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Architects and Engineers in the Digital Communication Age. A Study in the North-East of Italy

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Architects and Engineers in the Digital Communication Age. A Study in the North-East of Italy

Gabriele Giacomini

Abstract: The development of digital technologies can alter the professional fields. In this essay we will analyse the potential and risks of ICT for Friulian engineers and architects. To do this we will use two research methods - the first research method is qualitative and consists of 15 semi-structured interviews administered to experts; the second is quantitative and consists in a survey involving 329 architects and 335 engineers, using techniques of descriptive statistics. We will firstly evaluate the impact of BIM, 3D printing and robotics on professional practices and secondly identify and study the most important factors for the use of digital technologies. Starting from the public policies that the institutions insisting on Friuli Venezia Giulia have put in place, we will assess what kind of training of professionals (in a lifelong learning perspective) can play a significant role in supporting the innovation process of architects and engineers in the Friuli area.

Keywords: ICTs, digital technologies, professions, architecture, engineering, lifelong learning

Introduction

The advent of new communication technologies is bringing about a reconfiguration of the media landscape and significant changes to economic and productive life. Professions are changing along with changes to training programmes, the organisation of work, objects and services.

In this essay, which presents the results of research carried out as part of the project "Dal dire al fare digitale" at the University of Udine, financed by the Friuli Foundation, we will analyse the case of architects and engineers in the historical region of Friuli (the provinces of Udine and Pordenone), in the north-east of Italy. Today, the engineer is the one who uses mathematical knowledge to apply it to the design, construction and operation of machines, plants and systems. In the field of civil engineering, for example, the engineer may be called upon to design a bridge or a building, ensuring that it is safe, functional and durable. In mechanical or electronic engineering, he may work on the creation of advanced machinery or automation systems. An architect, on the other hand, is a professional who prepares plans for the construction of buildings and architectural works and manages their execution. While designing a building, architectural work or object, the architect considers not only functional aspects, but also aesthetic, cultural and social ones. This holistic view also extends to urban planning, where the architect studies and proposes solutions for the harmonious development of cities, ensuring green spaces, recreational areas and sustainable housing solutions.

Professions such as those of engineers and architects, although having a solid foundation based on education, public recognition and codes of ethics, are undergoing profound transformations due to technological innovations. Web 2.0 has promoted greater sharing and collaboration, emphasising the importance of combining technical expertise with communication and organisational skills. Concepts such as "making is connecting" emphasise the importance of being flexible and ready to work in multidisciplinary teams. Technologies such as 3D printers and Building Information Modeling (BIM) are revolutionising sectors such as construction, facilitating prototyping, design, construction and maintenance. These changes, part of the so-called fourth industrial revolution, require professionals to keep their skills up-to-date, balancing specialisation with the ability to adapt to a changing world.

In terms of methodology, a survey involving people registered with the professional associations of engineers and architects and interviews with experts was used. Through the intersection of these two methods, the aim is to understand how engineers and architects are involved in the progressive diffusion of digital technologies (especially BIM, rapid prototyping and robotics) and how institutions and social actors, such as professional associations, can facilitate the adoption of ICT and promote an ecosystem favourable to innovation, limiting the associated risks. In particular, the following areas of research questions are to be explored:

1. Are professionals in the provinces of Udine and Pordenone in favour of BIM? What are the positive innovations that BIM brings, and what are the difficulties?
2. Is 3D printing considered useful and is it used by professionals in Udine and Pordenone? Is the "maker" phenomenon considered relevant or not?
3. Is robotics known by Friuli Venezia Giulia professionals? How widespread is this technology in professional practice?
4. What are the factors of ICT adoption in the provinces of Udine and Pordenone? How important is training in the adoption of ICT by engineers and architects in this territory?

As we shall conclude, the strategies professionals intend to adopt to deal with technological innovation involves both acquiring specialisation (through lifelong learning and updating their CVs) and working with colleagues and clients (communicating through ICT, promoting initiatives by their professional associations and benefiting from public incentives). While specialisation requires technical knowledge, cooperation requires communication skills. In this context, the importance of lifelong learning clearly emerges as a pivotal element, not only to refine existing skills, but also to exploit the opportunities offered by technological innovations in a constantly changing work environment.

Technologies, culture and communication

The "liberal professions" have certain common features: a body which protects interests; the identification of an area of technical and scientific expertise; a mandatory training programme; the definition of ideological and ethical aspects; public recognition of the profession (Larson, 1977; Gallino, 1978; Gresle, 1989).

These features "stabilise" the professions, but the latter are still also subject to external influences like technological innovation. The spread of ICT is producing significant changes in day-to-day life at a social, political and economic/productive level (Shirky, 2011; Van Dijk, 2006). Gauntlett (2011) argues that since the advent of the Web users have been able to share the fruits of their creativity more easily. This process has been facilitated by the emergence of the Web 2.0, in which websites and online services have become more powerful when they include networks of people who work together. According to Gauntlett, this feature marks the start of a new phase for working methods and what it means to be a professional.

The greater ease in communicating information and knowledge (Bruns, 2008; Schwab, 2016) increases the importance of both hard skills (technical and specialist) and soft skills (communication, organisational and social skills). We see the emergence of the idea that "making is connecting" (Gauntlett, 2011). This new paradigm is reflected in the growing need for professionals to be flexible and ready to work in multidisciplinary teams. It is no longer just a matter of possessing a specific technical competence, but of knowing how to integrate it with a series of transversal skills that allow one to operate effectively in increasingly complex and interconnected contexts. According to Anderson (2012), after changing the world of bits (the industry of music, videos and publishing) digital culture is about to change the world of atoms and physical objects: through the web and new technologies innovators can create connections and networks. According to Anderson, a significant example are 3D printers, which make it possible to independently prototype new objects at lower costs than in the past. Manufacturing with 3D printers is changing several sectors, from small businesses producing customised parts, to doctors creating customised prostheses, to engineers and architects who can now bring their ideas to life in a more immediate and accessible way.

Another example of technology that has both technical and organisational, social and communication implications is Building Information Modeling (BIM), which is particularly relevant in the building and planning sectors. It is an integrated process that uses detailed, digital and three-dimensional information to support the design, construction and management of buildings and infrastructure (Liu et al., 2019). This technology affects the work of engineers and architects in several ways.

On the technical side, BIM allows for the creation of a virtual model of the building, enabling engineers to accurately simulate and analyse the building's performance even before its construction. This allows potential problems to be identified and resolved at the design stage, thus reducing errors, delays and additional costs (El Khatib et al., 2022). For architects, BIM offers a more complete view of the project, making it possible to have an extremely detailed three-dimensional representation, with the addition of information on materials, costs and timelines. This allows for a more innovative and environmentally sustainable view of the project (Lu and Shi, 2021). From a communication and organisational point of view, BIM has the effect of integrating different professionals into one digital working environment (Liu et al., 2021). In the past, engineers and architects often worked in separate silos, with little opportunity for communication and collaboration. With BIM, all stakeholders in a project can access and contribute to the digital model, facilitating communication and ensuring greater consistency between the different phases of design, construction and maintenance (Heaton et al., 2019)[1].

[1] In this sense, BIM represents not only an advanced technical tool, but also a new way of

These changes are so significant they are referred to as a Fourth Industrial Revolution or Industry 4.0 (Schwab, 2016; Temporelli et al., 2017). The Fourth Industrial Revolution is characterised by logistics, rapid prototyping, cloud computing, big data, robotics and the Internet of things. In terms of work carried out by human beings, it involves the addition of software and intelligent machines that are connected to the Internet. This leads to changes in the way people work and in general in the way not only goods but also services are produced (Jiao et al., 2021), and makes it necessary for professionals to update their tools and skills (Coskun et al. 2019). The challenge for the liberal professions in this context is twofold: on the one hand, there is the need to maintain and update the depth and specialisation of their skills; on the other hand, there is the need to navigate and integrate in a rapidly changing landscape, where technical skills must go hand in hand with the ability to connect, collaborate and innovate.

Methodology

We decided to use two methodologies to analyse how architects and engineers in Friuli use ICT and deal with opportunities and threats. The strategy of investigating the same object of research with different research methodologies is recommended by many methodologists (Brewer and Hunter, 2006; Booth et al. 2018) and is currently considered a fundamental practice for designing quality research work (Creswell 2003).

The first method is qualitative and consists of fifteen semi-structured interviews with open-ended questions with recognised experts in the sector. For a long period interviews with experts were popular in investigations on social issues but have been significantly developed since the 90s as a specific research method designed to explore qualified knowledge (Flick 2006, Przyborski et al. 2008). Experts are seen as "focal points" of knowledge on a specific subject matter. Borger, Littig and Menz (2009) argue that interviews with experts are helpful in the research phase and can offer researchers in-depth and quality knowledge.

The experts were selected with the aim of having the most balanced possible distribution across the local territory and in terms of their type of professional responsibility. These are figures in key positions in the field of architecture, engineering and territorial management in the provinces of Udine and Pordenone: Presidents of Professional Associations and key positions at the level of Professional Associations (who have a broad view of technical innovations and who guarantee a deep understanding of the needs

thinking and organising work in the construction sector. It enables greater design precision and promotes smoother communication between professionals, increasing the overall efficiency of the project.

and challenges of the sector), leaders of associations and organisations in the innovation sector, such as trade associations in the construction and SME sector, science and technology parks (who know market trends), heads of regional structures (who guarantee a strategic vision and connection with regional policies), academics (their experience in the university environment and research centres guarantees an understanding of advanced technologies and their impact on the sector). The choice of these experts ensures a holistic and in-depth understanding of the dynamics at play, given their direct involvement in innovation, education and professional practice in the region.

The proposed questions sought to explore the impact and perception of new technologies in the world of architecture and engineering. They began by asking which of the emerging technologies might be the most advantageous or the most disadvantageous for these professionals. The issue of technology adoption was then explored, asking what factors may influence whether or not these innovations are embraced. Training was identified as a potential catalyst for technology adoption and it was asked whether training opportunities existed in the Udine and Pordenone area, also seeking personal feedback on such courses. We then focused on the role of the territorial economic context in technology adoption, with regard to both the situation of Friuli Venezia Giulia in Italy and of Italy in the international panorama. Finally, suggestions were sought on possible policy initiatives that could promote the use of new technologies, and a general view of the future of professions in an increasingly digitised world was asked.

The second method consists in a survey comprising 52 questions administered in 2018 to a population of 4545 units (members of the Association of architects and engineers in the provinces of Udine and Pordenone). A total of 664 completed questionnaires were collected. In terms of the procedure for the survey, the online questionnaire was initially sent out by email from the professional association to all their members and there was a subsequent phase of fieldwork (with printed questionnaires) during training sessions by the associations. In both cases questionnaires were filled in directly by respondents. The survey sample is non-probabilistic (Bryman 2016). Tables 1 and 2 show the basic characteristics of the sample and the reference population.

Table 1 – architects[2]

	Population			Respondents			% resp. on total		
Age group	M	F	TOT	M	F	TOT	M	F	TOT
up to 29	22	29	51	6	12	18	27.3	41.4	35.3
30 – 39	184	211	395	32	35	72	17.4	16.6	18.2
40 – 49	226	183	409	33	28	66	14.6	15.3	16.1
50 – 59	345	139	484	78	24	111	22.6	17.3	22.9
60 and over	318	53	371	38	7	58[3]	11.9	13.2	15.6
Not answer	0	0	0	2	2	4			
Total	**1095**	**615**	**1710**	**189**	**108**	**329**	**17.3**	**17.6**	**19.2**

Table 2 – Engineers[4]

	Population			Respondents			% resp. on total		
Age group	M	F	TOT	M	F	TOT	M	F	TOT
up to 29	52	21	73	8	4	12	15.4	19.0	16.4
30 – 39	407	142	549	36	22	59	8.8	15.5	10.7
40 – 49	907	176	1083	93	21	118	10.3	11.9	10.9
50 – 59	536	37	573	53	3	63	9.9	8.1	11.0
60 and over	554	3	557	75	1	81	13.5	33.3	14.5
Not answer	0	0	0	1	1	2			
Total	**2456**	**379**	**2835**	**226**	**52**	**335**	**10.8**	**13.7**	**11.8**

[2] The total number of architects also includes 31 architects who did not specify which province they were registered in (5 aged between 30 and 39, 5 between 40 and 49, 9 between 50 and 59, 12 aged 60 and over).
[3] 1 respondent answered “other” regarding sex.
[4] The total number of engineers also includes 17 engineers who did not specify which province they were registered in (1 aged between 30 and 39, 4 between 40 and 49, 7 between 50 and 59 anni, 5 aged 60 and over).

By selecting members of the Associations of Architects and Engineers in the provinces of Udine and Pordenone, we gained direct access to a population that is officially recognised and qualified in their field. These professionals, through their membership of the Associations, demonstrate a formal commitment to their profession, and are assumed to be actively involved in day-to-day professional activities. Their experience and knowledge were therefore considered to be representative of current trends and practices in the field of architecture and engineering in their area. In addition to questions on socio-demographic characteristics and their professional situation, the subjects were asked about their knowledge and practices in the use of new digital technologies, and there were sections on BIM (favouring its use, opportunities and difficulties), robotics (knowledge of robotics, judgement on the importance of robotics and social robots), digital craftsmanship (knowledge and judgement on 3D printers and FabLabs, frequency of FabLabs) and technology refresher courses (what factors affect the adoption and use of new technologies, frequency of refresher courses).

Results and discussion

The two research instruments provided results for three digital technologies: BIM, rapid prototyping (3D printing), robotics. To recap, BIM is a process for the design, construction and maintenance of a building using a digital information model. It enables computable project simulations to be run for a building. Rapid prototyping involves the series of techniques for the physical production of a prototype starting from a three-dimensional digital model. Production is often additive and, in this case, refers to 3D printing. One of the most renowned locations for these activities are FabLabs, small workshops offering digital manufacturing services. Finally, robotics involves reprogrammable and multipurpose automation. Robots are automatic mechanical operators controlled by an electronic brain to perform movements and functions that would normally be carried out by human beings.

BIM. Information and communication for building construction

This section aims to answer the first set of research questions: Are professionals in the provinces of Udine and Pordenone in favour of BIM? What are the positive innovations that BIM brings, and what are the difficulties?

BIM has been defined by experts as a very important innovation: «BIM is certainly a winning technology that allows professionals to interact and obtain firm results », «because it makes it possible to have an accurate overview and control of the project phase and certainty over what has been made and how it has been made». Collaborative communication emerges as a strength.

BIM should not be seen «as an evolved design instrument, but rather [...] as a tool that makes it easy to share work, i.e. working in a network, which is the key to the future. It makes it possible for people to simultaneously work in a network and test a project straight from the design phase». BIM enables cooperation and helps different players enter into relations with each other: it is, in the sense Gauntlett (2011) intended, an information and communication technology.

It is an information technology because it contains all the data for each operational phase. The completeness of this information is an advantage for the construction as well as it is for future maintenance. As one expert explained, «I refurbished my home ten years ago, and I have under-floor heating. I did take photographs and remember more or less where the heating coils are, but I'm not 100% sure since they are now covered by the flooring, so these technologies provide us with a much more accurate picture». It is a communication technology because it promotes interaction between customers, technicians, builders and maintenance staff. BIM promotes and "automates" the exchange of information: «BIM is an innovative approach that places the sharing of information at the heart of the production process, enabling customers, professionals and contractors to interact simultaneously». It increases the transparency of the project and reduces project errors.

However, BIM represents a challenge in terms of how professional organisations are currently structured. A chairman of a professional association confessed: «BIM requires the implementation of a training strategy that could revolutionise how firms operate. I run a small firm with three employees, and since this technology requires a certain level of investment, I think it is more likely this will be made by large firms. As a result, BIM might be a disadvantage for small professional practices ». This introduces a new challenge in terms of the professional culture: «the technologies behind BIM are different to the ones that produced Autocad [...]. Back then there was a change in hardware, as the drafting machine was replaced by the computer. Now we have the same hardware, but the working method is changing. This is a cultural change! Cultural change is significant». This change «is especially problematic with established operators where the average age of staff members is above 40 because it can be taxing for people to change the way they do things after many years».

The survey enabled us to directly consider the opinion of architects and engineers in Friuli. On the whole, BIM is seen as an opportunity, thereby confirming the perceptions of the experts (table 3).

Table 3 – In favour of BIM

	Architects		Engineers		TOT respondents	
In favour of BIM	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Yes	231	88.5	158	87.3	389	88.0
No	30	11.5	23	12.7	53	12.0
TOT respondents	**261**	**100**	**181**	**100**	**442**	**100**

The open-ended questions "if you are in favour of the use of BIM, what opportunities do you see in it?" (280 respondents) and "if you are not in favour of the use of BIM, what difficulties do you see in it?" (44 respondents) make it possible to examine in more depth the attitude of professionals.

The biggest opportunity relates to the possibility to have greater "control over processes and projects", followed by the possibility to "improve various design aspects", "coordination, cooperation and interaction between individuals" and "speed up" of procedures and tasks; in fifth position we find the possibility to achieve "integration and interaction" between professionals, processes and tools. By aggregating responses regarding the communication potential of BIM we have the most "popular" feature of this tool. This confirms that which was theorised by Gauntlett: BIM promotes information and communication in the collaborative sense.

Only 44 professionals expressed an opinion on the threats of BIM. This small number confirms that BIM is seen more as a useful opportunity than a threat. The main reason professionals are not in favour of the use of BIM is its "complexity" and secondly its "complexity for small projects and firms"; in third position is the fact that it "generates confusion". While responses regarding the potential of BIM look to issues of information and communication, responses about criticalities point to professional and organisational culture: technology requires new skills, which are not easy to provide through training, and especially a new working culture, that is difficult to develop.

3D printing. A useful tool but "makers" are not very well known

The second group of questions is: Is 3D printing considered useful and used by professionals in Udine and Pordenone? Is the 'maker' phenomenon considered relevant or not? In the field of engineering, 3D printing can be used to design and make all types of objects using various materials. In the field of architecture, it can be used to define the requirements of clients, for example by producing models of projects.

This is what emerges from the experts we interviewed. In terms of engineering, the aim is principally that of producing new components: «technologies that could be very useful in the future are [...] 3D printing and "digital manufacturing" to produce new components and new structures that can be incorporated by buildings». In terms of architecture, the focus is on the possibility to offer clients physical representations of projects: «3D printing can be of assistance in the production of scale models that that in the past could only be made by hand ». During an interview in the offices of his firm, a chairman of the association of architects explained: «people say that 3D printing has replaced traditional modelling, but nobody actually uses traditional modelling any more. We have lots of models here, but the most recent ones are already several years old. Models are no longer made because people no longer know how to make them. They are difficult to make and expensive and people think they can easily be replaced by virtual versions ».

This last statement shows the complexity of the context which innovation is being introduced to. We have a combination of reasons revolving around efficiency, assessments in terms of cost and benefits and the availability or absence of expertise. Sometimes technology can replace skills that no longer exist or which are too expensive to develop and train in people.

The results of the survey provide additional data on the importance of digital craftsmanship for engineers and architects. The survey reveals that 36.8% of engineers and 26.8% of architects have a 3D printer (at home or in their offices). 3D printers are therefore used by at least one in three professionals: the tool "par excellence" of digital craftsmanship is used by a significant minority, which may comprise "early adopters" (Rogers 1962). Moreover, it is interesting to understand how the tool is used, e.g. whether the approach of architects and engineers is driven by the cultural "milieu" of the makers[5]. In this regard, the role of the maker, or digital craftsman, does not actually seem to be very well known amongst professionals (table 4).

[5] According to Anderson (2012), a maker is anyone who uses digital tools with a computer to develop and prototype projects independently and then shares his/her projects online and cooperates with other enthusiasts. We could argue that the culture connected to 3D printers has, at its core, physical and virtual communication and relationships.

Table 4 – knowledge of digital craftsmanship

	Architects		**Engineers**		**TOT respondents**	
Knowledge of digital craftsmanship	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Yes	51	17.1	39	12.6	90	14.8
No	248	82.9	271	87.4	519	85.2
TOT respondents	**299**	**100**	**310**	**100**	**609**	**100**

Another open-ended question that was put to professionals concerned their opinion on the role of the digital craftsman. Only 65 professionals responded to this - a small number that was consistent with other findings. The most frequent answer was "interesting idea", followed by "useful", then "excellent" and "the future".

However, while the role of the digital craftsman is not well known, the most renowned premises for the digital craftsmanship movement, i.e. the FabLab, is better known. Professionals more easily recognise this venue than the activity itself. While only 17.1% of architects have heard of a digital craftsman, 33.4% have heard of FabLab. Similarly, while only 12.6% of engineers have heard of a digital craftsman, 27.8% have heard of FabLab. Nevertheless, 89.1% of architects and 91.7% of engineers that know of a FabLab, have never been to one for professional or recreational purposes.

While the "maker" philosophy is probably seen as abstract, a FabLab is something more tangible and better known: a significant minority of professionals know this as a place where people can work together on the prototyping of models and objects. It is therefore a type of work that is still far removed from professional practice but is known by a minority that owns and uses a 3D printer and is aware of the training opportunities amongst peers and the collaboration offered by FabLabs.

Robotics. A technology for industrial sector specialists

The research questions in the third group concern robotics and are as follows: Is robotics known to professionals in Friuli? How widespread is this technology in professional practice?

According to an expert we interviewed, «I believe robotics (particularly collaborative robotics) is of fundamental importance for engineers. Robotics applied with artificial intelligence, at both an industrial level and in everyday life, is one of the areas of innovation that can provide the greatest level of development ». Nevertheless, at the same time, according to another expert who works as an engineer, «at this moment robotics might well be the technology I deal with less, but it could be useful indirectly since the engineering sector encompasses a very comprehensive level of professionalism ». While robotics is pivotal for a minority of engineers working as employees or consultants in industry, it is less important for professionals in the construction sector. Professionals working in industry probably see it as something normal and commonplace, while the majority of professionals working in the field of construction see robotics as the preserve of the future.

Looking to the results of the survey, it is significant to note that robotics is an issue which most professionals state they have little or no knowledge of, even though engineers claim to have higher level of knowledge of robotics than architects (table 5): this is linked to the mechanical and industrial specialisation of some engineers.

Table 5 – Knowledge of robotics

	Architects		**Engineers**		**TOT respondents**	
Knowledge of robotics	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Non-existent	139	44.1	78	24.4	217	34.2
Limited	154	48.9	157	49.1	311	49.0
Sufficient	19	6.0	60	18.8	79	12.4
Good	3	1.0	25	7.8	28	4.4
Professional standard	0	0	8	2.5	8	1.3
TOT respondents	**315**	**100**	**320**	**100**	**635**	**100**

An open-ended question allows us to reinforce this fact: for engineers robotics is essential when it is applied to industry, followed by applications for manufacturing and mechanics. No reference is made to construction applications. A relative majority of respondents from the association of architects stated that they were unable to answer the question, which may be interpreted as a poor knowledge of this subject matter. Industry represents the major opportunity for architects, followed by applications in medicine, professional spheres, and applications for manufacturing process and care services. Considering both categories, the most frequent response is "industrial sector", followed by "not sure", "manufacturing" sector, "medical sector", "all", "mechanics", "professional sphere", "automation".

Factors for the adoption of ICT and the role of skills

This section aims to answer the fourth and final pair of questions: What are the drivers of ICT adoption in the provinces of Udine and Pordenone? How important is training in the adoption of ICT by engineers and architects in this territory?

According to the opinions of professionals that were collected by the survey, the most significant factors for the adoption of new technologies are technical and specialist skills, followed by the availability of financial resources (table 6).

Table 6 – Factors in the adoption of ICTs

Factors in the adoption of ICTs	Absolute frequency	Percentage frequency
Technical and specialist skills	424	63.2
Financial resources	389	58.0
Organisational and relational skills	249	37.1
Structure of the work	206	30.7
Mentality of clients	194	28.9
Size of the company	163	24.3

According to some experts, training in a new professional culture is pivotal to the adoption of digital technologies but remains problematic. Indeed, «when you take on new people in your firm, if you need to educate them in your technology, you'll have no time for anything else. You need staff who already "know the ropes" [...]. There aren't enough resources to train someone». Universities are the places where engineers and architects are trained but «unfortunately universities do not produce designers. Universities award degrees to people who know what they were taught, but that's a far cry from the actual design process». If university is insufficient, professionals will need training on the job. A regional manager pointed out «lifelong learning became a requirement four years ago, so all technical staff need to accumulate a certain number of points based on training [...] which is why professional associations are offering their members a large quantity of courses, including free of charge». According to the chairman of a professional association «training is important. [...] There have been various courses on BIM with the association and through external training agencies. In general, I think these courses are quite effective».

According to some experts, the training offer is essential and is bound to increase: «these courses are here to stay and will be extended because there is an increasing need for professionals to update their skills ». In collaboration with territorial bodies, universities are involved in the creation of *competence centres*, «where entrepreneurs can first get advice on the possibilities their businesses could have, as well as information on practical issues or on the experimental use of a type of technology. These policies may also be extended to freelance professionals ». This is already happening: an expert who manages a technology park explains that «there is a project called "ARGO" within "Manufacturing 4.0". There will be four hubs, one in the province of Pordenone, another in Trieste, one in Udine and the last one in Carnia a Tolmezzo. These hubs will promote the potential and explain how digital technologies can be used throughout the entire supply chain of the construction industry».

As confirmation of the scale of the cultural challenge, some experts have expressed a perplexity about how lifelong learning has been organised to date. They feel that «courses and seminars are "disjointed"». As a result, they believe a more «systematic» approach is required: «I see training in much the same way as a driving licence: people should be tested on what they have learned. Every ten years people should be made to sit an exam to assess whether they have learnt new skills or know nothing more than they did a decade before. Every few years we should assess people's knowledge and level of professional development ».

The limitations of the current training offer are also confirmed in the survey's results. Indeed, even if professionals believe training is the most important factor, only a minority actually attend refresher courses - although this is a significant minority (approximately one out in three professionals has attended training courses on new technologies). Based on the information collected by the two methodologies we can say that technologies are viewed as an opportunity by the majority of professionals even though the training offer is not appropriate for the scale of the digital challenge. This is true firstly because technologies are complex to use for professional purposes and require a degree of specialisation that is difficult to acquire and make sustainable within small professional practices (which represent the majority in the north-east of Italy). Secondly, this is the case because bodies organising training, like professional associations, are not able to provide a structured and systematic offer.

In conclusion, the most surprising aspect of the "league table" that emerges from the survey (table 6) is that the size of a company is deemed to be the least important factor. Probably it is not so much the size of the firm that is important but rather its capacity to invest (in tools and skills): if a small firm has sound financial resources and expertise, its dimension will not prevent it from adopting new technologies; contrarily, if a large and structured firm has financial difficulties and for various reasons has unsuitable staff, it will find it difficult and challenging to adopt the new technologies. However, in general, a larger sized firm might be associated with more specialised skills and a greater investment capacity. ICT like BIM are by their very nature "collaborative" technologies and if firms want to adopt them it is advisable to develop networks – especially if they are small firms.

The strategic role of lifelong learning to promote innovation

At a regional level, Friuli Venezia Giulia has regional law of 10 November 2005, n. 26, "General framework for innovation, scientific research and technological development". Its aim is to promote an innovation policy founded on processes of interactions between companies, research centres, universities and civil society. The following initiatives are of particular importance for engineers and architects:

- Commencement of professional activity (grants for the first three years in business).
- Professional training (grants for training expenses in Italy and abroad).
- Professional development for bodies, colleges and associations.
- Purchase of innovative capital goods (up to a maximum value of 20,000 euro).

As well as these "structural" measures there are some ad hoc measures. For example, the region has promoted tender notices for incentives to micro-enterprises, co-working services and FabLabs. Thanks to these initiatives, according to an expert and regional official, «Friuli-Venezia Giulia is better placed than other parts of Italy».

Nevertheless, in the survey, professionals provided suggestions on how to get the most out of professional training (which is mainly overseen by the regional government). Training provides individuals with the tools to integrate new ideas and technologies into their daily work. It would be appropriate: «to create small public workshops to spread technology in all activities and businesses, beginning with those that are strategically most significant », «improve training through collaborations between professional associations, industry, government, universities», «change the entrepreneurial mentality with "simple" non-specialist courses», «incentivise the use of new technologies in schools, incentivise meritocracy, train teachers to use technologies, streamline bureaucracy, pass comprehensive and clear laws ». Some professionals also suggested that technical training alone is insufficient and that there is a need for solid and extensive knowledge, including soft skills (e.g. communication skills).

For Italy as a whole, the "Enterprise 4.0" national plan involves a series of measures, financial incentives and facilitations for digital development. According to the plan, in an ever-changing scenario, it is essential that engineers and architects not only keep their technical skills up-to-date, but also develop an open and adaptive mindset. Therefore, the plan promotes the training and professional development of managers, assistants and workers through tax incentives, "competence centres" and partnerships between universities and companies. The aim is to acquire knowledge on big data and data analysis, cloud and fog computing, cyber security, cyber and physical systems, rapid prototyping, visualisation and augmented reality systems, advanced and collaborative robotics, human machine interface, additive manufacturing, Internet of things and machines and digital integration of company processes.

The importance of qualifying for loans is confirmed by various experts, who hope to see an extension of the scope of the "Enterprise 4.0" national plan towards professionals. It would be appropriate to have «policies providing tax incentives or other types of incentives, since these new technologies are expensive. I believe this is essential because an engineering or architectural practice needs tools and therefore also needs incentives, as was the case with the "Enterprise 4.0" for industry through its role in the renewal of industrial machinery. Something similar should be done for these tools for professionals, that are mainly software tools ».

There was also interest in the "Enterprise 4.0" plan in terms of action on training. An expert believes in the importance of "competence centres", places where entrepreneurs can ask for information and advice: «these policies could also be extended to freelance professionals ». This is taking place with a project called "work in progress 4.0", which aims to train everyone involved in the innovation process: professionals as well as technical staff in the public and private sector, *executors* and customers. In other words, an innovative mentality must exist amongst professionals and the people who deal with professionals[6].

In conclusion, according to the interviewees, institutions should pursue three main lines of development: training, support in the purchase of hardware and software, networking among professionals. Training should be as widespread as possible with the aim of creating an ecosystem that is conducive to innovation. For example, there is an urgent need to provide suitable

[6] It is no coincidence that professionals believe the adoption of new technologies would be more useful for the government than the organisations they work for: while 30.3% of professionals believe the adoption of technologies would be very useful in their own working environment, this percentage increases to 45.6% for government. Professionals who work with government bodies believe that public officials would provide a better service if they were more familiar with new technologies.

training for BIM (since the European Union has made this obligatory for large contracts). At a national level, there could be a review of procedures for awarding tenders to reflect the advantages of BIM for customers. This also means training customers/principals – local council technicians, regional technicians – so they know what to ask for. Moreover, as the two methods of research revealed, additional investments are required in education and in lifelong learning (in order to promote a genuinely comprehensive range of abilities and expertise: technical specialisation as well as training on transversal skill and competencies and an interdisciplinary perspective) (Levy and Murname 2006). In this case, individual courses for specific technological issues - such as the ones organised by professional associations - are useful but not sufficient. Lifelong education should be strengthened, even by creating institutes and schools for this purpose.

A second line of action concerns policies to support the purchase of technologies. According to some experts this type of policy could be extended to make it even more accessible for professionals. For example, professionals are often not paid or are paid very late. Support for freelance professionals could therefore be extended with new loans/contributions (e.g. through the establishment of a consortium for issuing loans at a subsidised rate). Since contributions are currently only provided after a report has been filed (and once tools have already been purchased), there is clearly a potential problem. Creating institutions that can issue loans at a subsidised rate and offer credit support to professionals could be a significant development.

Finally, a third aspect concerns networks and pooling between professional firms. According to various experts we interviewed, if pooling between professionals were made more advantageous in fiscal terms, an impetus could be given to the use of technologies. Professionals could be given incentives - which could be in the form of free advice as opposed to material incentives - for creating networks. Even though the research we have conducted suggests that the size of professional firms is not in itself the main factor in determining the adoption of new technologies, the promotion of networks would certainly facilitate a contamination between different skills, synergies between professionals, collaboration as well as specialisation. In Italy, where a significant proportion of professional firms have only one professional, continuing education can serve as a compass, and it is important to highlight the opportunities of a collaborative approach both between professionals of the same discipline (e.g. between architects specialised in different sectors or in different technologies) and between professionals and other scientific and entrepreneurial realities (such as universities, science and technology parks, FabLabs). Even in the case of highly skilled workers, individual expertise, can easily be replaced in operational terms but the special alchemy that is created when different people work together (including with the support of ICT) is not easy to replicate (Salas et al., 2008).

Concluding remarks

The growing spread of digital technologies is a potential threat for some tasks in many different types of jobs with the level of threat depending on the degree to which tasks can be automated (Moretti 2013). Moreover, although digital technologies could replace certain tasks, elsewhere they could be complementary and improve productivity. This means that digital technologies can profoundly transform the nature of work, leading to new opportunities and challenges.

According to one expert, «Italy has traditionally always had a large and robust professional class, but as we have been seeing for some time, there is a trend towards a reduction in the number of professionals. [...] As well as a reduction in the number of professionals, I think there will be a reduction in their profit margins». The effect could be a progressive merging, or a closer collaboration, between smaller firms. The idea that "it's better to do things alone"[7], might become less compelling, including in light of advantages offered by digital technologies. This suggests a change in the landscape of the professions, with an increasing emphasis on inter-professional collaboration. According to another interviewee: «at this time, this profession needs to develop in new forms, with a collaborative approach between architects, engineers and other professionals, beyond existing models for professional firms, by exploiting technologies for remote electronic collaboration ».

To face the challenges of technological innovation, two potential strategies emerged from this research. The first strategy could be the acquisition of increasingly in-depth expertise and, at the same time, collaboration with other professionals: «compared to 50 years ago, when buildings simply had walls and floor slabs, all constructions have become extremely complicated. We now have electronics, plant and systems and plumbing that are all incredibly complex. It's impossible to think a single person could do everything on their own. The future requires specialisation and cooperation to move hand in hand». The rapid evolution of technology has amplified the need for continuous training and a wider collaboration network. The necessary expertise is specialist in nature but also sufficiently flexible for contending with changing situations and conditions. For the management of new technologies, symbolised by BIM and digital craftsmanship, the importance

[7] In the Friulian language "*fasìn di bessôi*" means "we can cope on our own". This is one of the most renowned phrases from the culture of the North East of Italy and highlights the cultural propensity to only count on oneself without working with other people or asking for help.

of both technical and humanistic skills has emerged, to enable individual professionals to keep up to speed with the changes the digital economy is producing on the workplace. While specialisation requires a technical culture, networking requires a relational and communicative culture: the close connection between a technical culture and a "humanistic sensibility" is the second possible strategy. This duality underlines the importance of training that integrates both technical and communicative, collaborative, interpersonal skills (Van Laar et al., 2017). From this perspective, receiving suitable training, both at university and throughout one's career, becomes essential.

In conclusion, rather than being preoccupied by or content with the "end of work" resulting from the introduction of new technologies, we should examine in depth the consequences of the latter on the working conditions of professionals and consider how institutions and social actors should react. On the one hand, the dynamics triggered by innovation could be positive for highly qualified workers: some of them could obtain an increase in professionalism, employability, flexibility, real participation, identity, satisfaction (Sennett 2008). On the other hand, technological transitions could result in occupational imbalances that could worsen the position of certain workers and make their working conditions less secure. The risk is a polarisation between people who make the most of technological innovation - and exponentially increase their productivity - and people whose positions will become less stable or less well paid or see some of their duties replaced (Sundararajan 2016; Brynjolfsson, McAfee 2016; Casilli 2019).

This research suggests that innovation associated with digital technologies should be guided. Once the advantages and issues linked to a technology have been understood, together with the factors that will determine its adoption or rejection, professionals, professional associations, training systems and institutions should develop solutions and responses to ensure an inclusive transition. A "protected innovation" or "governed innovation" approach does not simply require support for the purchase and adoption of software and hardware technologies, but above it requires educational policies, refresher courses and a new approach to the organisation of professions.

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