obligation. Despite that, recipients proved to spend their money mainly on essentials (food, home goods, utilities, gas) with less than 1% on expenses in cigarettes and alcohol; moreover, the cash donations double the households' capacity to pay unexpected bills and pay off their debts. Finally, the percentage of participants with a full-time job rose 12% point versus 5% in the control group. The reason for all those improvements is that, as one of the interviewed recipients stated, money augmented people's capacity for goal setting, risk taking and personal investment.

6.2.5 Why it is convenient giving money to everyone

One incredible proof of the high return of investment of direct allocation of funds is the program launched by the former Ford manager Lloyd Pendleton in Utah, in the early years of the 21st century, when the number of homeless people was exponentially growing (reported in the paper "The surprisingly simple way Utah solved chronic homelessness and saved millions" (McCoy, 2015)). In 2005, he launched a program to attack the problem at its root: every homeless person received a free apartment; 2 years later, he decided to expand the program helping them also with drug addiction, criminal records and debts. A homeless man costs the community around $16,660 a year in social services and assistance against only

$11k/person for Pendleton's program financing homes and counseling. After the first years, we can see a 74% drop in the number of homeless people in Utah, and the state was cruising to solve the problem definitively while saving a huge amount of money.

A similar program was carried out in the Netherlands, trying to eliminate homeless people first from major cities, then throughout the country. Between February 2006 and February 2014 there has been a reduction of homeless people by 65%. The problem was the economic crisis of '09, which eventually cut funds for the program and led the trend to reverse. It is estimated that every euro invested in this program has generated a 100-200% return for the state, plus a return for local businesses and society (better image of the cities, more taxes paid, low consumption of public funds for homeless care etc.).

6.3 Shortening of the working week

6.3.1 The history of the 15-hour working week

In the 1930s, at the beginning of the Great Depression, the British economist John Maynard Keynes theorized in the book "Economic Possibility of Our Grandchildren" (Keynes, 1932) that the greatest challenge of the first half of the 21st century for humanity would be learning to manage all its free time, which would have been about four times more than a hundred years before, allowing our society to work with a 15-hour working week schedule. Indeed, the first person to propose the idea of reducing the working week was Benjamin Franklin, who theorized that in the future people would follow 4 hours work per day system. The same John Stuart Mill, the father of modern liberalism, was a great supporter of technology as a tool to work less and have more free time, to live a more fulfilling life and develop all forms of mental culture. Historically the Industrial Revolution, contemporary with Mill's time,

brought the opposite effects, doubling the working time compared to 100 years prior. Only after 1850 the benefits created by the revolution began to be enjoyed by even the poor people, and in many countries the working week was reduced to about 60h/w (from over 70h/w 50 years before). Henry Ford was the first entrepreneur to introduce the 5-day work week, because he was truly convinced that working less would increase his employees' productivity (as well as leaving spare time for them to consume more goods, in this case his Ford-T cars) ("Taylorism and hours of work" (Nyl, 1995)). Following the example and the success of the Ford industry, eventually, the law to promote the 5-day week standard was propagated throughout all the US in 1938. In the '50s Nixon was a big supporter, like President Franklin before, of the 4-day working week, that would be feasible in a near future thanks to technological progress, which would allow citizens to focus more on their hobbies, leisure and culture. In the mid-60s a Senate committee predicted that in the 2000s the week would be reduced to 14 hours work format and that only 2% of the population would be enough to sustain the needs for the entire community. Isaac Asimov, during an interview with the New York Times, predicted that in 2014 the main social problem would be boredom, as humanity would become a guardian race of machines. Following his idea, several other thinkers began to see the upcoming large amount of forced free time as social threats, which would augment sloth, boredom, immorality and private violence. In the 1970s, sociologists spoke of the end of work as a next thing.

The mechanism jammed in the '80s, when the economic growth was no longer directed towards a reduction in labor (it actually increased in the US for example), but rather to an overproduction of goods. One of the disruptive phenomena that reshape the working landscape was the feminist revolution: in the '70s women contributed to 2-6% of family income for the United States, 10 years after, around 40%. Although a part of the household tasks was more redistributed (albeit unequally) in the couple, parenting has assumed over

time a more time-consuming role (modern working mothers spend more time with their children than housewives in the 60s). For a Dutch individual (the Netherlands has the shortest working week in the world), the workload, overtime, education and family tasks rose from 43.6 hours/week in 1985 to 48.6 hours/week in 2005. If half a century ago, boredom could have been seen as the future key problem for society, what most afflicts our modern life is the stress as a result of excessive workload. So where has people's free time gone? Economic growth can lead to an increase in leisure time and/or to a higher consumption: in the period 1850-1980 both occurred, while later all the growth poured into consumption. To keep up with the standard of life that is growing, we are obliged to work longer, giving up our free time.

Is it the natural course of things? Not indeed. Ford at the beginning of the 20th century experimentally demonstrated how working less leads to greater productivity; in 1930 the president of Kellogg's industry (the cornflakes tycoon) introduced for his employee the 6-hour working day ("Kellogg's six-hour day" (Hunnicutt, 1996)): resulting to this choice, he managed to hire other 300 employees and the firm recorded a 40% drop in the number of injuries. Workers were so much more productive with this new setup that he managed to pay them for a 6-hour working week the same amount as the standard 8 hour/day week. Beyond that, people had quality free time. Modern studies show that a person who makes use of his creativity as the main means of his work cannot be productive for more than 6 hours a day.

Summing up, a shortening of work would be beneficial for several reasons:

1) Reduction of stress, as a result of more free time, with an improvement in mental well-being. This could increase people's bandwidth (thus, making better decisions) and the time invested for recreational, volunteering and social activities.

2) Less work would imply proportionally less consumption (less GDP), with a huge environmental impact: it is estimated that if the entire world switched to the 4 days /week working week it could cut CO2 emissions by half in this century.
3) Reduction of injuries at work, since overtime is the main reason for those events.
4) Unemployment, particularly in times of recession with supply of goods much higher than demand.
5) Women can achieve greater social equality and equal distribution of work if men have more time to contribute equally to household chores (in Sweden, a country with less gender inequality, studies have been carried out showing that granting a few weeks of paternity would permanently improve the man's contribution to family life).
6) The elderly population could still enjoy the benefits of work, working a limited number of hours a week, and reducing the heavy burden on 30-year-olds.
7) Social inequality, as people's incomes would tend to converge towards a center.

To have a society that reflects these 7 points, we should first change our incentives to work, such as the fact that the deductions on employees are per person and not by hour (and therefore it's not convenient for employers to hire two people instead of one that works with overtime) and break the toxic mentality of extra work as a social status.

This discussion can be enriched by Derek Thompson's articles for The Atlantic called "the free/time paradox in America"(Derek Thompson, 2016). This paradox he refers to consists in the modern US society being made of a workaholic elite that work longer hours than poorer men in the country and experience all time low pick of happiness, while less-skilled poor soak up all the free time and the leisure, even though they would have the most to gain from working. According to the author, we can analyze 3 perspectives to understand the paradox of the current job market, and try to work on them to improve our society and reverse the trend:

a. The availability of attractive work for poor men (especially black men) is falling, as the availability of cheap entertainment is rising. As with any industry visited by the productivity goods, entertainment and its sub-kingdoms of music, TV, movies, games, and text (including news, books, and articles) have become cheap and plentiful. Meanwhile, the labor force has erected several barriers for young non-college men with low and middle skill and is increasingly challenging to adapt to the technological disruption of our time.
b. Social forces cultivate a conspicuous industriousness (even workaholism) among affluent college graduates. While some of the hardest-working rich Americans certainly love their jobs, it is also likely that America's secular religion of industriousness is a kind of pluralistic ignorance. That is, rich people work long hours because they are matching the behavior of similarly rich and ambitious people even though many participants in this pageant of workaholism would secretly prefer to work less and sleep at least until the sun is up.
c. Leisure is getting "leaky." Thanks to smartphones and computers, leisure activity is leaking into work, and work, too, is leaking into leisure. The radio set used to be a living room fixture, then to listen to the radio it was necessary to be at home. After, the car radio liberated the radio from the living room, and the television set replaced its corner of the living room. Finally, the smartphone liberated video from the television screen and put it on a mobile device that fit in people's pockets. Now somebody can listen to music, watch videos, and read—while checking on social media feeds that can act as the cumulative equivalent of newspapers, magazines, and phone calls with friends—on their phone, while at work. Meanwhile, these same mobile instruments of leisure are also instruments of professional connectivity: when

a boss knows that each of her workers have smartphones, she knows that they can all read her email on a Saturday morning.

Keynes got a lot wrong in 1930. He did not envision the rich working more, he did not foresee so many young men in poverty giving up on work, and he could not see the allure of cheap and personalized entertainment. But he accurately forecasted the difficulty of a wealthy class transitioning to a more leisurely lifestyle. "The strenuous purposeful money-makers may carry all of us along with them into the lap of economic abundance," Keynes wrote. "But it will be those peoples, who can keep alive, and cultivate into a fuller perfection, the art of life itself and do not sell themselves for the means of life, who will be able to enjoy the abundance when it comes."

6.3.2 The myth of economic growth

In the previous chapter, the underlying assumption is that people should trade part of their wealth in exchange for more free time to improve their overall wellbeing, therefore now it is interesting to discuss how our idea of progress shapes the way we live.

Today, the universally adopted indicator to assess the growth of a country is GDP (gross domestic product), defined as the sum of goods and services produced by a country, adjusted according to seasonal fluctuations, inflation and purchasing power. This calculation does not include, however, undeclared work (when for Italy it was considered in the estimate, their GDP increased by 20%) and work without pay (50% of our time, especially for women, including household tasks). GDP is then blind to many great innovations (for example free Skype calls, which however do not generate revenues, or to the vast amount of free information we can access through Google), while other social problems (gambling, diseases, drug addiction, crime, pollution etc.) and disasters (wars, natural disasters, crises) are a

golden godsend for GDP. All these problems can lead to doubts that GDP represents social welfare optimally.

Historically, GDP was adopted by Western countries after World War II, when it played an important role to allow countries to evaluate how long they would have been able to sustain the war effort according to the national production of goods, and it was later converted into one of the main tools that economists use to drive and shape our consumer society. GDP was perfectly functional in a war-supporting economy where victory largely depended on the production volumes of tanks, bombs, weapons, etc., but at the same time short-term matters such as debt and polluting the environment didn't matter. Similarly, other periods evaluated distinct aspects relevant for their society: in the 17th century the size of the crop, in the 18th the number of establishments, the size of the railway network and the volumes of coal mining, finally in the 19th the production of industrial mass within the national borders. Today, therefore, we force ourselves to evaluate progress with an old metric, which does not include education, health, culture, information etc. Distressed by how the United States were adopting GDP, the GDP inventor himself, Kuznets, advised not to include in the calculation of sectors like advertising, the financial sector and military expenditures to guide the country towards a growth of quality and not of quantity (this warning sounds very modern when considering the financial crisis due to the real estate bubble in ’07-’09).

Other indices are available, which partially correct GDP, including in their equations aspects such as pollution, crime, inequality and volunteering (Genuine Progress Indicator, GPI) or even the impact on the environment (HPI, Happy Planet Index). Although even these are not complete, they show how Western countries, which excel in the GDP ranking, have huge social problems and are positioned towards the middle of the rankings.

This chapter does not pretend to propose a new metric that sums up every relevant aspect of our society, but rather underlines how it would be important to change the way we think and organize at the very roots of our world if we want to realize the utopias and the dreams we have.

6.4 Robot tax and minimum wage

One of the solutions that has recently been discussed to cope with the societal disruption of AI is the introduction of a robot tax. Artificial intelligence and automation are partially replacing human workers with machines, and one of the side problems is that governments cannot redistribute the value companies create into the society through taxes.

The first applications are just 5 years old, and so far, there is no unanimous definition of what tax robots means. Some researchers think that the ultimate method would be asking companies to pay income tax on each robot based on the displaced human employee's salary. Others believe that companies should pay higher rates of corporate tax out of their profits for using robots in their workforce, since they offer higher efficiency compared with humans.

Until now the only country that has ever enacted a robot tax is South Korea, in August 2017 ("A Taxing Dilemma: Robot Taxes and the Challenges of Effective Taxation of AI, Automation and Robotics in the Fourth Industrial Revolution" (Kovacev, 2020)). More than taxing companies directly for using a certain number of robots, the law is an attempt from the country to disincentivize capital investment in AI and technology. As reported by the article "Automation and income tax" (Soled & DeLaney Thomas, 2018), the country's unemployment rate was at an all-time high, and there is a concrete fear that the automation is advancing much faster than the capacity of the society to adapt, disrupting more jobs than the

one created. A similar opinion is expressed by new York's Mayor Bill de Blasio in his call for an automation policy.

The main benefit of how we intend robot tax is therefore slowing down the job destruction from AI, allowing at the same time to re-invest the extra money coming from the taxes into more training for people and improving government assistant plans. This idea of redistribution of values created by robots/AI is pillar also for transitioning to a universal basic income system, as explained earlier in the paper.

At the same time a possible robot tax would come with several problems:

1) It is virtually impossible to define robot. Nowadays every object is becoming smart and has installed some AI system. People could argue that a simple vending machine is a robot. It would make no sense to introduce a rule without a clear definition of what should be taxed. Moreover, because different countries adopt different legislations and definitions, it would be necessary to adopt a worldwide definition of robots. Otherwise, it would be possible for multinational corporations to escape rules by moving intro countries with a more convenient jurisdiction.
2) One of the pros is definitely to reduce job destruction, but at the same time this means that innovation and productivity would be limited. Companies would be less incentivized to invest in AI and ride its trend.
3) Society would be less motivated to convert bad jobs into quality ones, by protecting the former one.

Similarly, to a robot tax, increasing minimum wages is one of the agendas that has been discussed with respect to the artificial intelligence's disruption. Some people claim that part of the extra productivity should be distributed as higher salaries for workers. But what most

of the researchers suggest is that, as written in the article “Minimum wage hike ignores impact of Artificial Intelligence”(Beth Daley, 2017) “For the workers themselves, implementing a higher minimum wage is a double-edged sword” . whereas higher salaries are in general a positive thing for workers, increasing wages in sectors with low productivity, such as the food industry, would discourage small enterprises to create new jobs, and on the contrary investing in robots and automation because human jobs would be less convenient. A great example is provided by the paper “People versus machines: the impact of minimum wages on automatable jobs” (Lordan & Neumark, 2018) . Regarding the US manufacturing job market, an increase in minimum wage of $1 causes the sector’s share of all jobs to drop nearly 2 percent for people 40 years old or more.

To conclude this discussion, both robot tax and augment of minimum wage offer some positive benefits for our society and seem to protect workers, but in reality, struggle to keep up with the AI disruption. Robot tax can potentially slow down the trend and allow our society to re-organize itself better, and eventually leading to an UBI. Augment of minimum wage seems more anachronistic and would generate the opposite effect of what is desirable: it would protect doomed jobs and not push workers to shift into more qualitied mansions.

7. SURVEY: GOVERNMENT PLANS

This last part of the survey aims to understand the stance from the each sample regarding some of the most likley governament plans that could be put in place to cope with the AI revolution. As already discussed in the introduction, new technologies like artificial intelligence create threats, as well as new opportunities that can improve our life. It is up to us ,as a community, to shape our society to maximize the value that those opportunities can offer. In this chapter I will analyze students' opinions regarding governamnet plans such as increasing the minimum salary, shortening the working week, universal basic income and robot taxes.

The first societal change discussed regards the salary of workers. It is pretty unanimous that AI will boost productivity at the work place, but it is less clear who will enjoy this extra value. Figure 24 shows the different opinions of the two sample groups. Concerning a possibile increase of the minimum wages, both ones seem to be pretty conservative. The POLIMI students mostly foresee a small augment, wherease the majotiry of the ICAM ones think the wages will remian unchanged. Neither of the two groups belive in a large increase. It appears that the respondets agree that people with low skills/qualifications (the ones more affected by a change in the minimum salary) will just partially enjoy the extra value created by AI.

The follow-up question wants to understand if they think, instead, that more qualified people will have higher beneficts from the AI revolution. Similarly to the previous situation, most of the french students agree on a stable scenario, whereas the large part of italians forsee a slight increase. In general POLIMI students are more optimistic toward an improvement in the salaries, but both sample don't anticipate a significant augment in their future wages.

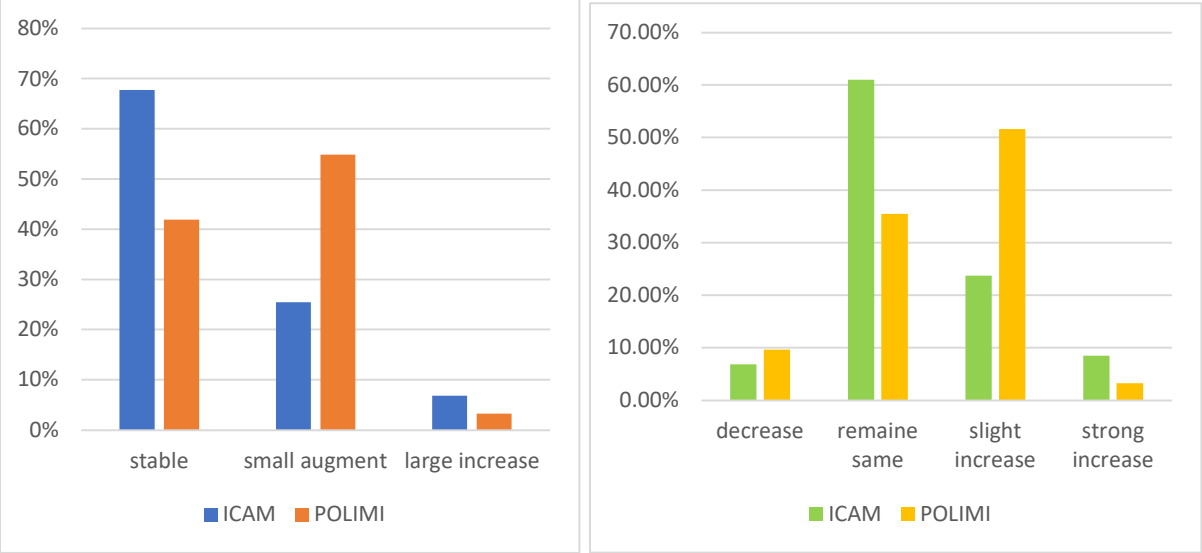


Figure 24: Will AI lead to an augment in the minimum salary for workers? (LEFT)- in the average salary of your field? (RIGHT)

The second government plan that will be discussed is a reduction of the working hours. The starting point of the discussion is the same of the previous proposal: AI will increase the productivity of our work, how society will adapt? A reduction of the working hours is basically the complementary solution of increasing salaries: either society converts the extra productivity in more money or more time for people.

For this question a scale between 1(not favourable) to 6(extremely favourable) is adopted. As shown by the table below, the two samples have significantly different opinions. The POLIMI one is polarized toward a strongly favour, with most of the surveys answering 5/6 or 6/6. The ICAM sample instead is milder, with a distribution centered around a median answer of 4/6. Moreover, the Italian sample does not have any answer below 3/6, whereas the French one cumulate around 20% of the total below that threshold.

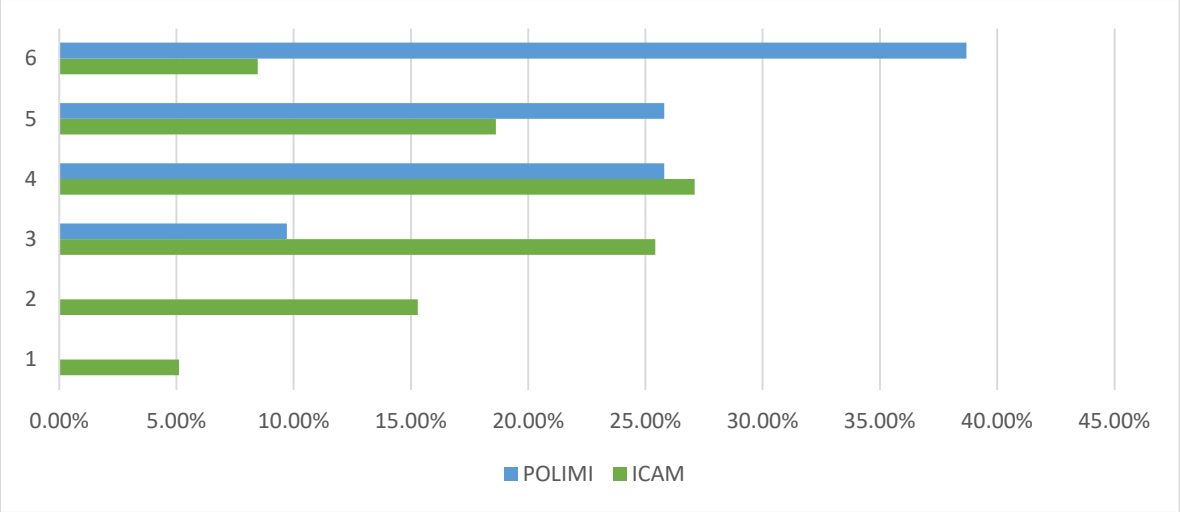


Figure 25: How favourable would you be to shorten the work week/to reduce working hours?

To enrich this analysis, I repeated the same question about the shortening of the working week, but considering the scenario in which this change would require a reduction in the salary. As natural, the averages of the two samples slightly decrease, but what is interesting is that the Italian distribution lose its polarization. Now the two distributions look more alike, even though the Italian group is still favourable to a possible shortening, the French one not (average lower than 3/6).

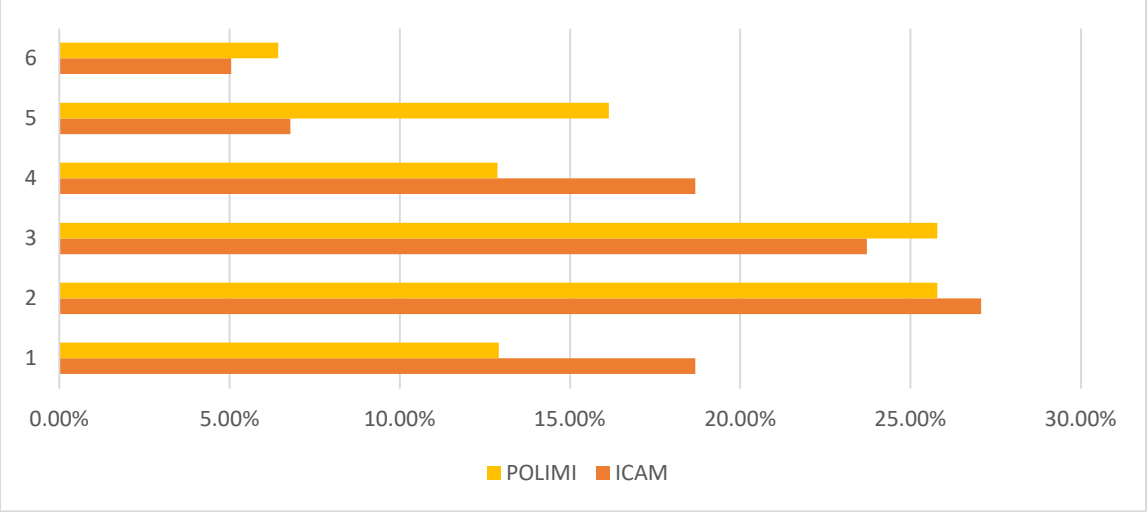


Figure 26: How favourable would you be to shorten the work week/to reduce working hours? (Considering a lower salary)

The third government plan that the respondents evaluated concerns a possible robot tax. AI will likely force some works to be performed partially or entirely by robots, which create value for companies but do not contribute to redistribute this last one into society through taxes. Results of this question are pretty similar, with a majority of the students from both samples moderately favourable. Respondents do not express a fervent desire to tax robots, coherently with a large part of the researchers: pushing too much on redistribution mechanism could potentially offset innovations and investments in the AI field.

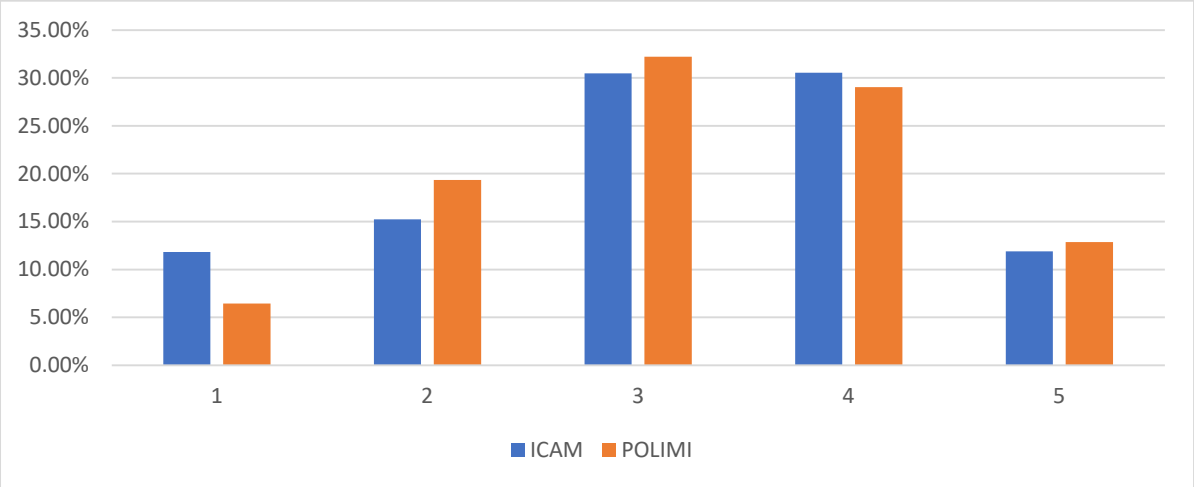


Figure 27: How favourable would you be to robot taxes?

The last government agenda I analyze regards the introduction of the universal basic income. Because the higher productivity and automation that AI will bring, some experts foresee human work less and less necessary in the next decades, and people will receive a minimum compensation to live freely no matter if they decide or not to work (universal basic income, UBI). The graph below expresses the appreciations from 1-5 from an introduction of the UBI. The averages of the two distributions are similar, but we can notice a strong percentage of French being highly interested (5/5) in the idea or mildly interested (3/5), whereas a significant part of the Italians not (almost 50% below 3/5).

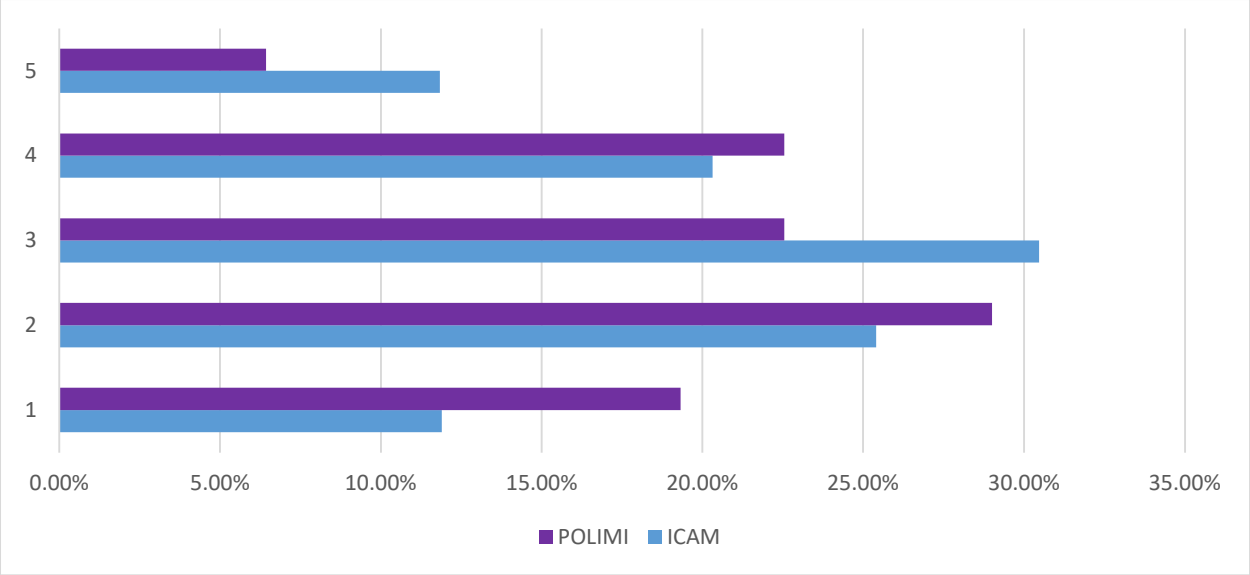


Figure 28: How favourable would you be to UBI?

To integrate this analysis, it is interesting to understand how likely a possible UBI introduction is for the two samples: ICAM students are more or less in a 50-50 % situation, whereas Italian one is more positive. There is a clear contrast in the POLIMI sample: although they think UBI will be necessary, they expressed a really low level of desirability for its adoption.

Figure 29: Do you think that, because of AI and the progressive automatization of our works, UBI will become necessary within 50 years? (LEFT ICAM, RIGHT POLIMI)

To conclude this last chapter, respondents answered two broad questions regarding the overall impact of AI on our society (graph 30) and the role that governments should have in the regulation of future AI applications.

Regarding the first one, both samples are pretty positive on the positive impacts of AI both for the society and the environment; in particular, 60% of the POLIMI group think that both these aspects will enjoy some benefits from AI. From the other side ICAM students are more conservative, and there is a 15% of them foreseeing ant improvements.

Concerning the last question, most of the students ask for a mild or strict regulation from the government to ensure AI applications will not harm anyone and their effects will improve society. Despite a strong optimism for the possible benefits of AI, students agree that rules are necessary to control such disruptive technology.

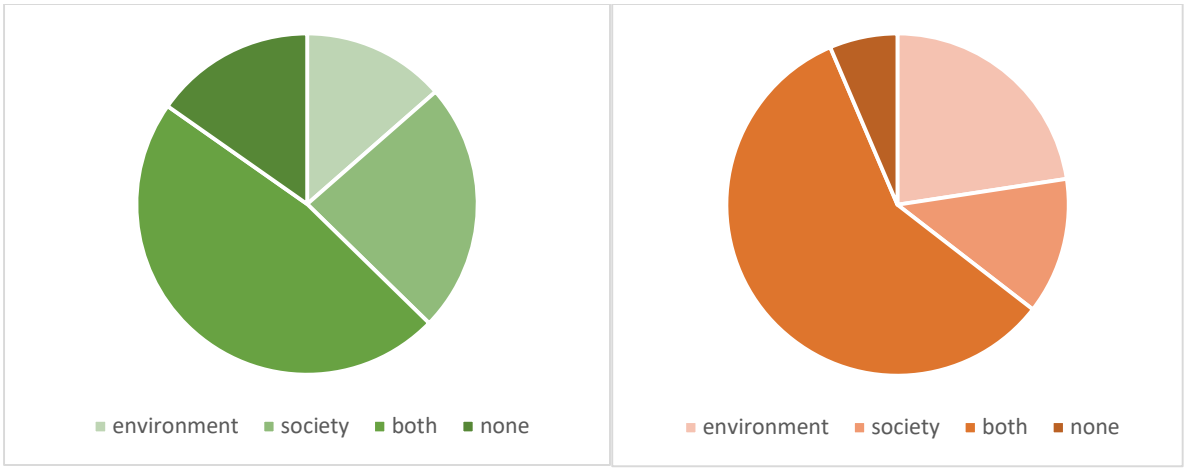


Figure 30: Do you think AI will lead to improvements in our society? (LEFT ICAM, RIGHT POLIMI)

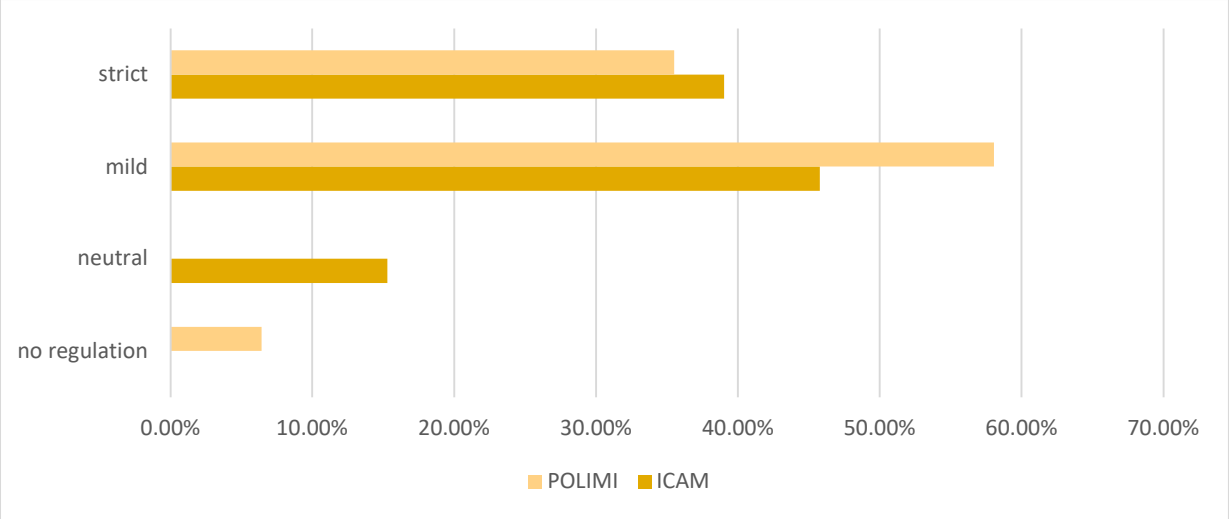


Figure 31: What should be the role of governments in the regulation of future AI developments?

8. DISCUSSION AND CONCLUSIONS

8.1 Main findings

This work aims to analyze the extraordinarily complex topic of the AI revolution and its effects on the world of work and our society. The approach adopted, based on the binomial analysis of the literature and the application of a survey, led to several interesting conclusions about the macro themes taken into consideration.

First of all, considering the level of general knowledge about AI, the two samples have a comparable preparation, but with two substantial differences. The first is that the French one draws on a greater range of sources, and their imprinting is more theoretical. This is one of the reasons why most French people consider themselves moderately or greatly confident in discussing on artificial intelligence, whereas Italians are less or not confident at all. The second difference is that Italians have a more positive attitude towards AI technology while the French are more intimidated.

The second topic of interest is the impact of artificial intelligence on work: both classes are quite aware of the importance within their sector and their future works, especially Italians. Most students expect a slight decrease in the number of jobs or no movement at all. The idea that emerges is, thus, an AI that will modify the content of occupations, but will not create mass unemployment; this perception is coherent with a large part of the literature, especially for high-skill jobs.

It is therefore interesting to analyze how they think the world of work will change. Both samples appear confident about future improvements in the business dimension of work (performance, quickness, and managerial performance), while there are contradicting opinions on the more qualitative dimension (quality of life). In addition, the French sample is

more aware of the phenomenon of polarization of workers, one of the trends with greater consensus between experts.

One of the big questions I asked myself while writing the survey is: How ready are students for the AI revolution? On a general level, POLIMI students are very aware of the importance of soft skills, often considered the key to the transition to more human-centered work, while the French ones have better knowledge of coding / informational skills, important for understanding the applications of AI.

Going deeper into this examination, I analyzed how important they consider, how much training they are receiving, and how much time they are dedicating to the development of the main soft skills that, according to the literature, will be the most critical for AI disruption rides. There is a slight misalignment between what universities and what students think is important to ride the AI changes, but both agree on the most (analytical thinking) and least important skills (emotional intelligence). ICAM students would appreciate a more active learning-oriented approach, while POLIMI students would be interested in developing better interpersonal skills. There is also a gap between what they think will be relevant and the time they are investing: both samples are working on creativity the least, even though none of them think it is the least relevant, and ICAM students highly value analytical thinking but are not working as hard in other skills.

The last part of the thesis deals with the government plans that most researchers are discussing to cope with the AI disruption. Unlike the previous chapters, the latter is more subject to ideological criteria. It is interesting to understand how students imagine the future and what kind of society they want to build.

As for the Italian group, the main interest lies in shortening the working week: there is a strong consensus on converting the extra productivity that automation and artificial

intelligence will bring into more free time. The French, on the other hand, are extremely fascinated by the prospect of a universal basic income: although they consider its application less necessary than the other group, the vast majority are in strong favour of it.

Both samples are positive concerning the impacts that AI will have both socially and environmentally, especially POLIMI students. In general, I noticed a greater optimism toward technology for the Italian group, while ICAM students were often more conservative and fearful. Despite the general view of the benefits of AI, both groups have expressed desires for strict or moderate regulation by governments.

8.2 Limitations and future research

The present study has several limitations that lead to avenues for future research. Study limitations and possible extensions of my survey mainly concern the characteristics of the sample size and the content of the survey.

First of all, due to the relative length of the survey, the number of participants is quite limited. This structural problem is compensated by the homogeneity of the two samples, especially for the French one. This situation opens up different expansion opportunities: repeating the same work, but with groups of students from non-engineering faculties or extending it to other samples from diverse cultures. This second opportunity is particularly interesting: in fact, most of the students in my survey belong to the country of the location of the two universities, and therefore the comparison is essentially between French and Italian students. Although I have noticed some different cultural and ideological interests, more contrasting results could have been obtained by analyzing people from more diverse countries.

The second area of expansion concerns content. To limit the length of the survey and increase its usability (and therefore the number of people who took part in it) some interesting topics have been eliminated (such as a more detailed analysis of the biases that AI introduces) while others have been simplified.

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Appendix: Questionnaire

Knowledge

How much do you think to know about AI?

Nothing	Familiar	Solid knowledge	Deep	Expert
□	□	□	□	□

Concerning AI, have you ever read/attended/watched?

book	conference/seminar	videos	courses	none
□	□	□	□	□

How confident do you feel discussing about artificial intelligence, machine learning and deep learning?

1	2	3	4
□	□	□	□

Are you scared of robot?

afraid	neutral	pro tech
□	□	□

Impact on job market

How much do you think AI will impact your sector?

1	2	3	4	5
□	□	□	□	□

How much do you think AI will be relevant for your future job?

1	2	3	4	5
□	□	□	□	□

Concerning your sector(s), what do you think will be the impact of AI on the number of jobs?

destroy a lot of jobs	small loss	neutral	small increase	significant increase
□	□	□	□	□

How do you perceive the possible de-personalization of human works due to AI in your sector?

Really problematic	Slightly	not a prob
□	□	□

Within the next 5-10 years, how do you think AI will impact the following aspects in your field:

	Positive	Neutral	Negative	Don't know
Performance	□	□	□	□
Quickness	□	□	□	□
Quality of work	□	□	□	□
Management performance	□	□	□	□

Flow of info	□	□	□	□

Some people claim AI will eventually be an obstacle to many high skill jobs because it will take away part of the decision-making power. Do you agree with this sentence?

no	partially	neutral	yes
□	□	□	□

Researchers claim that future development of AI will escalate the issue of polarization in the job market. Do you agree?

no	partially	neutral	yes
□	□	□	□

Skill

Which kind of skill will be more relevant to face the changes due to AI?

Hard	Soft
□	□

How would you assess your knowledge about coding/informational skills?

1	2	3	4	5
□	□	□	□	□

Looking forward, do you think your university is helping you to develop the right set of soft skills for embracing the change from AI?

	1	2	3	4
Creativity	□	□	□	□
Analytical thinking	□	□	□	□
emotional intelligence	□	□	□	□
interpersonal skill	□	□	□	□
active learning	□	□	□	□

How critical will they be for your job ?

	1	2	3	4
Creativity	□	□	□	□
Analytical thinking	□	□	□	□
emotional intelligence	□	□	□	□
interpersonal skill	□	□	□	□
active learning	□	□	□	□

How much are you currently working to develop your soft skills?

	1	2	3	4
Creativity	□	□	□	□
Analytical thinking	□	□	□	□
emotional intelligence	□	□	□	□
interpersonal skill	□	□	□	□
active learning	□	□	□	□

Everyone uses AI system that provide suggestions without knowing anything about how they works, such as Google. How do you think managers will deal with recommendation from AI?

passive use of AI	follow blindly recommendation	active use of AI tools
□	□	□

Looking at the future, what is the added value that AI tools can have for your work?

accomplish more tasks	acess more resources	deeper understanding
□	□	□

In the next 50 years, which is the likelihood that computers and machines will do much of the work currently done by humans?

<20%	20-40%	40-60%	60-80%	80-100%
□	□	□	□	□

Government plans

Do you think that the increase of productivity due to AI will lead to an augment in the minimum salary for workers?

stable	small augment	large increase
□	□	□

What about the average salaries in your field?

decrease	remaine same	slight increase	strong increase
□	□	□	□

Because AI would probably increase our productivity, how favourable would you be to shorten the work week/to reduce working hours?

1	2	3	4	5	6
□	□	□	□	□	□

…Even considering a reduction in the salary?

1	2	3	4	5	6
□	□	□	□	□	□

Are you favorable to robot tax ? (Based on each robot for the displace human employee's salary or higher rates of corporate tax out for using robots in the workforce)

1	2	3	4	5
□	□	□	□	□

Are you favourable to a universal basic income? (intended as a government program in which every adult citizen receives a set amount of money regularly. The goals of a basic income system are to alleviate poverty and replace other need-based social programs that potentially require greater bureaucratic involvement)

1	2	3	4	5
□	□	□	□	□

Do you think that, because of AI and the progressive automatization of our works, UBI will become necessary within 50 years?

yes	no
□	□

Do you think AI will lead to improvements in our society?

environment	society	both	none
□	□	□	□

What should be the role of governments in the regulation of future AI developments?

no regulation	neutral	mild	strict
□	□	□	□