A study of the impact of digitalization on Engineering Education Institutions in France

Analysis of the answers to the survey (Focus) launched by CTI

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Initials Last name (10 pt, Arial font bold)
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ABSTRACT

Sometimes, when you discuss with students about their future, some of them, especially girls, say" I will study chemical engineering because I do not like computer science and data processing". In our society it is no more possible to think like this, because of the importance that data take everywhere, and so it is important to convince young people and their teachers of this evolution!

Commission des Titres d'Ingénieur (CTI) decided in February 2019 to launch a specific enquiry called "focus" on the practices of engineering education institutions to make those institutions explain to society what they did or what they are doing or going to do concerning digital education and digital processes.

This enquiry included 4 parts and should have been answered in 4 pages by each institution:

-one is about the pedagogic methods linked to the digital technologies developped, one of them being distance learning

-one is about teachings organized in the institution either if this institution is devoted to fields originally far from digital preoccupations, or if it is inside this field

-one is about the changes in the organization of the institution linked with digital technologies

-one is about the changes in the jobs that the institution aims for its graduates in the next future

This enquiry had 3 major aims:

-Make institutions aware of the necessity to turn to digital, and for those that had already made this evolution, say to other ones what they were doing.

-Share good practices between institutions

-Discover the evolution of jobs as anticipated by institutions

The results are quite interesting and even surprising, they concern more than 40 institutions on the 201 French institutions and we share them in this paper.

1 INTRODUCTION

1.1 Context

Many reports deal with the new jobs that engineers will have to face within 50 years and, as nobody really knows which form these jobs will have, much of the reports deal very widely with numerical skills or with the societal impact of this numerical (r)evolution, or more specifically with IA and Big Data.

The fact is that the quick evolution of both hardware and software in the last 20 years has surprised most of us, even scientists belonging to the digital community, and some algorithms that we could not apply in 1990's because of the insufficient speed of the hardware are now completely usable and sometimes of very current use now.

But the influence of digital is much larger than those technical points. A strong shift of paradigm is operating in the organizations too. So it is necessary to imagine Digital (r)evolution inside higher education institutions more globally.

That is why CTI, the French Accreditation Agency for engineering programs, after having added in 2018 a specific question to the data that engineering education institutions have to give it each year:" what did you put in place in the digital domain", has decided to launch a more detailed focus on these themes.

It concerned, in a mandatory way, all institutions asking for periodic accreditation in 2019 (about 50, that is a quarter of all Engineering Education Institutions) and all the institutions that wished to answer, too.

At the end of the accreditation campaign all the results were synthetized and a communication made inside CTI and outside CTI newsletter for example).

What can be the impact of an accreditation agency on these problematics?

We had already launched focuses on other problematics: Sustainable development, Innovation, Safety and Health at Work; these were new subjects for institutions at the time when the focus was launched, and we observed that these focus had a strong effect on all the institutions because they made the institution have a deep reflexion.

In this specific case we were both trying to share good practices, to discover what is done and perhaps create a dynamic of collaboration between institutions

1.2 Data already obtained at CTI

In June 2018, among the 201 French Schools of Engineering, representing 1047 different programs, 751 included mandatory digital education and 358 included it as optional courses [1]

New pedagogies based on digital methods were put in place in 302 programs, including use of Moodle but also of SPOCs, MOOCs, virtual classes, serious games.

What is very curious is that engineering institutions also mentioned in this field of data that they were teaching "Word". This is now taught in all disciplines, even at the secondary school, it is very strange to imagine that an engineering institution considered that it is part of the digitalization process!

During audit we could also discover more precise information on this subject, and as informatics tools were one point of the Eur Ace label delivery, experts already asked elements on this point.

But this was not sufficient to have a global idea on the state of digitalization because, for example, chemical or agricultural engineering did not give us specific information on this field and, for the time being, no recommendations either have been emitted by CTI on this field except a guideline document "Compétences en numérique de l'ingénieur" included in "Analyse et Perspective" but it was a long time ago [2].

It is the reason why the CTI's assembly decided in January 2019 that launching this focus [3] was necessary to have a real idea of things.

2 THE QUESTIONS ADRESSED IN THE FOCUS

2.1 Pedagogic innovations in link with digital

Digitalisation being a powerful vector of pedagogic transformation that goes far away from technology, CTI is very interested because evaluation of programs is not only on their content but also on the means that institution uses to teach the program, and particularly on the pedagogic innovations. Some of them need specific equipment that can be bought in common by some programs or even institutions.

The French government had previously published a report on this subject in June 2018 [4].

For engineering especially, this is really very important because virtual teaching is very often opposed to presence teaching but there are now digital twins that make distance experimentation possible; distance learning is more and more used especially for continuous education even if engineering often need specific organizations blending theoretical and practical education, for labs for example.

Nothing was said in our procedures about distance learning, so it was necessary for CTI to understand the actual extent of this kind of teaching, to be able to define new norms of coaching for students or to have an idea about the minimal face to face time necessary for a "good engineering education". The coronavirus episode made these elements more important than ever, and we can now observe that things change very quickly inside institutions: a new focus on the same subject that will be launched next year will be very instructive.

The questions that CTI addressed to institutions were the following:

-Did the institution answered to call for projects, at national or international level, on these subjects?

-Which devices have been put in place or are being put in place at the level of the institution, of the site, or of the network to which the institution belongs?

-Which good practices could be shared?

-How the impact on quality of apprenticeship of the students with these new actions or devices can be measured?

All these questions were rather general ones but CTI wanted to get a broad view on those practices because very different fields are under the name pedagogy. For example, Learning Analytics can be as well considered as a pedagogic innovation as a change in organisation.

2.2 CONTENT OF THE CURRICULA

The content is context dependant

All the same disciplines cannot be taught in Chemical engineering, in Agro sciences Engineering and in Computer Science Engineering. That is the reason why CTI asks the institution to precise the field of the programs taught.

The analysis and report made by CTI after reception of the information of the institutions had to be presented according to these two categories:

-Programs outside the field of digital engineering

-Programs in the field of digital engineering

But CTI is not interested by description of desktop tools teachings for example.

This classification is sometimes a little subtle because for example Geology is not in the field of digitalisation but Geomatics is.

The questions

From programming to automatic apprenticeship, through datamining, cyber defence and AI, all activities should have been described with the corresponding durations and the levels of teaching.

Are those teachings directly linked to the field or to the evolution of the program in terms of new job opportunities?

How these teachings are integrated and are complementary to traditional teachings was another interrogation.

Which activities supporting those teachings have been put in place: from conferences to projects, numerous modalities are possible depending on the student's year addressed in the curriculum.

Another aspect which is of great interest to CTI is the societal impact of this digitalisation. It must not be underestimated: institutions are invited to explain how they introduce the subjects with their students.

2.3 Changes in organizations linked to digital

As told in the ministry report [4], digitalization can lead to a global transformation of the organisation of the institution. It is not only to buy an ERP or a sophisticated software but it goes far beyond the use of this device.

The institution had to describe digital tools or organisations already put in place and the new tools that will be in place in the future. This must be done at the local level, at the network level or at the site level.

The social climate of an institution can be impacted by these evolutions: how does the institution act to take into account this phenomenon?

2.4 Changes in the job graduates will occupy

Even if Pole Emploi, the French agency for jobs, has published a report [5], few documents have been published on the evolution of jobs and functions. It seems to CTI that institutions have to realize a study of those evolutions for example putting in place an observatory, or realising a technology watch or working with professional associations.

But this is not enough the case actually, it is no more possible to go on saying that nobody knows the future of engineers' job, because students and their parents have to know but also because those attractive jobs with new forms of employment could be more attractive to the new generation than to the previous ones and so, it could contribute to the attractiveness of engineering education.

2.5 Global evaluation made by the institution

The institution is invited to give details on what is its future, what is easy or difficult to put in place, and on the conduct or modification of its strategic plan.

This part was also very important because it could indicate generic difficulties that institutions had to face and to which solutions could be brought.

The institution has the necessity from time to time to have a glance on itself and on its practices, so the end of the focus consists in the analysis the institution has, on its involvement, on those four dimensions of this digital (r)evolutions, for example:

Does it change something on the employability of the graduates?

Does the institution think it has still to progress?

3 THE ANSWERS OF INSTITUTIONS

The amount of answers was a surprise for us: some institution wrote 32 pages instead of the 4 pages that where asked because they had previously defined their strategic plan on digitalization and wanted to explain it. All institutions wanted to share their best practices, and very few of them had done nothing: some were more concentrated in distance learning, some were more focused on new disciplines for the future.

But the more interesting effect is the site effect more important than the network effect: in a specific place (Toulouse for example, or Lyon), the region can create a dynamic through collective actions or specific call for projects that all institutions (private or public) follow, whatever the field of their discipline is and whatever network they belong.

The third point is the weakness of evaluation of those new practices for the moment. In France the idea of making research on human factors inside Engineering Higher Education Institution is something new and so not very developed for the time being.

3.1 On pedagogic practices

This field was the more developed by institutions and was a real shock for us because as distance learning is never indicated by institutions in their accreditation file, we did not know it was already existing. But this did not mean that they did not do it: they only did not tell us! Nearly all of them have developed even through Moodle some Distance education in a form more or less sophisticated. It makes CTI more mandatory to define quality norms for this kind of education that is ignored by CTI till now.

Under the idea of pedagogic innovation, we meet very diverse answers in their level of abstraction: some are in link with evaluation of learning outcomes through portfolios, some institutions are using these new opportunities to begin a reflexion on the job of the teachers.

Use of virtual reality and digitalization of labs are something quite specific to science and technologies and few schools are making experiments in this domain because a serious investment is needed. They can have obtained the money through calls for projects.

However, many schools have answered to call for projects, regional or national ones less on the international level. The specific call named IDEFI that has pedagogic aims is very often quoted. Inside Universities a Bonus (that is a specific gift of money) was organized on the form of a call project and many new devices were bought through it.

This new experiments very often apply to distant publics (Africa for example) or to continuing education students but also "prevented students".

Something very interesting was presented by several schools: the use of new pedagogies to attract high school pupils through MOOCs for example, these MOOCs can be realized by students, if the institution has the infrastructure to realize its own MOOCs.

Many institutions have adapted their networks to be fitted with BYOD and the some bought digital tablets to all the students.

We also observe a real interest to "Learning Analytics" some school already experimenting it for a specific part of their students, other one having the strong purpose to investigate it soon.

3.2 On what is taught in the programs

Something is common for all engineering institutions, time devoted to teach data analysis, it seems that more and more engineers of all fields become also data scientists

-for institutions in the field of digitalization: cybersecurity, IoT, Big Data are the items that comes more frequently and less frequently AI and machine learning

Few information is given on the amount of hours dedicated to those teachings and too few school develop what they teach concerning human impact of digitalization but more often appears the management of change or of digital transition in factories. Some institutions are very concerned by data protection not only in their organisation but also in their teachings.

-for other institutions: tools of modelling or simulation are the most important item, but also embedded systems, BIM, all what concerns Factory of the Future, and bioinformatics, Geographic Information Systems, or cyber physic systems are taught in the schools devoted to those sector but more surprising was the fact that life sciences have drastically changed their teaching to fit with the digitalization.

The general idea is that institutions really saw the digitalization as a change of paradigm on data before introduction of new tools, and they managed the evolution of their programs as such.

3.3 On Organisation and management of the institution

In France there is a real problem at this moment to find the good software for the management of a big institution.

The French state has elaborated software for management of students and teachers that revealed not to be very performant (Cocktail) and it was difficult for a public institution to escape those tools.

But there are also many initiatives to manage Learning outcomes by portfolio, to manage Alumni through social networks, to manage skills of students recruited.

But moreover institutions want to produce indicators of satisfaction of students and teachers. This preoccupation for quality joins the preoccupation of evaluation agency on this field and we will have to build things together.

We observe that many people have been devoted to the management of digitalization inside the institutions, in the aim of increasing service to users.

GDPR is a problem taken very seriously by institutions and the choice of software tools sure enough to manage the security of system worries institutions.

3.4 On Jobs Evolution

Programs in computer science or software have been put in place to answer the demand on system security and data analytics.

Data scientist are needed in every field of activity but also specialists in Geographic information Systems.

Global managers of digital systems are needed such as Chief Digital Officers, they can be educated through our generalist engineering departments.

Some institutions have or will put in place a council for prospective especially for health application of engineering or agriculture engineering, BIM is also developing very quickly as well as jobs for Industry 4.0, "data and mobility" can also be a challenge for the future.

Institutions insist on this digital transformation, so they are preparing graduates able to adapt, this is the main result of this enquiry.

3.5 On the lessons

Institution regret that they do not have good indicators to measure the apprenticeship of their students. Many schools are interested by Learning Analytics.

Some institutions that did not have this digitalization in their strategic plan are reorganizing it just now.

But everyone insists on the necessity to make teachers and staff evolve as well as students.

4 CONCLUSION

A focus is not enough to make situation evolve, it is necessary to broadcast very largely its results, this was foreseen, but the Covid 19 makes all plans change, as well those of institutions as those of the accreditation agency!

A debate on distance learning will be realised in June after the presentation of the analysis of the results of the focus on this specific dimension through the newsletter: schools are awaiting this evolution of our rules especially those concerning teaching to prevented people.

Another focus will be launched next year and the results compared to the result of this year, so it will be very easy to discover the importance of real situations such as Covid 19 on the evolution of practices.

They are perhaps better boosters than an evaluation agency!

On a more general point of view, the answers show that institutions have well understood the importance of this digital (r)evolution, more than tools it is a real change in minds that is prepared by HEIs.

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