Build to think, build to learn: what can fabrication and creativity bring to rethink (higher) education?

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Abstract. With the global digital transition, we are witnessing, it is clear that learning is no longer done in isolation and without the use of many digital resources. However, the teaching approaches that are still dominant in higher education are largely marked by old paradigms. Without saying they are wrong; however, one can only witness that they no longer fully correspond to the world we live in and should consequently be adapted. In this paper we propose to introduce the Design Thinking and akin approaches found in FabLabs in order to define a learning space complementary to the traditional teaching experience of higher education, which are rather organised in silos: faculties, departments, degrees. Such a place, which we call a FacLab and which can be described as a physical space extended by a virtual digital space, can be seen as a FabLab embedded in the academic environment. It would favour transversality, encounters, co-construction, collaboration, serendipity and most importantly the putting into practice of transverse skills around the mainly digital factory of the tangible and the intangible, supported and sustained by the methodologies resulting from Design Thinking and related creativity approaches. Here we present our approach and the first developments we have implemented.

1 Introduction

The digital transformation has had and continues to have a significant impact in the world of higher education that has not yet been fully taken into account. It involves both teaching the technologies and skills needed to use them in all areas, but also integrating these technologies for learning and teaching. However, we can see that the current education system is still largely based on approaches that are no longer compatible with the consequences of this digital transformation. The essential milestone is marked by the appearance of Web 2.0, which has had an impact not only on technology but also on access to and dissemination of knowledge. On the one hand, there has been the development of many tools and environments to support learning with technology, and on the other hand,

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there has been the development of the notion of digital skills and digital literacy as a new area in which students need to be trained.

1.1 The traditional education system

The traditional pedagogical model in higher education is often referred to as "instructivism". This approach is totally institution- and teacher-centered. It is the teacher who decides what is to be learned and how. The teacher is the main teaching agent, holder of the knowledge to be transmitted. The learner is passive and receives pre-determined information from the teacher. The main characteristics are: The instructional content/outcomes are predefined; the knowledge is communicated by the teacher only; the teacher is considered as the expert; and the emphasis is placed on the content over the process [1]. To simplify, this approach can be summarized by saying that it is purely transmissive. The point here is not to judge whether it is right or wrong, but to stress the fact that the context of the digital world around us changes the education paradigm. With the advent of the Web, new pedagogical approaches have developed to varying degrees. Resource-based teaching puts as a basic principle the interaction and selection of learning resources (of all types, including human). Problem-based teaching which sees learning as the set of processes aiming at understanding and/or solving problems. Constructivism, on the other hand, sees learning as a construction carried out by the learner through a set of activities of which he or she is totally or partially at the initiative. The teacher then becomes a facilitator and curator. And finally, connectivism, which encourages the learner to build his or her knowledge network and to know how to use it [2]. These approaches are not exclusive, and often teachers' pedagogical practice is a combination of several aspects of these approaches. It should also be noted that all these approaches are based more or less on an abundance of educational resources (mainly since the advent of the Web and its deployment). The digital transition has brought about a two-fold disruption in the higher education sector: on the one hand, information technology has become an indispensable medium for learning, and on the other hand, it is an integral part of the disciplines taught [3]. The learner evolves in a complex digital environment that combines both formal (those to be used in the institution) and informal (those discovered and learnt to use independently) digital learning tools, in addition to the digital tools of the discipline. With the notion of person-plus, which we can refine as learner-plus, Perkins [4] explains that we are not formed as isolated individuals, but by other people, through the use of symbolic media and the exploitation of the work environment, artifacts and tools. This notion is extended to the professional world with the concept of professional-plus [5]. It develops the idea that professional knowledge and skills go beyond individuals, and situates them in their physical, technological and social environment. Learning to become a professional means extending and combining one's knowledge and skills with a distributed human and technological environment. Teaching methods should be adapted accordingly to particularly to take into account the increased learner's digital learning and working environment.

1.2 The new kid on the block: WWW

The emergence of the web, and especially its evolution and expansion, has introduced a disruptive element outside the protected space of universities. The advent of Web 2.0 in particular has made it possible to provide infrastructures that empower users to become not only resource consumers, but also resource producers. The learner quickly found himself between two worlds: a relatively closed space providing resources in limited quantity, a priori relevant, validated and certified, and an open space providing almost limitless

resources, but whose quality and relevance remained to be determined. In addition, this open space of Web 2.0 offered its users the ability to take the initiative, to experiment, to produce, which the university space did not allow to the same extent.

The development of Web 2.0 and its ability to offer virtual spaces for sharing and collaboration has seen the emergence of learning environments that promote constructivist or connectivist pedagogical models. However, these systems are rarely adopted at the institutional level. They are more often the result of individual initiatives by teachers wishing to improve their pedagogical approaches. The emergence of mobile phones and then smartphones has made these environments even more ubiquitous [6]. These pedagogical environments based on the Web 2.0 model generally combine social media with a connectivist pedagogical approach. The objective is to refocus learning on the learner and enable him or her to be more active through participation and knowledge production [7]. The educational 2.0 or pedagogy 2.0 is supported by different aspects such as: participatory web, open web, collaboration, sociability, open classroom and web as a learning platform [8]. From the reading of articles that relate experiences of teaching based on Web 2.0 it is not clear whether it is technology that brings new forms of pedagogy or new forms of pedagogy that brings the use of Web 2.0 technologies. The development of the Web is reflected in a pedagogy of abundance. Two questions then arise: how can teachers be allowed to take advantage of this abundance to get the most out of it for their teaching, and how can learners be armed to get the most out of it for their learning [2]?

1.3 Education System Challenges

Among all the reports that examine the challenges facing higher education, we rely on the EDUCAUSE 2019 report [3], which is based on discussions and interviews with a board of experts. Each year, this report proposes directions to address the following questions: What is on the five-year horizon for higher education institutions? Which trends and technology developments will drive educational change? Among all the topics discussed in the more or less long term, we will particularly highlight some that are quite consistent. Digital fluency which is presented as an evolution of digital literacy. Digital fluency is seen as a combination of co-creative skills with the ability to take advantage of evolving technologies and goes beyond what is usually considered digital literacy. Digital fluency integrates critical thinking and complex problem solving. The report also refers to the need to review and rethink teaching practice. This renewal of practice reflects the changing role of the teacher from knowledge transmitter to facilitator and curator. It relies on digital tools to implement learner-centered teaching methods. This theme joins another: the need to rethink learning spaces, which involves physical as well as virtual spaces. The aim is to enable learners to be active and collaborative. In the same perspective, the report stresses the need to develop cultures of innovation and to integrate them into curricula. What emerges from this report, but also from the reports of previous years, is that the evolution of teaching in higher education is strongly intertwined with digital technologies. Thus, the ability to master and exploit these tools in creative and innovative ways, whether called digital literacy or digital fluency, is part of the foundation that must be developed within academic institutions.

Digital literacy implies “capabilities which fit an individual for living, learning, and working in a digital society”. There are competency frameworks, such as DigiComp [9], that describe competencies so that educational approaches and skills assessment strategies can be defined. However, there are still many issues to be addressed. How to integrate digital skills learning into curricula? In a transversal way or specifically? How can teachers be trained to master these skills and transmit them? How can we keep skills frameworks up to date when digital technologies and methods are constantly evolving?

In the evolution of their role, teachers must progress simultaneously on two fronts: on the one hand, they are expected to use and master more and more digital tools for their teaching, but on the other hand to develop and put into practice active learner-centered pedagogical approaches in which they play a facilitating role. These approaches are themselves supported by digital environments. The answers to these challenges are still very technology-oriented: massive equipment purchases, platform deployment, etc. These responses still overlook too much the fact that digital skills go far beyond technical skills and that they also probably imply an evolution in pedagogical methods. What remains equally complicated is the ability to assess the acquisition of these skills.

1.4 Systems, Tools and Services

With the advent of new technologies, digital environments dedicated to education have developed. Most of them are grouped under the terminology of Learning Management Systems (LMS) [10]. They provide a set of features to support and disseminate learning resources, administrative functions, assessments, and grading. These environments have now become widely deployed and widespread in most universities. They are used to deliver distance learning, but also for blended learning and even face-to-face learning. They replicate traditional teaching models in their design, with a teacher delivering and transmitting learning content and students passively accessing these resources. Little initiative on the part of students is possible in these environments. The adoption of these environments in universities is often motivated, rightly or wrongly, by various factors. They are seen as a means to increase the effectiveness of teaching, a promise to enrich student learning, a response to student expectations regarding the use of new technologies in teaching, a competitive advantage through the integration of the Internet on campuses, a way to meet expectations to expand access to university education and finally as a means to control and regulate teaching [11]. The integration of LMS is also based on a technical approach that aims to automate teaching, such as the automatic scoring of exams, for example. The first learning management platforms have basically reproduced the predominant transmission model of learning based on a teacher and curriculum centric approach. Teachers are delivering and transmitting learning content and students passively accessing these resources. Little initiative on the part of students is possible in these environments: students can use a wiki only if the teacher has first decided to enable it. Although these environments have evolved since their emergence, their initial design continues to impact how they are used. To some extent, as raised by Coates et al. [11], “LMS are based on an overly simplistic understanding of the relationship between teachers, knowledge and student learning. Built-in functions may not encourage awareness of or experimentation with sophisticated pedagogical practices.” In response to this situation, alternate environments have been proposed, some within the academic world, such as the Personal Learning Environments (PLE) [12], others outside such as the Khan Academy. Many environments that appeared with the advent of Web 2.0 have also brought new opportunities for (self-)learning: Wikipedia, Youtube, Stackoverflow, etc. It is interesting to note that PLE is defined as a concept, a learner-centered pedagogical approach and as an environment that supports this approach. The PLE also expects to integrate and bridge formal, informal and even life-long learning. Alternate models of transmission of learning have been recently introduced such as self-regulated learning or social learning. They are currently emerging alongside traditional models. These models expect to place the learner at the center of the learning activities; to enactive and empower him-er to actively participate in learning activities; to connect formal and informal learning; and to introduce peer-based interactions to sustain learning activities [13]. New types of learning

management platforms are accompanying this evolution. They have been highly motivated and influenced by the advent of the Web 2.0 ecosystem [14]. Web 2.0 tools demonstrate an obvious potential application in an educational context.

These new systems are based on different representations of learning activities: distributed activities; social activities; and user-centric activities. The technical implementations respectively result in Web 2.0 extended LMSs [15-16]; mashups-based environments [17-18]; social and collaborative environments [19]; Personal Learning Environments (PLEs) [20-21]; and e-Portfolios [22]. They expect to encourage self-regulated and peer-based learning by offering features for collaboration and cooperation between peers. The recent emergence of Massive Open Online Courses (MOOCs) [23] and more precisely xMOOCs or eXtended MOOCs such as Coursera, EdX or Udacity has introduced an additional dimension in the design of teaching platforms with the enrolment of huge crowds of students. In order to face the imbalance between teaching staff and learning crowd, they crowdsource some of the teaching activities to students: assessment, tutoring. However, these platforms substantially reproduce the same transmission patterns of learning as LMSs and remain instructivist, centralized and teacher-directed. It should be noted that in the early days of MOOCs, xMOOCs competed with connectivist cMOOCs [24] or MOOCs that promoted an open and decentralised pedagogical approach involving groups of people who learn together. Since then, xMOOCs have largely dominated the sector and the term MOOC now systematically refers to xMOOCs.

1.5 Digital Literacy / Digital Citizenship

The term Digital Literacy has become very popular and is currently considered as a hot topic [25], but its definition and implementation are still widely debated. Digital literacy can be defined in a global way as encompassing all the multiple literacies that concern the use of digital technologies [26]. More precise definitions that aim to provide competency frameworks also agree that digital literacy goes well beyond the technical skills that allow a person to operate a computer or use software [26-28]. The digital literacy framework proposed by Ng [26] includes technical as well as cognitive and socio-emotional skills. UNESCO [29] defines it as “a set of basic skills which include the use and production of digital media, information processing and retrieval, participation in social networks for creation and sharing of knowledge, and a wide range of professional computing skills.” Potter and McDougall [30] refers to the notion of "dynamic literacies" which brings together distinct traditions that contribute to an attempt to account for changes in the way meaning is given to the digital age.

Many recent studies on learners' skill levels have reached the same or similar conclusions: “for the current generation of students, a lot of their digital capabilities, in particular the use of mobile phones and social media have been gained informally where they explore these technologies themselves or with peers. There is a role for educators to expand their horizon in the use of digital technologies for educational purposes in formal settings [26].”

Higher education has long neglected the need to integrate digital skills into curricula. These skills were considered marginal and did not require special attention [31]. Different reasons can be given. One of them concerns the model or metaphor representing the digital learner, which was widely adopted from the beginning. The "digital native" model described by Prensky [32] has become widely and incorrectly established. The widespread acceptance of the "digital native" was that all learners born in a digital world are naturally competent to appropriate its resources and exploit them in a relevant way. It was therefore unnecessary to waste time and resources teaching them. It was finally shown that this

model was far too simplifying and unifying and that it conveyed a poor conception of the digital learner [33-35].

However, a model of how the learner's behavior with digital information technologies and resources is represented remains useful for defining appropriate digital literacy training strategies [36]. The visitor/resident model [37-38], for example, is a model that reflects the diversity of behaviors, regardless of age and gender, taking into account attitudes towards technologies. In this model, each learner is placed in a continuum between two extremes: the visitor and the resident. Visitors sporadically use ICT when the need arises, while resident incorporate ICT in all facets of life, whether for fun, learning or working. For the former, technologies and the web are a tool, for the latter they are rather a place. This model is all the more interesting because it is complemented by a second dimension that takes into account the learning context, institutional or informal [39]. This dimension is consistent with studies that show a significant differentiation of digital skills and uses between the personal context in which they are generally quite developed and the institutional context in which they are rather non-existent.

Another factor that has pushed back training in digital skills is that many teachers themselves are not digitally literate and have not been trained to become so. Moreover, for a long time, the reaction of higher-education teaching personnel has been to consider the huge number of educational resources available on the web as a risk rather than an asset. There has long been mistrust of Wikipedia, with the choice of refusing to use it rather than promoting its critical use.

The teaching of digital skills in higher education focuses mainly on the technical dimension. Evidence of this can be found in the use of the term “computational thinking” often focusing on purely engineering skills. In addition, a number of barriers to the development of this education can be identified: the absence of a boundary between the personal, extracurricular context and the institutional, intra-school context; the commercial nature of the extracurricular context, as well as the difficulty of evaluating information online [40]. In addition, teachers frequently report a relatively poor presence and quality of ICT training during their training [41-42].

2 Initial insights and experiments for a FacLab

The elements mentioned in the introduction show that it is necessary to evolve pedagogical approaches in higher education in order to integrate the new skills induced by the digital transformation and the prevalence of technologies. The deployment of a FabLab in an academic context then appears as a space that is able to promote the meeting of formal and informal learning, the different disciplines of the academic world and digital literacy. Our first experiments convinced us that an academic FabLab could not be based solely on the traditional FabLab and makers approaches and that it was necessary to support and structure the fabrication process with methodologies that respect the organic dimension of making. Our choice was Design Thinking, whose teaching showed us the possible complementarity with fabrication. Moreover, the very notion of manufacturing had to be generalised to the academic context to enable the making of the intangible as well as the tangible, which an approach such as Design Thinking allows. Complementarity is also found with making at the prototyping stage of Design Thinking.

2.1 Design, Design Thinking

Design Thinking (DT) is defined as "a design methodology that provides a solution-based approach to solving problems. It's extremely useful in tackling complex problems that are ill-defined or unknown, by understanding the human needs involved, by re-framing the problem in human-centric ways, by creating many ideas in brainstorming sessions, and by adopting a hands-on approach in prototyping and testing [43]." The d.school at Stanford splits the whole process into five stages: 1) empathise; 2) define; 3) ideate; 4) prototype; and 5) test. This approach provides tools to address the uncertainty inherent in open problems. It makes it possible to resolve them through a succession of divergent and convergent phases, which end with a tangibilization of the solution in the form of a prototype that is tested by users and other stakeholders. DT is by nature problem or challenge-based and multidisciplinary. It is possible to integrate this approach into courses that provide students with skills that they do not or very little use in traditional teachings [44]. Past experience [45] shows that DT allows students to get involved in solving open and wicked problems based on real cases. They must communicate and collaborate with peers. The way of thinking they must develop puts them in a position to simultaneously apply their formal learning as well as their informal skills from the real world. Introducing DT in education allows complementing traditional learning in HE as it encourages risk-taking and learning by doing [46]. It differs from the traditional Problem-Based Learning (PBL) approach in two ways. The first difference is that participants define the problems themselves instead of receiving pre-defined problems. The other difference comes from the explicit strategies proposed by DT to solve the problems.

2.2 Fabrication, FabLabs, Makers

Seymour Papert can be considered as the initiator of the pedagogical approach on which the makers' movement is based. With constructionism, he proposed to build a learning environment in which knowledge is built in the learner's mind through the act of making something that can be shared outside [47]. Gershenfeld [48] launched the idea of FabLabs as spaces in which anyone could use technological tools to solve problems in their daily lives.

A FabLab can be defined as a "small-scale workshop with an array of computer-controlled tools that cover several different length scales and various materials, democratizing manufacturing technologies previously available only for expensive mass production [49]."

A study carried out in Denmark on more than 1000 young people between the ages of 11 and 16 [50] shows that they are much more consumers than producers of digital media and technologies, that few of them already have digital manufacturing skills, that few of them implement or tangibilize their creative ideas, that they lack knowledge of design processes for this purpose. Faced with this, schools are focusing on learning office literacy. It probably explains why FabLabs are gaining more and more popularity with kids in schools [51]. They are also beginning to settle in higher education. However, a model for academic FabLab has yet to be defined. Angrisani et al. [52] describe the evolution of a FabLab installed in the academic environment, from a first spontaneous version initiated by a group of teachers and students to a second structured and institutional version. The challenges identified are to find the right compromise between different facets: theory vs practice; research vs teaching; job vs training, fun vs engagement, individual activity vs group work, specialization vs multidisciplinary, public interests vs private interests. Haldrup et al. [53] explain that by opening a common space that brings together users, producers, technologies and materials, the FabLab creates a "hybrid hub" that weaves links between these actors. Because of their openness and lack of regulation, it creates a bizarre bazaar that stimulates trade, manufacturing and knowledge. According to them, "working

through materials" allows new forms of learning and research. From a pedagogical point of view, Halverson and Sheridan [54] consider the FabLab as a framework based on three components: 1) making as learning activities; 2) makerspace as communities of practice and 3) makers as contexts of participation that open up new forms of interaction with learning. Smith et al. [55] raises that "design thinking can provide students with a general understanding of the creative and complex process through which artifacts and futures emerge in processes of digital fabrication."

3 From an idea to a FacLab: a journey

Bennett and Matton [36] evoke the notion of third place as being at the same time a metaphorical, virtual and physical space. They are potential learning places where hierarchies are loose and open to the skills provided by learners as well as to lived experiences and other cultures. This third place is a meeting point where the intersection between personal, informal (external to the institution) and institutional, or formal knowledge takes place. In this way, it is in a way similar to the notion of PLE. They suggest involving students in these different places of the third place to complete and extend their digital practices and he proposes to concretize it in the form of a digital manufacturing space. In this direction, we propose to create such a third place which would be hosted at the University with the characteristics of a FabLab and which would aim to revisit the pedagogical methods in the digital society in an open and mediating place: the FacLab. The manufacturing dimension (to be taken in the broad sense, because it is possible to "manufacture" a service) encourages the use of know-how to learn and evaluates the skills acquired directly through the products manufactured. The realizations, the fabrications indirectly form a portfolio of proofs of the acquired digital skills.

We describe here two experiences that have gradually informed our thinking on the introduction of Design Thinking and FabLab as a means of reconsidering pedagogical methods in higher education.

The successive developments of the two experiments: service innovation lab and FacLab are "manufactured" by applying the methods they are intended to train the learners in.

3.1 Service innovation lab

The service innovation laboratory was launched in 2008. It was first of all organized as a transversal project that would enable master's students in information systems to articulate and put into practice the different courses of their degree. It therefore took a first technology-oriented form with as its starting point a theme for which the students had to develop a prototype of a technical solution using frameworks such as Drupal. Practice quickly showed that the students already had a satisfactory command of the technological aspect. A new orientation then emerged to favor innovation and creativity in the proposed solution. The integration of Design Thinking methods quickly became necessary to reach the current approach which covers the 5 steps of Design Thinking from an initial design brief at the beginning. The objective is then to raise students' awareness through workshops, serious games, etc. which leads to the making of a mockup to be evaluated by users. It should be noted that we have always sought to promote an interdisciplinary approach by opening this laboratory to students from other faculties. This year we were able to experiment with a mixed population resulting from a master's degree in information systems and a master's degree in public management. With the development of this laboratory, the need has gradually arisen to have a space dedicated to it and more widely

dedicated to the implementation of these methods of facilitating creativity and innovation through tangibilization and prototyping. A discussion then opened on the forms of existing spaces which led to the proposal to set up an academic FabLab which was initially called FacLab (Faculty Lab). Here, the notion of making is to be understood in a broad sense: it can be the production of a physical object (tangible artifact) or a virtual service (intangible artifact). It is mainly about shaping an idea, achieving something that can be triggered by someone. That is why we prefer to use the term “build” to the term “make”, but “design” works also well as it refers to the act of conceiving.

Each year we give a general theme, if possible, a topical one, from which students organized in groups will define their own problems which should lead to the proposal of a digital service. For the year 2019, for example, the chosen theme was the federal elections of the parliament taking place every four years in Switzerland.

To allow students to get immersed in the DT approach they are not familiar with, we first do a workshop with them from Stanford's D.School, which is either the Wallet project or the Gift Giving project. These projects allow in about 90 minutes to complete a complete cycle of the 5 steps of DT, from empathy to testing. Then at each session, a workshop allows to progress along the 5 phases towards specifications, prototyping and then service testing. Between sessions, students document their work using a collaborative online toolbox of tools. Each workshop builds on the results of the previous ones while considering that these results are not sacred and can be reviewed over time. The first workshop is a brainstorm that is summarized in the form of a mind map as well as a design brief with 3 proposals corresponding to the most rational idea, the most innovative idea and the most exciting idea. During this period, students must also collect references of all kinds, which they must enrich by annotating and tagging them to create a corpus of common resources. The objective is to allow them to immerse themselves in the field of the theme and to feed their thought process. The next workshop is an innovation game proposed by Hohmann [56]: "remember the future". This game is based on the assumption that it is easier to understand and describe a future if you break the direct link from today by projecting people in a futuristic fictional time and then to ask them to remember a time in the past that is in the future for us now. This technique, sometimes also called back casting, helps prevent simplistic or marginally incremental ideas. It is based on gamification and storytelling. The result is a story that describes how someone would use the expected service. The 3rd workshop consists in defining a stakeholder map, along with personas and associated scenarios. This leads to the 4th workshop which synthesizes the whole in the form of customer journeys. The 5th workshop uses an innovation game [56]: the "product box” but adapted here in the form of a "service box". It allows to define a vision of the service by focusing on the essential elements that are exposed on the 6 sides of the box. Each side answers a question in an illustrated synthetic form: what? how? how? who? with what values? for what results? Each group must then define a set of features that allow the objectives to be achieved. These objectives are then prioritized using a "buy a feature" [56] workshop. During this game, each participant has a budget (materialized in the form of fake money). Each feature is assigned a price or threshold from which it will be selected. Bids are made on two rounds with an open discussion between the two rounds where everyone can express the reasons why they have selected or not a feature. This step allows to define and refine the critical functionalities of the service. The next two workshops are dedicated to making the prototype with a wireframing tool, then to tests with users. A final workshop allows to work on the business model with the popular Business Model Canvas [57]. Each group then presents the service proposal it has developed and analyses the results of the user tests.

At the end of the spring semester 2019, students completed an evaluation questionnaire consisting of three questions: what worked, what should be improved and suggestions. In

terms of what had worked, there was general agreement with the approach, with the main positive points being that it had worked well:

- The division at each session between theory (20%) and immediate practice (80%).
- A concrete project carried out from start to finish.
- Varied and progressive workshops with a common thread/red thread.
- Group work with the need to be organized in order to function.
- The process of group co-construction: starting from vague ideas which are progressively refined to arrive at a prototype that can be used by users for evaluation.
- The disciplinary mix/heterogeneity of groups.

Negative points and proposals for improvement concern only technical and practical organizational aspects.

3.2 FacLab

The idea of an academic FabLab has emerged over the years with the development of the service innovation laboratory. Initially in the form of the need for a permanent space dedicated to the laboratory, a space organized in an adapted and open way that is essential with the Design Thinking approach. The classrooms and seminar rooms available at the University are not designed for this purpose and are difficult to arrange at each laboratory session. The need for space has also been felt through the prototyping process, which requires equipment to produce artefacts and prototypes and to be able to preserve the productions produced. In a second step, the need for this space also emerged with the generalization of the Design Thinking approach, for example through the organization of hackathons. Hence the need for a space that is continuously open and available to accommodate residencies that can address all disciplines and fields of the University and "mix" them in a transdisciplinary approach. The FacLab was then built over two successive hackathons. At each hackathon a call for participation was sent to all audiences inside and also outside the University. The first hackathon named “Draw me a FacLab” resulted in a manifesto that validated the value of creating a FabLab within the University and defined its principles. Following this first hackathon, the FacLab was symbolically installed in a teacher's office and then in a library office. Subsequently, the FacLab was integrated into the University's digital strategy plan, which provided it with institutional support, resulting in the allocation of the premises of a former 370 sq. m. cafeteria. The second hackathon was held on the theme "Hack the FacLab" and took place over several days when we were able to take possession of the allocated space in the old cafeteria. This made it possible to define the layout of the space, define what an academic FabLab can be, define how the FacLab works and its economic model. The FacLab now hosts the service innovation laboratory, as well as brainstorms, and hackathons. A low budget version 1.0 of the "maker" space was set up with a vinyl cutting machine, 3D printer, milling machine, and laser cutter. Manufacturing awareness workshops for schools have started and training sessions of the different machines are taking place regularly.

One observation that emerges from the students' feedback during the service innovation laboratory or other similar activities concerns the integration of these open time slots within a "standard" curriculum. A gap is created between the two, which amounts to requiring students to be creative and innovative on commission when all their previous training and the rest of their current training has not trained them in this type of method. This observation raises the question of the integration, particularly pedagogical, of spaces such as FabLabs or makerspaces within higher education institutions.

4 Conclusion and future work

The idea here is not to argue that what has been done in the past is wrong and should be discarded, and that new approaches are ideal and will solve everything. Rather, it is a question of taking into account recent approaches that will undoubtedly make it possible to complete the existing system and, above all, to better connect the inside of the education system with the outside world, the formal and the informal. The combination of DT and making / fabrication makes it possible to implement pedagogical approaches that are complementary to current approaches that are very similar to problem-based and challenge-based learning (PBL, CBL). DT provides a framework that structures the process leading to making. Making provides support for the prototyping phase of DT. The whole offers an interdisciplinary and collaborative practice space. It also proposes a possible solution to the question of the development of digital skills by allowing this space to be opened up in a transversal way to any discipline.

The value proposition of a FacLab in the context of higher education could be seen as a systemic disrupter. In fact, introducing a FabLab in an academic environment challenges many of its long-established paradigms valuing collaboration, openness, interdisciplinary work, rapid prototyping, trial and error, etc. Therefore, the success of the FacLab could be measured by its ability to go from a potential to an actual disruption, for example by enabling new way to teach, learn and do research. To this end, the exploratory dimension in which the FacLab is grounded through making, exploring and prototyping represents a true paradigm shift we think holds tremendous potential. FabLabs and academia are not opposed, they are highly complementary to the point we think their combination represents much more than just a juxtaposition.

FabLabs are often seen as holding potential to support innovation. Similarly, we expect the FacLab to bear a comparable advantage for the three core traditional missions of universities: teaching, research and service to the city. Moreover, it also represents an additional collaboration entry-point for companies and civil society for joint work and even acting as a third place between students, researchers and the industry.

One particular challenge for the FacLab as an academic FabLab immersed in an academic environment, is to find ways to articulate the existing teaching practices with new approaches. The maker approach makes it possible to propose a solution to the following problem: should digital skills be introduced transversely into the curriculum or should one or more specific courses be dedicated to them? The answer here is to propose a specific open space in which transversal issues can be brought and addressed.

Other challenges include the need to set up mechanisms that allow the same actors (teachers and learners) to navigate without risks or constraints between the formal institutional framework of academic education that will continue and the informal framework of FacLab. Another challenge concerns the obvious contradiction between a curriculum-based and highly goal-oriented scholar context and an experiment-based and highly explorative fabrication culture [55]. A midterm direction could be the setup of a Bachelor in Fabrication. In the meantime, we are currently designing a continuous education program on “fabrication of the intangible”.

One of the next directions of evolution of the FacLab will be the development of knowledge and skills management processes to ensure the sustainability of the knowledge and skills developed over time. The knowledge and skills developed are seen as common goods that need to be shared and mutualized. It is therefore necessary to document them in a form that allows each participant to appropriate and develop them. Another direction is to develop the FacLab as a physical and virtual space and to allow a flexible integration between the two. Finally, it is a question of promoting reproducibility by setting up a FacLab kit that allows any institution or organization to develop and install its own FacLab

and to develop a network of sister FacLabs allowing each body to share its assets of knowledge, skills and experience with the rest of the network. We are currently prototyping this in Italy and have plans for other countries.

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