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New paradigm in design-manufacturing 3D's chain for training. Case of design and manufacturing in a « Fab Lab for education »



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Keyword : 3D Printing, design, manufacturing, learning process, training

Resume : We propose in this paper to show the impact of 3D Printing technology on design activity and to understand the main differences between designing a part with traditional technology and with the support of a Fablab's.

1 Introduction

"The developement and use of « Fablabs » have increased tremendously over the last few years. A lot of Scientific and technological Institutions have implemented the use of Fablabs. If 'Fablab' quarantees a technical prototyping platform for interesting innovations and inventions then the 'design process' of this structure warrants an urgent attention. The integration of 3D printing technology has been greatly constrained by the production capacity due to its design process. Similarly, teachers are faced with a challenge with the theoretical aspect of the product design process. A risk of accelerated loss of skills of future generations to understand all phases of product development exists. This poses a risk for future generations to fully understand all the phases of the product development. In this renewed acceleration of the transition from idea to realization of the object, we will try to show how greatly impacts of the mental processes are very pregnants in prior to the artifacts conception. In making a quick transition from theory to finished product, we will try to show the great impacts of mental processes leading to these finished

products. It's appeared relevant for us to ask some essential questions when a real industrial revolution arrives It appears relevant for us to ask essential questions when a real industrial revolution unveils. Like always, innovators jostle our certainties and the major and potential users watch unfold technology progress asking himself more or less some questions about essential changes that they impose and involve. As always, innovators jostle for our certainties while major and potential users watch the technologies involved in the making unfold without inquiring about the processes that are involved in the making of the new products. The Fab Academy is a Digital Fabrication Program like Neil Gershenfeld (1) has described it. The Fab Academy is a Digital Fabrication Program, as Neil Gershenfeld(1) described it :

For education, a fablab proposes an advanced digital fabrication for students and access to technological tools and resources. For education, a fablab offers an advanced digital fabrication for students and provides access to technological tools and resources. We have developed at ESPE Aquitaine the necessary rapid prototyping facilities. We have developed at ESPE Aquitaine the necessary prototyping facilities. In our teaching in technology (design and manufacturing artifacts), we arrive to ask ourselves three questions that we seems today more matures for asking some more and more others. In our teaching in technology (design and manufacturing artifacts), there are three questions that we need to ask ourselves and others

The simple question is : How to build an object with a part very simple, coming from a simple solution, in an minimal time? The simple question is : How do you build an object from very simple materials in a minimal amount of time ? The interest of this approach is that each students in his Fablab is a part of a globalized FabLab. The interestinmg aspect of this approach is that each student in this Fablab is part of a globalized Fablab. The local branches of FabLab work with other participating FabLabs and experts around the world via a distributed educational model where we pool our common knowledge to provide a unique, but mutual educational experience. . Our students (budding designer) are in connection with other Fablabs around the world and can upload on their parts server (2) and can observe all parts that have been designed by others. For example, we can connect our proposition with the Fablab CCSti (3) and other Fablabs in the world. (4). Tout ceci est théoriquement en place et potentiellement opérationnel. However, if this system is working today, the point of interest is that we can engage our students in a

collaborative design process. With this approach we can describe the thinking process that is involved when students design and build each part of the product. We propose in this paper to show the impact of this new technology on design activity and to understand the main differences between designing a part with traditional technology and with the support of a Fablab's. We also study the impact on design education.

2 An accelerating revolution.

A new context is identify in Figure 1 by (Koren, 2010)

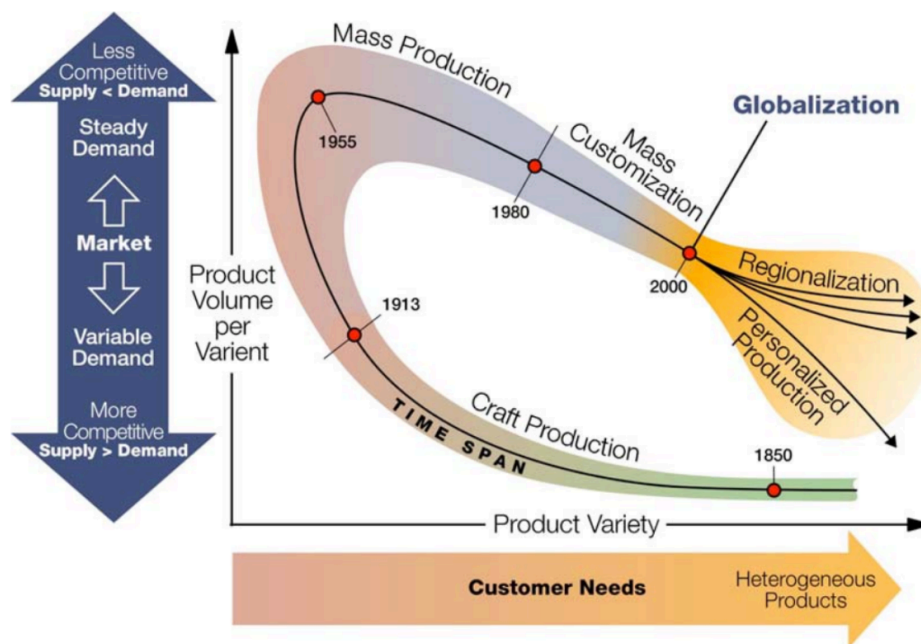


Figure 1 : Evolution of paradigm in manufacturing (Koren, 10)

In september 2013, Snecma General Electric has integrated the first fuel injectors printers with 3D prints. Some time later, NASA did the same with its rocket engines.. The same year, the A350 does itsfirst flight with structured parts created with 3D printer. The 3D printing principle is based on what we call the additive fabrication. The principle is relatively simple: Create part, sometimes with complex shapes, by successive of materials layers, then have it created with volumic designer.

Saving file using a STL format allows the e printing machine to store all data to build the parts correctly. Today, the first mechanical parts made of steel are on market. The use of titanium and super 'alloy steel' has given way to a new revolution

of product development. The last question that needs an answer to is the acceptable technology maturity level (RTL: Technology Readiness Level)

These are some benefits of 3D printing:

1. mass gain of 25 to 60 per cent according to applications,
2. one mechanical part integrating multiple functions ,
3. Permission of technologic maturity level, TRL7

One of the obvious benefits is its substantial compression of design cycles. The machinery is directly modified in its design phase because it's the 3D printing who permit parts manufacturing. (maybe several in one single printing).

The additive fabrication allows one to visualise the design process. Indeed these allow realization of design solutions and unsuspected potentiality given that the designer from the principal constrains of manufacturing.

3 Limitations in learning of design process of parts

In the previous introduction, we focused on accelerating design process. This acceleration although is in line with the paradigm shift from the thinking design to manufacturing, it limits the designers' conception of the processes that are involved in the design.

We have identified three major questions which disturb the design principles of our students: These are functional specifications compliance, impact of the assembling on design, impact of manufacturing on design.

We have chosen to illustrate our paper, with an example. This exercise has been submitted to our students during the primary phases of questioning around this radical posture changing. Design a machine with a rotating shaft supported by ball bearings. This proposition impose two essential things. Dimensioning of parts and the possibilities of mounting one part with the others. Firstly the 3D design disturbs our certainties: What are the geometric specifications that we have to give for the parts to position themselves correctly with the other parts and that they perform their functions correctly. The files transferred after design in manufacturing process of 3D additive disturbs again our perceptions.

We propose to show how S2i's students (S2i: Industry science) are led to re-evaluate their knowledge about conventional design phases (Assembling of a pivot connection with conventional mounting of ball bearing). They are to understand some

different kinds of design phases. (development of a pivot connection by 3D printing prohibiting the assembly and disassembly). They are to analyse the design phases by a 3D virtual modeler for a conventional assembly and then the design phases by a 3D virtual modeler destined to a 3D printing.

We show the differences and similarities of the different phases of design by developing a comparison matrix.

3.1 Question 1: compliance with functional and dimensional specification

The first question is about the the transfer of dimensional specifications in manufacturing process. We submitted some questions about designing in digital manufacturing processes. Indeed, the technological specifications and dimensional specifications from functional specifications of parts (technical performance guarantee, for example, guiding quality in rotation) are constrained only by the capacity and quality of manufacturing system which builds them. The adjustment between parts in assembling have always a sense or not? The nominal dimension that we use, seems today only the workable references. How do you think a a rotating shaft, $\varnothing 40 H7g6$, would fit in a bore? Indeed, it's not possible to identify in a 3D software, a dimensional tolerance on parts volume. This means that the quality of guiding in rotation which is normally guaranteed by the adjustment i can not be modeled in the 3D software. Gradually, we see a very significant risk: the loss of technological knowledge by young designers. Independently by the operational control of a software 3D.

3.2 Question 2: impact of assembling in design

The additive manufacturing is also involved in this transformation of the relevance of the dimensional specifications from the design phase. We can consider the design of assembling bearings. We have taken into account only the specific points in its design.

Step 1: Identification of critical points in the development of the technical solution.

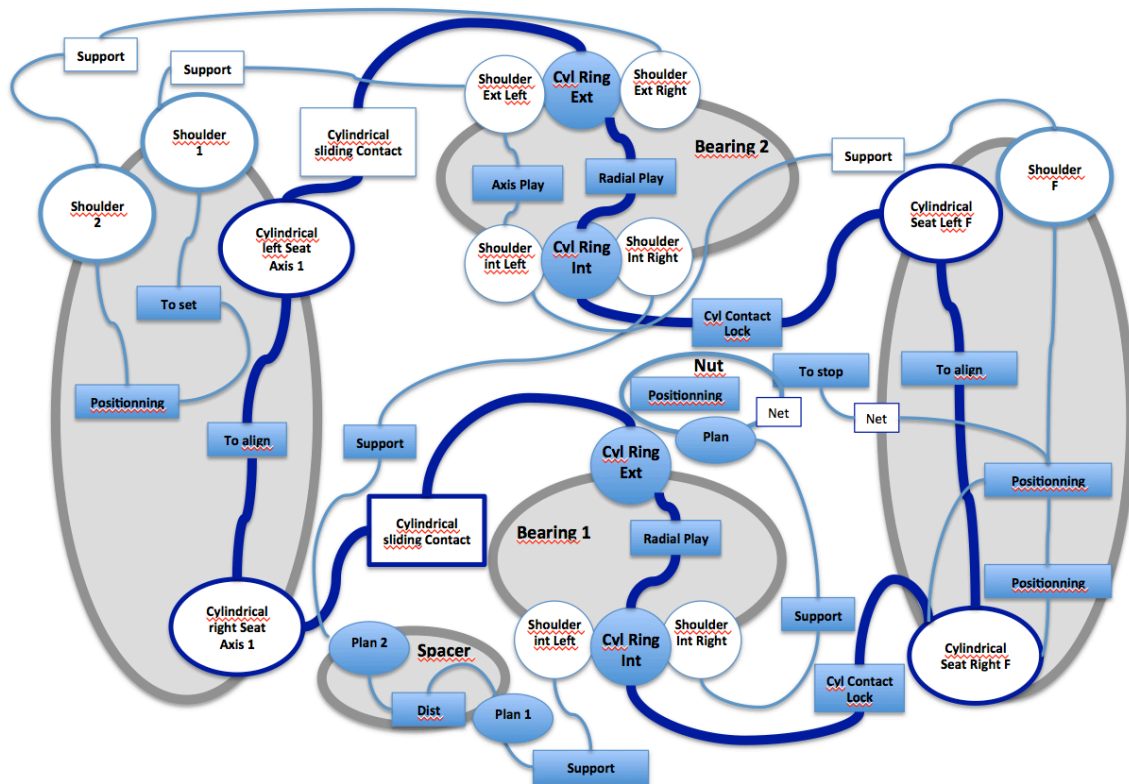


Figure 2 : Functional , structural and dimensional analysis

Step 2 : Emergence of design invariants and the functional surfaces to be considered in further process. It appears that some surfaces exist only because we need to add a nut and locking washers and only for assembling reasons.

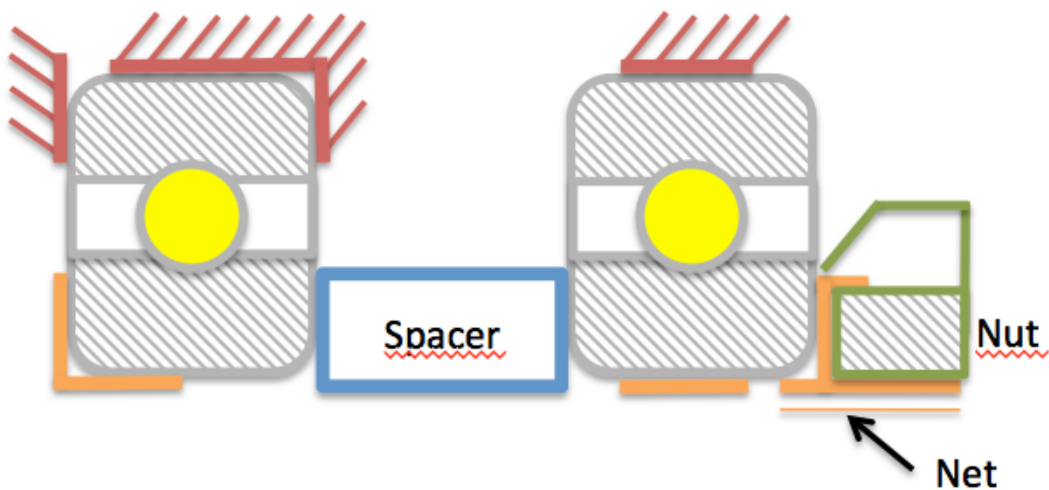


Figure 3 : Result after theoretic analysis

Etape 3 : Proposed result by a designer with 3D software help

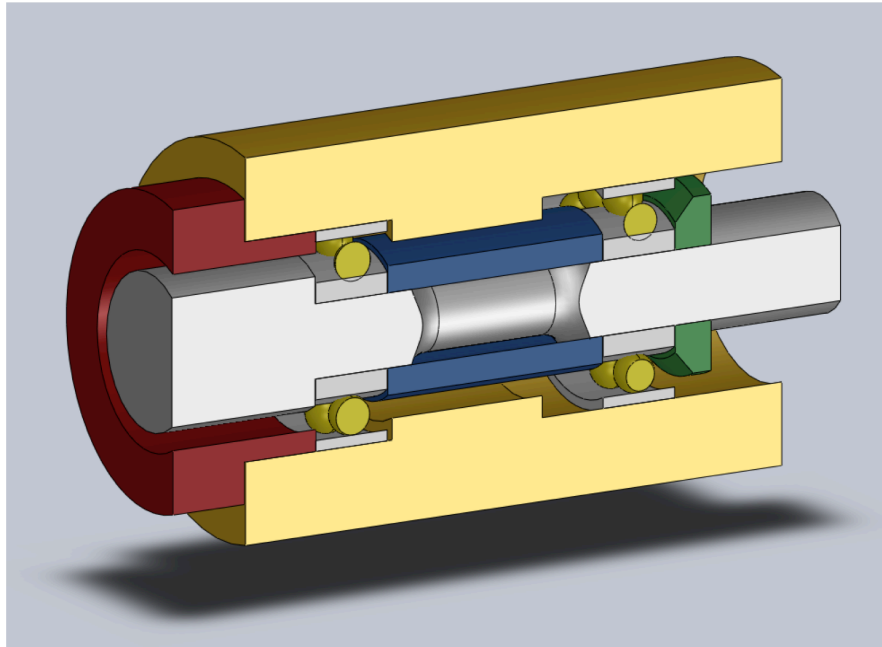


Figure 4 : Résultat après intégration dans modèleur volumique

only the surfaces with an impact are a right response to design problem seen. The others surfaces are only there for force transmission, assembling, and manufacturing constraints, ... The acceleration of design process by digital will be able to find best perennial solution and the best efficiency solution.

To achieve this design, not only the last analysis is relevant but also the dimensional specifications. All parts are assembled with each others correctly.

3.3 Question 3 : impact of manufacturing on design

The third interrogation turns around the design and assembling of the different parts of mechanism. The proposition of technical solution in Figure 4 came from 3D solver. It can be injected on 3D machine (manufacturing additive). But in this case, if we don't modify the shape, the reality, their appearance, the costs could be very high, but with a poor quality design.

In future, the possibility to manufacture with a 3D printer will place a great demand on the the assembly system, which, in turn will call for the strategy to be altered. we could imagine that the parts that maintain the bearing on shaft could be directly builds by a 3D printer. We could merge all parts in one single step.

We propose to modelize this new concept of new possibilities in Figure 5, where we propose to add a technological solution matrix, the new performances of manufacturing additive. We name this new typology : integrative or non integrative specifications. Our modelization 3DPL is based on (Ponche, 2013)

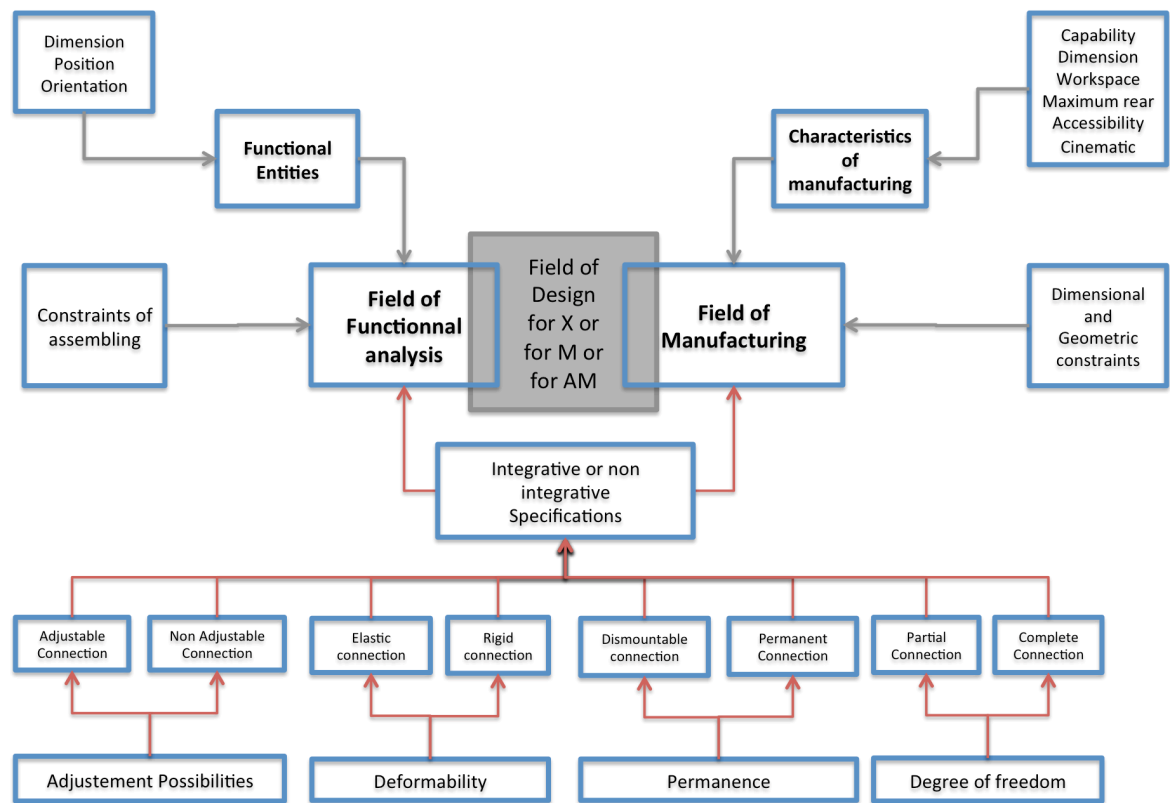


Figure 5 : 3D printing model for learning, 3DPL

4 Conclusion

Today, the issue for teachers and researcher of design is to modelize the new design process. This new design process of integrating new possibilities where design and manufacturing are completely mixed. Conclusion

We hope to demonstrate that major differences exist in the conventional design for a classical assembling and a new design for 3D printing and finally an unconventional design. A Comparison matrix of technological solutions adopted for one or other solution shows the strengths and weaknesses of different ways of thinking.

A new way of thinking appeared. This would be good for our students to address some problems and exploit the full potential of 3D printing.

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