PEGASO
Università Telematica

STARTUPtoEU - Storytelling Ancient Roman Traces Up to Europe

N. 2018-1-IT02-KA201-048538

DOING BUSINESS IN THE CULTURAL HERITAGE SECTOR

A guide to start your business employing 3D printing technology

Co-funded by the
Erasmus+ Programme
of the European Union

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Acknowledgements:

I would like to express my very great appreciation to Prof. Stefania Febbraro for the information provided in the drafting of the questionnaire and Dr. Rosario Elia (3DnA S.r.l.) and Dr. Francesco Di Bennardo (Enclopius Edizioni Sas - Museum Shop) for the valuable and constructive suggestions coming from the case studies reported in the last section of this document.

Publication:

This publication was prepared within the framework of the ST.A.R.T.UPtoEU (STorytelling, Ancient Roman Traces up to Europe) project N. 2018-1-IT02-KA201-048538

Published by Pegaso Online University, 2021

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1. Introduction

The European Commission has always paid great attention to the theme of digitization of Cultural heritage and, more generally speaking, to the application of new technologies in this field. Accordingly, the European Commission has issued, since 2011, several recommendations on this topic, such as the "Recommendation on digitization and online accessibility and digital preservation of cultural material" and the "New European Agenda for Culture", aiming at assisting European states in developing strategies and improve the digitalization of their cultural heritage. Furthermore, promoting solutions that make cultural heritage accessible to all, including digital means, was also one of the objectives of the European Year of Cultural heritage (2018) and of the related European Framework for Action on Cultural heritage, which "aimed to capture and scale-up the success of the European Year of Cultural heritage, encouraging more people to discover and engage with Europe's cultural heritage and to reinforce the sense of belonging to a common European space" (https://ec.europa.eu/culture).

More recently (2019), in line with these objectives, 30 European countries (Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Estonia, Finland, France, Greece, Hungary, Italy, Ireland, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and United Kingdom) signed the "Declaration of cooperation on advancing digitization of cultural heritage", with the objective of working together to better use digital technologies in the field of Cultural heritage and aiming at enhancing its use and visibility, improving citizen engagement, and supporting spillovers in other sectors (https://digital-strategy.ec.europa.eu).

Among the aspects addressed in the "Declaration of cooperation on advancing digitization of cultural heritage", the European Commission's Expert Group on Digital Cultural heritage and Europeana (DCHE Expert Group) contributed to the development of guidelines for comprehensive, holistic documentation of European 3D cultural heritage assets. As part of this contribution, a list of basic principles and tips for 3D digitization of tangible cultural heritage was drawn up. These basic principles are mainly tips for professionals, institutions, and other custodians of tangible cultural heritage (including local and regional authorities) who are in charge of managing cultural heritage buildings, monuments, or sites and do not have any experience with 3D digitization. The list of the aforementioned basic principles is reported below:

1. Consider the value of and need for 3D digitization
2. Select what to digitize and for what use cases or user groups
3. Decide whether to digitize in-house or outsource
4. Clarify copyright aspects and plan for open and broad access
5. Determine the minimum quality needed, but aim for the highest affordable
6. Identify the different versions and formats needed for the different use cases targeted
7. Plan for long-term preservation of all data acquired
8. Use the right equipment, methods and workflows
9. Protect the assets both during and after digitization
10. Invest in knowledge of 3D technologies, processes and content

Together with the described priority of safeguarding and, at the same time, valorize and exploit the European Cultural heritage through digital means, the European Union has set as a strategic objective to enhance creativity and innovation, including entrepreneurship at all levels of education and training

(Council of the European Union, 2009) in order to raise competitiveness and employability of young European citizens.

Indeed, European economy requires citizens, and particularly young people, to be innovative, creative and flexible in order to face the challenges given by the modern dynamic and volatile economy and to take advantage of the opportunities that arise from new technologies. Entrepreneurs, in this context, play an important role in the economic and social well-being of European citizens (European Commission, 2015) and, therefore, the development of the entrepreneurial capacity of European students is one of the key policy objectives of the Member States (https://ec.europa.eu/social).

According to these two aforementioned priorities, the ST.A.R.T.UPtoEU (STorytelling, Ancient Roman Traces up to Europe) project aims at recovering the common identity of partner countries (once Roman provinces and now European members) and to develop the social and educational value of European Cultural heritage in the digital era, in order to promote innovative practices and entrepreneurial education with an intercultural and holistic approach. More in details, the project aims to join together the digital transformation in the Cultural heritage with the need of an innovative and sustainable entrepreneurship, supporting youngers, since their school age, in developing their entrepreneurial mindset, also when approaching to the unique and extraordinary European Cultural heritage.

In line with the mentioned project purposes, this document aims to provide school students with a simple tool to familiarize with the entrepreneurship in the Cultural heritage sector. More in details, since the digitalization of the Cultural heritage is a relevant pillar of the project, the guide will address its objective with a particular focus on the entrepreneurial opportunities given by the 3D printing technology with a particular focus on merchandizing activities.

The reminder of the documents is organized as follows:

- Section 2 introduce the 3D printing technology and processes.
- Section 3 Analyzes its applications in the field of Cultural heritage.
- Section 4 is dedicated to the Business Model Canvas and to its general structure and figures to synthetize a business idea.
- Section 5 is devoted to the hypothetic business model of a new venture which aims at producing and selling Cultural heritage gadgets using 3D printing technology.
- Section 6 aims at providing a practical vision of the topic, through the analysis of two very different entrepreneurial activities (a museum shop and a big digital company), both helpful to in-depth address the business of 3D printing in the Cultural heritage and its future pathways (the interview protocol has been reported in the Appendix of the document, after the reference list).
- The Last section concludes.

2. 3D printing technology and processes

3D printing technology, also known as 3D stereoscopic printing, was developed in the mid '90s by the Massachusetts Institute of Technology in USA. It can be defined as the manufacturing of 3D products, using various materials, starting from a digital file (that may or not originate from a scanning process) and through a computer aided design (CAD) optimization (Basic et al., 2018).

At the beginning, 3D printing technology was mainly used for prototyping in the fields of mold manufacturing and industrial design, but today, 3D printing has gradually expanded and has changed both its applications and sectors in which it is used. Indeed, it is employed in several industries, such as, for examples, the automotive, the aerospace, the architecture and medicine ones, both for prototyping and to generate replicas of original pieces.

3D printing technology uses photocurrent and paper lamination technology to produce objects by printing them, layer by layer, with powdery materials, such as metal or plastic, through digital technology material printer. In the printing process, unless you wish to replicate an existing object that may need a scanning process, the first step is computer and software modeling, then it involves the slicing of the 3D model, which can be printed after exporting it in the file format that fits the 3D printer.

Scanning technique and technologies

As aforementioned, if you wish to replicate an existing object, the first phase of 3D printing process involves the scanning of the original piece. The acquisition of 3D digital data has a major impact on the accuracy of the final object, for this reason it is considered a critical step for the entire process (Greggio, 2017).

The different methods of image acquisition are mainly based on different types of sensors that have some fundamental distinguish properties:

- Quality: The accuracy of the sensor will have substantial effects on the fidelity of the final replica to the original. It fundamentally lies in three main characteristics: resolution, accuracy, measurements and environmental sensitivity.
- Portability. Constraints such as lack of electricity and local accessibility are common problems.
- Acquisition time. Devices with faster acquisition times are preferable.
- Flexibility. Objects are of variable sizes, materials and types. The sensor used should be able to range as much as possible between these characteristics.
- Price. The cost of the sensor can vary considerably depending on the aforementioned characteristics.

Scanning acquisition techniques can be divided into passive and active.

Passive techniques are generally easier to use, but often they do not assure accurate results because they highly depend on the light of the surrounding environment. Photogrammetry is the most widely used technique and consists of building the 3D model from images obtained from calibrated cameras.

Active techniques sensors use an emitting light system which is used to highlight surface structures and details. For this reason, they are not recommended for imaging glass or metal objects that may need a prelaminar process which includes covering the surface of the object with powders with

reflective properties. Active techniques are mainly based on two different approaches, images triangulation and reflecting time. The triangulation-based devices, basically, identifies the position of the projected reticle and calculates the information through a simple triangulation. These systems are suitable for the digitization of small to medium-sized objects. Time-of-flight-based devices, on the other hand, digitize an object by measuring the time that passes from the incident of the laser ray on the surface of the object to its reflection. This technology can produce high resolution digital images of large buildings or open spaces.

In any case, it is not possible that a single set of images is enough for the complete digitization of an object. Indeed, to obtain a high-quality three-dimensional model, we need many images from different points of view that, afterwards, need to be joined together during a process that is called "image registration" or "alignment" ("pairwise alignment", where each image is grouped two by two, is the most commonly used process, in this sense). The last phase is the optimization one, that is considered very important for the faithful reproduction of an object and includes the elimination of outliers and the refinement of areas not perfectly shown in the image (the so called "holes").

The last phase includes the definition of the scale in which we wish to reproduce the object and, finally, the elaboration of the final three-dimensional model that can be passed to the appropriate printer according to the desired characteristics of the output we wish to obtain.

Printing techniques and technologies

Once an adequate digital shape of the object that we want to produce has been prepared (whether the result of a scanning process or an independent digital creation) in a format that is suitable to be received by the 3D printer, we can pass to the next step and print it.

3D printing techniques can be divided into two broad categories: those that are based on subtractive processes, which to date refer mainly to CNC (Computer Numerically Controlled) instruments and those that refer to additive processes (Greggio, 2017).

- Subtractive techniques

The term subtractive refers to methods based on the concept of producing objects by removing material from a single block, through a Computerized Milling Machine (CMM).

The main advantage of this type of production is the wide variety of materials that can be used, including wood, stone and metals. Unfortunately, these machines have a considerable number of geometrical and kinetic constraints, mainly due to the engraving's limitations given by the arm that, rotating, sculpt the object. Due to these complex movements of these machines, they are often costly and time consuming.

- Addictive techniques

Unlike the subtractive technologies explained above, additive technologies, developed in the last decade, do not involve extraction from a single block but by adding material (melting a thin filament of plastic or some other material) layer upon layer. There are different types of addictive 3D printing technologies on the market that differ depending on both the process and used the materials (Du, 2020):

- FDM (Fused Deposition Modeling), with its main materials as ABS and PLA.
- SLA (Stereo Lithography Apparatus), with its main material as photosensitive resin.
- 3DP (3-Dimension Printing), with its main material as powdered material, such as ceramic powder, metal powder and plastic powder.
- SLS (Selected Laser Sintering), with its main material as powdered material.
- LOM (Laminated Object Manufacturing), with its main material as paper, metal film and plastic film.
- DLP (Digital Light Processing), with its main material as liquid resin.
- FFF (Fused Filament Fabrication), with its main materials as PLA and ABS.
- EMB (Electron Beam Melting), with its main material as titanium alloy.

As far as the application to the Cultural heritage is concerned, in the following table we synthetize some of the most relevant characteristics of the mostly used aforementioned technologies (Greggio, 2017).

Technique	Cost	Usability	Flexibility	Adequacy for Cultural Heritage	Accuracy
Subtractive	Low/Medium	Low	Low	High	High
FDM	Very low	Medium/High	Medium	Very Low	Medium/High
LOM	Medium	Medium	Low	High	Medium
SLS	Very High	Medium	Medium/High	High	Medium/High
Photopolymerization	High	Medium/High	Medium	Low	Very High

3. Applications in the Cultural heritage sector

3D printing technology can be very useful in the field of Cultural heritage, because, unlike the traditional approach which requires the production of rubber molds to be applied manually on the original artefact (with the risk of ruining it) and then create resin copies (necessarily in a 1:1 scale), 3D printing gets a better and customized result in a much more flexible and less invasive way, allowing to obtain copies of the artifact (or a part of it) in any scale, automatically and at a more affordable cost.

The application of these technology and processes to the Cultural heritage sector steams from an ongoing shifting from the traditional Cultural heritage approach, towards a multi-layered and multi-sensorial experience, winch involves new ways of interaction with ancient artifacts. This interaction can be achieved in multiple ways that are not limited to the field of knowledge (including restoration) but also to the economic exploitation of the Cultural heritage (Ballarin et al., 2018).

Replicas can be used in many ways (Balletti et al., 2017):

- to set up alternative museum exhibitions, such as tactile museum tours (for blind and visually impaired persons).
- to temporary or permanently substitute the originals and to produce a perfectly fitting packaging for ancient artefacts.
- for education, experimentation, study and research.
- for restoration, re-creating missing portions of an object.
- for merchandising (producing, with cheap reproduction technologies, accurate small-scale replicas of the artworks conserved in museums or in a Cultural heritage Institution or freely inspired gadget not coming from the scanning of an artifact).

Below we will briefly analyze these applications in order to provide a comprehensive understanding about the possibilities given by 3D printing technology in the Cultural Heritage sector.

Tactile pathways for blind person

Three-dimensional printing can be very useful in helping blind people to enrich their cultural experience of sculptures, and artistic artifacts in general, through touch, avoiding a direct touch of the original. Even though original three-dimensional objects are more intuitively appropriate to be replicated for these purposes, 3D printing of paintings and photographs can also be made to provide visual support to blind persons (Greggio, 2017).

Temporary or permanent substitution of the original and production of packaging suitable for transporting artifacts

A tangible copy, printed with 3D technologies, can take the place of a given artifact that, for a variety of reasons, must be removed from its original environment. Replacement can be limited in time, such

as because of a loan for a temporary exhibition, or permanent (removal of a statue from its location to protect it from environmental degradation). By substituting it, the visitor can still appreciate the ancient Cultural heritage in the location for which it was designed and created and, at the same time, the original will be preserved and protected. If an artifact is requested for a temporary exhibition, the museum may also choose to lend a copy of the artefact in order to drastically reduce the purely practical and economic problems of transportation. For these purposes, another important 3D printing application to the Cultural heritage is related to the creation of customized packaging (or support structures) for the storage, transportation or display of fragile artifacts. There are, indeed, important risks involved in handling objects of great cultural value, mostly related to the difficulties and errors during the manual process of production of these supports. Computerized process that takes its cue from the 3D digital model can result in a customized automatically support structure that may be more suitable for the preservation of the object (Greggio, 2017).

Education and experimentation in museums

The relationship between ancient and modern is now a defining element of education when it comes to Cultural heritage. In the past two decades, museums have seen substantial changes in terms of technology application, which has been used to represent ancient artefacts in new ways, thus providing the creation of high-quality digital heritage experience. Adopting new technologies can contribute to open new paths for exploration and exploitation of the Cultural heritage improving the communicability and the fruition of it, through a new reading tool. The final purpose of integrating technology in the Cultural heritage domain is to provide a multi-level and multi-sensory experience that, nowadays, involves touch, smell and haring as well as sight. Studies in the field of cognitive psychology and neuroscience, indeed, demonstrate that the learning experience is basically multisensorial, thus changing the traditional paradigm of education and moving it to the so called “situated learning” which is deeply dependent on the context that surround us and our senses (Balletti & Ballarin, 2019). The availability of an excellent quality of three-dimensional copies, in line with this ambition, can be used for educational purposes during visits, while preserving the originals. This possibility can provide a multi-sensory access to objects that cannot be touched, either for preservation or because they are too big or too small to be understood properly. 3D Printing can thus play a crucial role in the education, when it comes to cultural heritage, both in classrooms and in the museum context, having the potential to become a standard technology for exhibition design and educational efforts (Neumüller et al., 2014).

Study and research

In the field of study and research, technology, in general (and 3D printing in particular), is consistently helping in obtaining meaningful insights. The advantage of employing these techniques for research purposes lies in the possibility to study ascent object and artefacts without physically touching them and without subtracting them to visitors. In some cases, 3D printing can also be the only way to study certain artefacts that, for example, cannot be exposed to lights. An example of activities in this direction can be the one, for instance, conducted by the Redpath Museum in Montreal where 3D

models of three Egyptian busts were reproduced by scanning the mummies using echography and equipment generally used for medical purposes.

Restoration

Three-dimensional printing technology can also contribute to the restoration of the Cultural heritage. Many sculptures and monuments, indeed, have essential missing parts which can be replaced by artificial copies in order to give to the public an idea of what the original shape looked like. Moreover, digital copies can also be exploited before the restoring intervention on the original artefacts, by providing a copy to be studied and treated as drafts, thus eliminating useless invasive procedures and reducing any risk (Greggio, 2017).

Merchandizing

The last, and to the purpose of this guide, more relevant exploitation that can be made of the 3D printing technology in the field of Cultural heritage, deals with the production of gadget and, generally speaking, to economic exploitation. Indeed, in the past 30 years we've witnessed an extension of the function of the Cultural heritage management moving from and exclusively education purpose to a broader one, that includes the commercial purpose. Museums are now seen by visitors as an experience that includes not only the exhibition, but also the shopping environment, that deals with products and services that can widely extend the visit. The shopping opportunities, in this sense, can act as a key tool in the dispersion of cultural knowledge and identity and, therefore, the increased commercial awareness has led to greater differentiation in the merchandise (Kent, 2010). In this line, also productive methods have been enriched and 3D technologies have been recently applied in the field of Cultural heritage merchandizing. Therefore, it is worth exploring the qualities of gadgets and souvenirs created through additive manufacturing and to analyze some possible issues coming from production and commercialization of these products.

- 3D printing souvenirs and gadget characteristics

3D-printed gadgets are neither mass-manufactured nor handmade. Rather, they can be customizable like handmade objects, but made through less handcrafted methods, as in mass-manufacturing (Nam et al., 2019). As highlighted by Du (2020) and by Anastasiadou & Vettese (2021), 3D printed gadgets and souvenirs have some strengths, mainly related to their reliability, creative process and customization.

A. Reliable (re)production

The first advantage consists in the possibility to reproduce in different scales the original shape of the ancient artifact with an extremely high precision and benefitting from the machines' ability to replicate it in quantities. This characteristic can preserve the artefact integrity and authenticity and therefore results in a value added that should be explained and shown to tourists in order to let them perceive

adequately the advantage given by the exploitation of this technology. If producers and sellers will be able to extensively transfer this value to the market, there are already evidence, in the museums' marketing research, that have highlighted the appreciation by the tourists and their willingness to pay more (premium price).

B. Creative productions

3D printing technology can be employed not only to reproduce original artifact with a high level of reliability (in the case of products coming from the scanned digital identity of the original artifact), but rather there is an enormous variety of products that can fabricated in order to provide tourists with a wide range of applications that certainly include home decor, but extend to include also, for example, refrigerator stickers or cookies cutter, freely inspired by the Cultural heritage shapes. Of course, this possibility may extend the Cultural heritage valorization and exploitation, which is certainly enriched by the different alternatives of use of the objects printed through 3D technology that leads to ensure the image diffusion of a given artifact.

C. Personalized production

3D printing technology to produce gadgets and souvenirs inspired by the Cultural heritage can be defined as new business opportunity that still needs to be deeply analyzed in order to define the consumption model and the degree of attention given by consumers. However, research in the field has already investigated, even in only a few case studies, the attractiveness of these products and mainly has evidenced that most relevant opportunity in this field can be given by personalization. With the support of 3D printing technology, a company (that may or may not be the museum bookshop located on site) can offer the opportunity to select the desired intangible cultural heritage image and, thanks to a computer software, adjust it to the different requirements of any given customers. In this way interactivity, memorial significance and fun can be integrated into a unique buying experience (Du, 2020). Despite the use of plastic materials (even if bioplastics ones strongly and positively affect the intention to buy, due to their capability to be environmentally friendly) and the exploitation of a mass-production technology, researchers found that the traditional view of the souvenir as a kitsch object was abandoned by tourist that re-evaluated souvenirs as non-static mediator of individuality, memory, sentiment and experience, thus favoring an enhanced connection to the heritage site. However, research in this field has still a lot to do, particularly addressing what appends to consumers' behavior and perceptions when gadget is not produced in-situ, but sold through an online channel and according to how different psychographic or generational characteristics affect preferences for different materials and perceptions of object authenticity (Anastasiadou & Vettese, 2021).

- 3D printing souvenirs and gadget issues

As mentioned by Du (2020) there are several problems that may affect production and selling of 3D printed object inspired by or scanned from original Cultural heritage artefacts, namely concerning the

popularization of technology, the cost of printing and the quantity of production. These main concerns are reported below together with an additional topic of interest that is related to property rights.

A. Popularization of technology

After many years of research and development, 3D printing technology has now reached the point where it can be highly diffused on the market. However, this process is still ongoing and at the present stage, 3D printing is still conceived as high-tech, difficult to use and expensive technology. This general view mainly leads to two problems. On one hand, as long as the demand and diffusion of this technology remains low, competition between manufacturers and therefore technology prices will also remain high. Additionally, a still underdeveloped diffusion of this technology leads to a relatively low appreciation of the artifacts made with this technology by the public, since tourists are not informed about the advantages in terms of reliability of reproductions compared to the standards historically adopted for the production of gadgets and souvenirs.

B. Cost of printing

Progresses in 3D printing technology are leading to a gradual reduction of materials costs. However, the most faithful reproductions of ancient artifacts, even in terms of visual impact, are made with materials that still have prohibitive costs (metal or ceramic) and 3D printers required to reproduce artifacts in these materials are also still very expensive. So, high value-added reproduction that can be sold at a higher price, still need technology to mature.

C. Production volumes

One of the main competitive advantages of 3D printing products may lie in customized services, which can result in personalized production of gadget in a relatively short time. However, personalization by 3D printing can certainly satisfy some consumers need, but sometimes it cannot fit visitors' schedule. In other word, since printing a customized 3D replica may need at least 20 minutes, this may not be consistent with tourists' programs. Even if some may say that tourist could order the souvenir before visiting the cultural site, this is not a typical behavior in the souvenir market, since, normally, it is expected that tourists buy the souvenir of the artifact after seeing the original. For these reasons 3D printing market in the Cultural heritage may suffer a problem related to production lenght, given that for a shop that is focused only on this production, volumes will hardly be able to cover fixed costs.

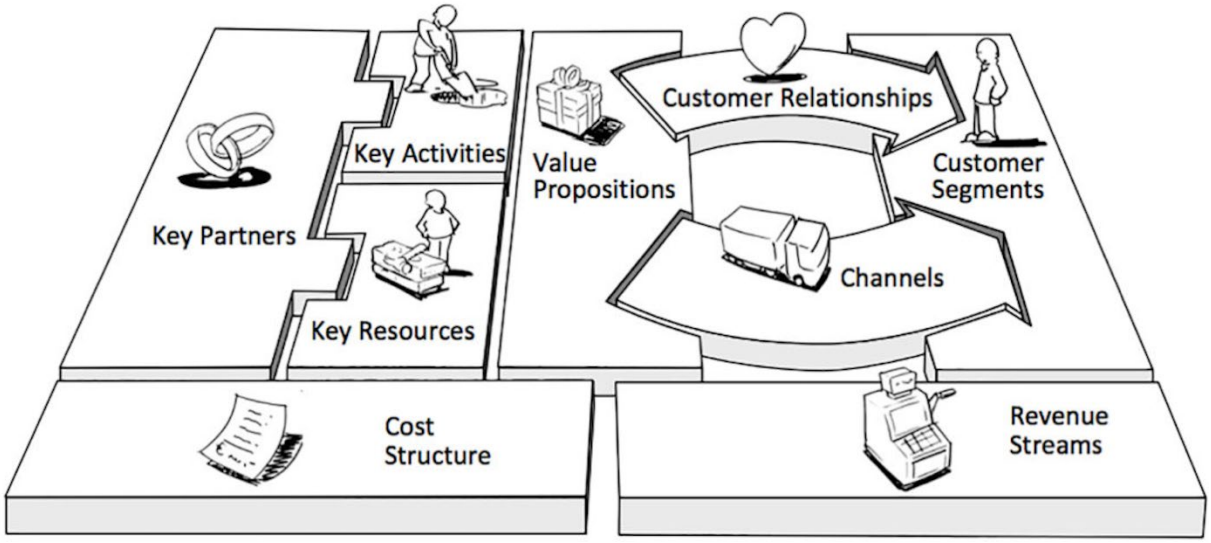
D. Property rights

The increasing use of 3D technologies in the Cultural heritage sector has significantly boosted the need to protect original artefacts. Make 3D scanned models widely available can indeed result in an abuse of the historical heritage, since the download of 3D digital models from the web (some museums provide this service to disseminate and promote their artefacts) can result in an illegal commercial utilization (Vasiljević et al., 2021). The issue concerning property rights is extremely hard to address

with reference to the entire European context, since each Member State has its own approach to the topic. In Italy, for example, there are four different possibilities in relation to if the Cultural heritage artefact has fallen into public domain or not and if it is placed inside or outdoor (in other words, if it is visible from the public soil, such as the Colosseum, for example). In case the artefact is of public domain and is placed inside (so is not visible from the public soil), the solution is easy, because it is expressly regulated by the Code of Cultural heritage, which establishes that "The Ministry, the regions and the other territorial public institutions can allow the reproduction as well as the instrumental use of the cultural assets they are administering". Concessionary fees and royalties, generally paid in advanced, connected to the reproduction of these cultural assets are determined by the public authority and are not due only in case of a strictly personal utilization or for research and study purposes. In case the artefact has not fallen into the public domain, but is, as in the previous case, located indoor, there is a significant variation because, in this case, on the artefact, that has not fallen into the public domain, the author or another owner (heirs, for instance) can still claim the rights on the commercial exploitation. This is the case of an artefact whose author is still alive or has not been dead since at least seventy years (given that, unless there are no official heirs, the artefact falls into the public domain after seventy years since the death of its author). There is, therefore, a discrepancy between how artefacts are protected by copyright law and those protected by the Code of Cultural heritage. In this latter hypothesis under consideration, for photos or videos that show artifacts that have not fallen into the public domain, it will be necessary, in any case, to apply to the public institution that holds them, in order to assess the existence of any licensing agreements, because it could be possible that the rights of economic exploitation of the artefact have been given by the author (or by his heirs) to the institution itself and that, therefore, royalties should be paid to that public institution and not to the author. There are two more possibilities that are not expressly regulated by Italian law and are both related to artefacts that are located outdoor. The first one is that of an artefact that falls into the public domain. Think, for example, as aforementioned, about the Colosseum, an architecture on which there are no copyrights. In this case, given the silence of the law, we may think that it should fall under the landscape right and therefore that no royalties should be paid for reproducing in 2D or 3D this artefact. However, by analyzing foreign laws, there are examples in the opposite direction (Egyptian State, for instance, wanted to impose royalties on photographs of pyramids). Lastly, when it comes to artefacts that are externally located and are not in the public domain, if we want to follow the ministerial indications, the same conclusions should also be applied in this case and artefacts should be reproduced without permission. Therefore, we may synthetically say that, in many countries, laws are not covering similar types of hypothetical, cyber-crimes and that the relationship between intellectual property and digitization has not been fully legally regulated (Vasiljević et al., 2021). Thus, a legislative intervention is needed, either at communitarian level or national one, in order to clarify what should be the behavior when it comes to the exploitation of Cultural heritage for commercial purposes (Corin, 2021).

4. The Business Model Canvas: a tool to briefly describe how a company creates, delivers and captures value

The objective of this section is to propose the essential elements for the description of a business model. Among several alternatives that would have possible solution to address this topic (the synthesis of a university strategic handbook would have turned out too voluminous and inappropriate for the purposes of the present document) it has been decided to propose the model described by the Business Model Canvas (Osterwalder & Pigneur, 2010), which effectively summarizes the essential elements for describing a business model in a quick, simple and visually appealing format. The Business Model Canvas (BMC), in order to obtain the result of describing the business model in a simple and effective way, without leaving out any main element of how a company is designed and managed, is developed on 9 building blocks as described in the following figure.



- Customer Segments

The first building block defines the different groups of clients the company wishes to reach and do business with. Without profitable customers, no company can easily develop and survive in the long run. Therefore, the first thing you should do when setting up your business is hypothesize who are going to be your possible clients and group them into different segments with common characteristics. These characteristics can be either personal characteristics (such as age, education, wealth and other) or common needs and behavior (if requires a distinct offer, if can be reached through different channels, have different profitability or willing to pay). Once the segments have been identified, the company must select which segment (one or more) is appropriate and which can be ignored. Then it will be possible to design the Business Model of our company, taking into due consideration the needs of the selected customer segments.

- Value Propositions

The second building block of the BMC deals with the identification of products and services that create value for a specific customer segment as above identified. This building block explains why customers may chose our company over others. Are we going to solve a particular problem in an innovative way? Are we going to satisfy a particular customer need that is not covered by others? Through our value proposition we explain how our unique bundle of services and products satisfy the need of a particular segment, therefore the value proposition can be somehow revolutionary/disruptive or similar to existing offers but characterized by additional features or attributes. In this sense, for example, customization, which comes from a sort of co-creation of the product/service, can represent a possible way to join together a tailormade approach with a mass production advantage, which is based on economies of scale. Furthermore, the design, the brand, the product accessibility or the price (giving the same value for a lower price can help targeting price sensitive segments) can be ways to create value for a given customer segment.

- Channels

Once customers have been identified and the value proposition has been described, we need to identify the way these two former building blocks can be somehow joined. In other words, we need to identify how communicate and reach customers to deliver them our value proposition. Communication and customers touch points are essential to address several objectives, such as: raising awareness about our products and services, making customer appropriately appreciate our value proposition, deliver the product and services to them and, finally, providing post-purchase support. When it comes to the different channel types, we can identify five different ways to reach clients: sales force, web sales, own stores, partners stores and wholesalers. Of course, these channels are different in terms of structure, degree of control and profitability because they can be directly managed by our company or somehow intermediated by our partners. Regardless the chosen channel, to target the single group of customers, it is necessary that the channel will be able to respond to different needs that chronologically can be distinguished in:

1. Awareness: how does the channel contributes to raise the awareness about our products and services?
2. Evaluation: how do we help customers to appreciate our value?
3. Purchase: how does the purchase process work?
4. Delivery: how do we deliver the product/service to the client?
5. Aftersales: how do we provide support after the acquisition process?

- Customer Relationships

This building blocks addresses the issue concerning how the company establishes relationships with its costumer segments. Of course, depending on the business, the relationship can range from personal to automated and from long-lasting to a single purchase activity. The main elements of this building block are represented by customer acquisition process, by the retention of acquired customers and, finally, by the upselling process. We can think about customer relationship as a nexus of different elements such as, for example, personal assistance, developing of communities (either online and offline ones), automated services or co-creation processes.

- Revenue Streams

This building block represent the way the aforementioned ones are translated into cash inflows derived from the purchase activity. It is essential to note that earnings are different from revenues, since to obtain company's profit you have to subtract costs from revenues. Of course, each segment can originate different revenue streams (since it is possible to sell different product and services) and each revenue stream is heavily dependent on the cost structure and on the production capacity. In addition, it is essential to note that different business can have different revenue streams also depending on the one-time transaction model or recurring revenues resulting from an ongoing payment deriving from multiple transactions or from post purchase activities. To identify and calculate revenue streams, a given company should firstly address the issue of the price setting. In other words, for each customer segments, it is needed to identify what product/service will be delivered and what price customers will be willing to pay. Several pricing mechanisms can be adopted. Strategies on this point can be divided into two main categories: fixed and dynamic. Fixed price strategies are the ones according to which prices are set depending on, for example, the type of product or as a function of the purchased volume. Dynamic pricing strategies, on the other hand, take in account the interaction between supply and demand (real-time market) or on negotiation power and yield management (depending on inventories and time of purchase).

- Key Resources

This building block identifies the most important assets a company needs. Every business requires a certain amount of resources in order to create and deliver its value proposition. These resources can either be physical or intangible and can be related to production as well as to channels or to relationship activities. Physical resources are, for example, manufacturing facilities, buildings, vehicles, machines, systems, point-of-sales systems and distribution networks. Intellectual resources can be brands, proprietary knowledge, patents and copyrights, partnerships and customer databases. Every enterprise requires human resources, but people are particularly prominent in certain business models. For example, human resources are crucial in knowledge-intensive and creative industries. Some business models, particularly at their initial stage, call for financial resources and financial guarantees, such as cash or lines of credit. Afterwards, once the business is profitably ongoing, it may need fewer financial resources and can be self-funded (through its profits). Of course, resources can be differently controlled, because they can be owned or leased by the company, but when they are not strictly under the company control this may result in a higher risk.

- Key Activities

This building block is dedicated to what the company must do to make its business work. Of course, this block changes a lot according to different business models. Industrial companies, for example, are heavily concentrated on the production process, while commercial companies need to implement activities to effectively buy and sell products.

- Key Partners

This building block includes the analysis of partners and suppliers that are essential to make the business work. There are three main reasons why companies develop partnerships: optimize their business (focusing on main activities and improve economy of scale giving in outsourcing less relevant

activities), reduce risk or acquire resources. Partnerships can also take different forms, such as strategic alliances, joint ventures to develop new business or buyer-supplier long-lasting relationships to assure reliable supplies.

- Cost structure

The last building block deals with the cost structure of the company. Companies usually have both fixed and variable costs. We define fixed cost such costs that do not change according to the amount produced and sold. On the other hand, we define variable costs such costs that change if the amount produced and sold changes. For example, fixed costs include salaries, rents, and physical manufacturing facilities (because even if the company doesn't produce or sell any product, still must pay these costs). Variable costs are, on contrary, the ones that directly and proportionally raise with production activities, such as, for example, the cost of employed materials.

5. Modelling the business of a new venture in the cultural heritage merchandising sector: how to entrepreneurially employ 3D printing technology

The objective of this section of the document is to define a hypothetical business model for the production and sale of reproductions and gadgets inspired by cultural heritage and made with 3D printing technology. As we have had the opportunity to see in previous sections of this document, and as we will have the opportunity to see in the case studies section, there are several possibilities to start a business in this sector. In choosing the business model, the major discriminators are essentially related to two main elements. The first is the availability of sufficiently trained human capital to manage some of the key steps in the production process. On this point, on one hand, the technical skills are necessary for the use of software for the eventual scanning of objects, their digital design and for the management of machinery. On the other hand, the artistic skills and creativity are necessary to create not scanned objects, but freely inspired by cultural heritage. Secondly, the availability of physical (and therefore financial) capital. On this point, as already highlighted in the previous sections of this document, the business model can vary a lot depending on the materials to be used, the speed and volume of production, as well as the precision required by the client. While waiting for the research and development of technologies, both in terms of materials and machinery, to make further steps forward thus allowing to obtain high volumes with extreme speed and with a highly valid production from the qualitative point of view and with a limited effort in terms of investment in equipment and machinery, it is clear that, also for the purpose and for the recipients of this document, the only conceivable solution is represented by a business model with limited investment from the technological and technical point of view and that has, as its distinctive element of competitive advantage, the creativity in the design of objects to be produced. Therefore, in the continuation of this section, they will be explored, and represented through the structure of the Business Model Canvas, the distinctive elements of this type of single-business start-up. Thus, at first, the main customer segments will be identified, then we will move on to the analysis of the value proposition, the communication and sales channels, through which the value proposition will reach the customers, and then, after the definition of sales revenues, we will examine resources, activities and partnerships and conclude with the cost structure.

Customer segments

The business we are imagining has two main macro-segments of clients. The first is represented by museum bookshops (and, in a broader sense, cultural sites). The second is represented by tourists and, in general, by lovers of cultural heritage.

With reference to the first macro-segment of customers, the one that we could define as Business To Business (B2B), in the segmentation process there is first of all a methodological problem, that is, to

define if it is necessary to segment the final market of consumers to which the single bookshop is interested, or if it is sufficient to segment the bookshops themselves. Given that the first solution is extremely complex, since, as we will say later, we do not imagine focus the production on a single cultural site and, therefore, segmenting customers of a large market, such as the international bookshops one, is difficult and perhaps not useful at this stage, we suggest segmenting the bookshops. In the segmentation of bookshops, there are three fundamental variables: volumes, geographical location and needs. With regard to volumes, it will be necessary to divide the clients of the B2B macro-segment into homogeneous clusters in relation to their size. Regarding this point, for example, the number of visitors where the bookshops are located can be a good proxy for dividing the market according to its size. Geographical location represents a further important element since, in identifying the most profitable segments, it will be necessary to consider the trade-off between transportation costs and expected sales volumes and margins. Lastly, from the point of view of the needs to be satisfied, the type of product to be supplied will be important. With regard to this aspect, the distinction is not useless because products can be distinguished between gadgets freely inspired by cultural heritage and faithful reproductions of the it (coming from scans of the originals). Given that bookshops located within the cultural sites have the responsibility to enhance and disseminate the cultural heritage in an appropriate manner, it is unlikely to assume that poor quality reproductions can be sold in the official store. Therefore, in the B2B segment, it will be necessary to produce faithful reproductions that manage to convey to buyers the same emotions as the original, even if on a smaller scale.

With reference to the second macro-segment of customers, the Business To Consumer (B2C), the business model we imagine refers to two main types of customers. On the one hand, tourists who have visited the site and, on the other, cultural heritage enthusiasts who have not (yet) visited the site. As we will see through the analysis of the Museum Shop case study, indeed, 3D production technology, if properly conveyed through the right channels as we will discuss later, is potentially able to disregard the in-person visit to the cultural asset or subvert the logical order of the purchasing process. Normally, the purchase process in this sector provides that the visitor buys the reproduction of the asset they have just visited, or a gadget freely inspired by it, once the visit is over. However, this is not necessarily said, since, indeed, the purchase of the reproduction or gadget may be a means to entice the potential visitor to go to the cultural site and visit the original artifact in person. With reference to the segmentation of this market, it is clearly possible to differentiate two types of customers depending, firstly, on their needs. On this point, according to the first sections of this paper, two distinct clusters emerge. A first segment that has the need to have a faithful reproduction of the cultural asset and a second that, instead, is interested in a freely inspired gadget or on a less faithful reproduction. In the first case, customers will be interested in a reproduction resulting from the scanning of the original that is able to reproduce in an extremely reliable forms, in the second and third case, however, the need to be met is totally different (the gadget, in particular, responds to the need to have an object that, in addition to reproducing the cultural heritage shape, may also have a function of use other than the typical decorative or furnishing) and can be further segmented according to the required degree of customization. With reference to this latter aspect, it is clear that the speed of production of the product will not be dependent on the personalization that, from the technological point of view, has no impact in this regard, but will need the appropriate sales channel, about which we will speak later. In addition to the needs to be satisfied, clients can be segmented, clearly, according to socio-

demographic variables, psychographics, spending capacity and, lastly, geographical origin (but to the end of this business, we think it is not that much relevant).

Value propositions

The value proposition refers to products and services that the company intends to propose to the market and must therefore be articulated according to the customer segments identified in the previous paragraph. In general, having assumed that the business model we're hypothesizing is essentially not very capital intensive, thus it doesn't require a huge investment in industrial equipment, it goes without saying that the competitive advantage cannot be based on economies of scale deriving from mass production with low creative value, but on product differentiation. Therefore, both with reference to B2B and B2C, we assume that the company focuses its value proposition on a product with a relatively high creative value. If with regard to the production of gadgets and reproductions from scans that may be delivered to bookshops, the level of customization can never be high because it would require a time of realization that does not fit with the agenda of cultural sites visitors, with reference, instead, to B2C, we could assume a higher level of customization of the product that could, for example, provide the names of visitors or the date of the visit (or even be made on order according to a co-creation process). Gadgets should then have different functions of use such as those reported in the case of Museum Shop (cookie cutter, pen holder, etc.) so that the usability of products can exceed the classic decorative function. A further element of strength that the value proposition must contemplate is represented by the use of entirely biodegradable materials (bioplastics) that should be able to intercept the favor of customers that are increasingly engaged to the theme of circular economy and environmental impact. On this point the company should focus its communication campaign, emphasizing how the gadgets of its production are consistent with the objectives of the U.N. Agenda 2030 and the European Green Deal. This aspect will serve to convince customers, along with the differentiation of the product, to recognize a premium price on which is based the entire business model that, as mentioned, it was decided not to focus on the cost/price leadership.

Channels

In terms of channels, it is assumed that the value proposition can be communicated and transferred to the market essentially through one type of channel for B2B and two types for B2C. With reference to B2B, the sales force will play a central role in raising awareness of production. It is believed that the bookshops can be reached personally, proposing a catalog of creative gadgets, personalized for each bookshop depending on the characteristics of the cultural site to be enhanced. On the point it is essential to adequately plan the orders in the long term, in such a way to allow the company to fulfill them on time, considering both the length of materials delivery and the production capacity of machinery (and possible replacement of the equipment due to obsolescence).

Regarding the business to consumer, in this case the company could use two channels. A dominant role is assumed to be given to the online channel. The online channel has the advantage for this kind of company (characterized by a limited investment in physical capital), to be able to be more flexible in carrying out the orders and to be able to offer, as previously mentioned, a highly personalized product without having stringent production deadlines. On this point we could think of using an intermediate channel (Amazon, for example) for standardized products and the direct channel (the website), where the company could propose a dynamic and effective customization of the product,

even assuming a preview of the object. The customization could be brought to the extreme consequence of making the website in the same way as an online Fab Lab, a place where customers can create their own gadgets inspired by cultural heritage according to their own preference in terms of aesthetic and function of use. In addition to the online channel that, of course, could intercept the whole B2B macro-segment, we could also imagine the opening of a retail store, obviously not located within the cultural site, but in its surroundings or in the historic center of a city. A similar possibility would allow, on the one hand, to place the products to the final consumer without the intermediation of the bookshop and, on the other, to target those customers who have not just visited the cultural site and who have the availability of time to wait for the customization of the gadget. This would, therefore, significantly increase the unit revenue, but, on the other hand, would increase considerably the fixed costs. On the communication side, of course, maximum importance could be given to social networks (especially Instagram).

Revenue streams

Revenue streams will be essentially differentiated according to the client's macro-segment and to the level of product customization. Lower prices will be set for higher volumes and less personalized orders, typically obtainable in the within B2B. Higher prices will instead be set in the B2C market that will also be characterized by a more personalized production. While for the gadgets the price will have to reflect the cost of the creative idea of the human resources that have conceived, for faithful reproduction, derived from scans of the original, the selling price will have to take into account the cost of the scanning process that, of course, will have to be divided on the entire production volume. The final price would range from 5 to 10 euros for the smaller gadgets, up to 100 euros for the most faithful reproductions or for customized products.

Key resources

The key resources will mainly be human, technological and financial. From the human resources point of view, these will be fundamental both for the creative process, for the collaboration with clients aimed at the definition of customized products and for the productive process, both with reference to software and hardware. Scanners, software and 3D printers will similarly be central resources since the alignment of the production structure with order volumes and with the value proposition will depend on the correct identification of these tools. Lastly, financial resources, mainly aimed at financing investments and supporting the company during the start-up phase, which is generally loss-making, will be taken over. To get adequate funding, the company can rely on partners, on the banking system and on some modern forms of financing, such as venture capital (more likely informal venture capital, otherwise known as angels' financing) and crowdfunding. Of course, communitarian and public financial funding may also be an important source of capital for early-stage companies in this field.

Key activities

The main activities that the company will have to carry out can be divided into two categories. On the one hand, we will have the administrative and marketing activities, and on the other, those more related to the production function. The former will mainly consist of accounting management, human resource management, financial planning and customer acquisition and retention. The latter will involve the entire production process, from the eventual scanning of an original artwork, to the

technological design of the product and to printing. The production activities, of course, will have to take into consideration the customization required by customers and, therefore, work with them to define the product that will be printed.

Key partnerships

There are several partnerships that will become important in this business. First of all, for the B2B segment, museum bookshops (the concessionary companies). With this type of partner, a relationship of product co-development will be established, within which, it will also be necessary to define the optimization of production and delivery schedule. In B2C, on the other hand, the partnership with the public institution holding the image rights of cultural assets will be of primary importance. A possible agreement for the exploitation of these images will become necessary and will translate into a real partnership for the valorization of cultural assets that, inevitably, will pass through the sharing of a production aimed at safeguarding the integrity of the asset. Other central partnerships will be related to distribution channels and supplies. With reference to this latter aspect, in particular, it will be necessary to establish agreements for the supply of materials that guarantees not only the continuity of supplies, but also their adequacy in terms of quality. The supply issue also concerns the engineering side (scanners, software and printers). The need for one or more partnerships in this sense is linked not only to eventual replacement (due to obsolescence), but also, and above all, to maintenance.

Cost Structure

From the point of view of the cost structure, it is good to distinguish fixed costs from the variable costs of the company. In an enterprise such as the one we are describing, the main variable costs will be of two types. The cost of the materials, indeed, represents, by definition, the most obvious variable cost, since it will increase according to the products volume. If from the conceptual point of view, the cost of the materials is crucial in a production company, in this company this cost will be completely marginal, considering that the outflows for the purchase of the raw materials is completely irrelevant. On the contrary, two other variable costs of substantial importance emerge. On the one hand, royalties, if any, (royalties can range between 15 and 30% of sales value and are not due in the case of B2B sales, as, in this case, the bookshop will be responsible of paying them to the public institution) must be paid to the owners of the cultural heritage that the company intend to represent in gadgets or even reproduce as a result of a scan and, on the other hand, the costs of intermediation. The latter are divided into two categories. On the one hand, we have those related to payment systems (generally ranging between 2 and 5% of transactions) and, on the other, those related to intermediaries' distribution channel (such as, for example, Amazon) that often reach a rather high onerousness (around 18%). Fixed costs, instead, are mainly related to the costs of human resources. Expected that the main competitive advantage, we said, should be derived from a human capital capable of designing and producing innovative and creative gadgets, these resources should be properly remunerated. Similarly, other relevant fixed costs will be depreciations of machinery (which are expected to be replaced every 5 years) and rent payments, both with reference to the production plant (which is imagined to be located in a not expensive area, but functional from the point of view of logistics to facilitate the shipment of products) ant to the stores used for direct sales in the B2C market.

Key Partners

-Cultural heritage Sites and museums
-Technology Suppliers
-Materials suppliers
-Online selling channels
-Bookshops

Key Activities

Production
-Support in customization
-Scanning original artifacts
-3D printing
Administrative
-Marketing
-Partnership management
-Financial planning

Key Resources

HR
-Creative digital sculptors
-Printer's operators
Tech
-Scanners
-3D printers
-Software
Financial:
-Owner
-Banks
-Crowdfunding
-Business Angels
-State and Eu funding

Value Propositions

-Mass production gadgets inspired by Cultural heritage
-Customized products inspired by Cultural heritage
- Cultural heritage replicas from digital scanning
-Creative products
-Environmentally friendly materials and production

Customer Relationships

-Sales force
-Products Co-creation
-Upselling
-Promotion
-Social network (WoM)

Channels

Online
B2C:
-Own website
-Intermediated online channels
Offline
B2B:
Sales force
B2C:
Direct stores

Customer Segments

B2B (museum Shops)
-Small/Medium/Large
-Domestic/International
-Scanned products and gadgets
B2C (tourists & art lovers)
-Scanned products/gadgets
-Customized/mass products
-Domestic/International

Cost Structure

Fixed:
-HR
-Rents
-Depreciations
Variable:
-Royalties
-Selling fees and financial expenses

Revenue Streams

B2B
High volumes, lower prices, mostly mass production

B2C
Reduced volumes, higher prices, mostly customized production

6. Case studies

In order to complete this document by integrating theoretical and practical aspects with empirical evidences from the world of business, two case studies will be illustrated below. The choice of the companies to be interviewed derived from the need to provide the reader with the vision of both large companies and SMEs when it comes to addressing the issue of applying 3D printing technology to Cultural heritage exploitation for commercial purposes. To obtain relevant information both with reference to the general context and to the particular business model of the interviewed companies, a questionnaire (reported in the appendix of the document) was prepared and administered to the directors of the two companies during a visit carried out on October 28 and 29, 2021. Each visit lasted about 3 hours and during them it was possible, not only to conduct the interviews (both to the directors and to employees involved in the 3D printing process), but also to visit the production laboratories and view some of their activities and products. The first case study is certainly more in keeping with the need to explore the business context that this guide aims to analyze. The first case is in fact focused on an enterprise of small dimensions that produces and commercializes 3D printed gadgets realized on inspiration or scanning of cultural artefacts. The second case is instead related to a large company, whose main activity focuses on the production of components for the avionic and automotive sector. However, the second company also have had an experience in the field of cultural heritage, both, marginally, with the production of gadgets that, more extensively, through collaborations with museums for educational purposes.

Case Study 1: Museum Shop

The mission of Museum Shop (https://www.museum-shop.it) is to provide travelers with a tangible sign of the experiences and emotions they had while visiting Italian museums and cities and continue to recall them even after departure. Moreover, the objects they produce and sell are configured as a communication and dissemination tool for the Italian Cultural heritage. Indeed, they not only complete the traveler experience, but also aim to reach those who have not yet visited the country and motivating them to do so.

The company has been engaged, since 2004, in the museum merchandising sector with the design and marketing of t-shirts, shopping bags, mugs, stationery, books and statues, all inspired by the art and culture of the Italian country. Even though a particular attention is paid to graphic and stylistic research, each product is enriched with in-depth information about the Cultural heritage it is inspired by, in order to pursue an educational purpose also.

The company is organized in two different but connected business activities: merchandising production for museum bookshops (Business to Business) and direct sales to the public (Business to Consumer).

On one hand, Museum Shop produces its own merchandising independently and then they sell it to the museum bookshops (B2B) with which they have established a partnership. The main Italian bookshops where their products can be found are the Colosseum,

Palazzo Massimo, Musei Capitolini, Villa Adriana, Vatican Museums, Leonardo's Last Supper, Doge's Palace in Venice. They also have collaboration with Cultural sites located abroad, such as, for example, the British Museum and the Cleveland Museum of Art (on the occasion of exhibitions dedicated to Pompeii). Since 2012 Enclopius Edizioni (which is the legal name of the Museum Shop company) has been the exclusive merchandising dealer of the Superintendence of Salerno and Caserta which includes important sites, such as Paestum and Capua Museum. Moreover, since June 2015, they had the exclusive sale for the merchandising activity in Pompeii and Herculaneum bookshops.

On the other hand, as aforementioned, since 2007, they also have a retail (B2C) activity which is carried out both on the online channel and through their three shops located in Naples. The first shop was opened in 2007 at Capodichino airport, a stopover with six million passengers.

The second was opened in 2011 at the Naples cruise terminal. The third Museum-shop is in Naples city center, in the heart of the old town. The shop is located inside the famous Palazzo del Panormita, the pride of the Neapolitan Renaissance architecture. Its venue, a fifteenth-century room built on medieval and Roman wall structure, is very suggestive and this alone would be worth the visit. Furthermore, these shops also host an intense cultural dissemination activity with exhibitions, book presentations and concerts.

Their products can be mainly divided in three categories: home décor, jewelry and merchandizing. The first category includes products such as marble and bronze sculpture, porcelains, canvases and paintings. When it comes to jewelry, they sell gold, silver and coral handmade necklaces, earrings, bracelets, rings and pendants. The merchandizing area mainly includes books, stationery, T-shirts, shopping bags, cups and bottles.

As far as the 3D printing technology is concerned, we may say that their production is mainly concentrated in home décor products. They both produce 3D reproduction coming from the scanned originals (such as statues) and from invented and freely inspired objects (such as the Giulio Cesare Bust pen holder, cookies cutters or fridge magnets).

As mentioned by Francesco Di Bennardo, the idea of starting to produce objects using 3D printing technology came from the dissatisfaction given by the impossibility of faithfully reproducing, in a handcrafted way, some forms of the original artistic artifacts. Mr. Di Bennardo pointed out that the first artefact that inspired the adoption of this technology was the

Venus (or Aphrodite) Callipyge, a marble sculpture of the Roman era, dating from the first to the second century, and preserved in the National Archaeological Museum of Naples. It is a copy of a bronze original from the Hellenistic period of the third century BC and shows her refined and perfect forms according to the canons of ancient Greece.

To reproduce the perfect forms of this statue, it was firstly necessary to have the permission by the Naples National Archaeological Museum to digitally scan the original statue. This process took a full day, but, as a result, it was possible to have an almost perfect digital version that can be three-dimensionally reproduced in different sizes, but still maintaining the proportions and the perfect shapes of the original. After obtaining the scanned digital version, however, it is necessary to adjust and model the result so that a file compatible with the 3D printers in their possession can be generated. The last process involves 3D printing of the artefact with additive technique.

Unless you have to produce an object that does not need to be scanned from the original, for example because the digital file is already available (because it is made freely available by the entity that is in possession of the original artifact) or because it is the result of an own creative process, this procedure does not change depending on the object to be reproduced or the material that will be used. Moreover, the great advantage of using scanners to define the digital identity of the artefacts to be reproduced lies in the lack of invasiveness of the process that does not require touching or moving the original as is done using previous processing techniques. This allows to preserve the asset but at the same time to obtain a 3D reproduction that allows to evoke the same emotions given by the original.

The only thing that changes, depending on the object to be reproduced (typically depending on the size of the object) and on the materials to be used, is the time required for printing.

With reference to the needed time to produce a 3D printed object, we should keep in mind that it takes about 20 minutes to produce a small object (5cm gadget, for example), while to produce larger objects (statues of 40 cm in height, for example) it could take a few hours.

With reference to the materials employed in this process, they typically use bioplastics (PLA - PolyLactic Acid) that are different than most thermoplastic polymers in that the former derived from renewable resources like corn starch or sugar cane (and also hemp). Polylactic Acid is, indeed, fully biodegradable and has some characteristics similar to polypropylene (PP), polyethylene (PE), or polystyrene (PS). As mentioned by Mr. Di Bennardo, the advantage of using these materials is that they are fully natural and in the actual context of great attention to sustainability and environmental engagement, it is a primary commitment to reduce waste, resource employment and emissions. Employing these

materials, the only pollution effect they have is related to the supply chain, given that some of their suppliers are located in United States. Bioplastics employment is not the only advantage of using this technology. The process, indeed, if compared to traditional manufactures, reduces (to the point of eliminating) production waste because 3D printers use materials in such an effective way that they do not use unnecessary production inputs.

Of course, when it comes to technology, we are talking about something that is constantly evolving. Whether in reference to processes or equipment and materials, we are seeing continuous evolution. Typically, the process requires the use of scanners, software and printers. Obviously, it is possible to buy on the market machinery of different value, from a few hundred euros up to millions of euros. The cost of a 3D scanner ranges between 8 thousand and 50 thousand euros and printers' costs also varies a lot, depending on what the production need is. Less expensive machines (about 300 euros) clearly have a smaller size, less reliability (a duration of 1-2 years), a lower speed and less precision. On the other hand, higher cost machines (let's say about 5.000 euro) allow a quite reliable production and a long-lasting amortization (5 years). However, we may say that the main issue, that will be probably solved through additional research and development in the next few years, is not related to equipment and machines, but to materials. The challenge is to adapt materials so that the melting and solidification (cooling) process (needed when the adding layers in a 3D production process) becomes faster and allows the 3D printers to work at a higher speed with the same reliability and precision. Finding a solution to the time issue is a primary challenge because it can also affect the products differentiation, since, for example, gadget personalization can be done easily but it may need time to be realized and this may not fit tourist schedule if we wish to sell these products in the museum's bookshops.

In terms of costs and revenues, we may say that the business is pretty much worth it. Revenues are approximately 20 times the cost of employed materials. Energy consumption is not at issue at all, since small printers consumes more and less as much as a personal computer. Therefore, the cost of the goods sold is mainly affected by the cost of personnel and by royalties (if any) and by financial overheads due to the online channel. Obviously, these costs must be added to the administrative and structural fixed costs (e.g. rental fees for sales areas), by promotion costs and taxes, as every business.

Moving on to the themes of protection and enhancement through 3D printing technology, Dr. Di Bennardo states that there are several important contributions given by the application to the Cultural heritage. First of all, by scanning and reproducing the Cultural heritage in 3D we won't have anymore the risk to lose the original shape of an ancient artefact in case it gets destroyed. Once upon a time, we would have been able to appreciate a destroyed artifact only through a photographic reproduction (and therefore in 2D), which certainly does not have the merit of allowing us to relive the emotions

given by a three-dimensional object that is a faithful reproduction of the lost heritage. Furthermore, the valorization of Cultural heritage is strongly related to the dissemination process. Through 3D printing it is possible to make heritage known in a more effective way, not only through the commercialization of reproductions, but also by using them for educational purposes (think of the case of tactile museums) or research (the reproduction can also be made larger than the original and allow a more effective study of the work). In addition, 3D printing can be an excellent solution in the case of temporary replacements of works loaned for exhibition purposes that must leave their location temporarily or that must be restored. Or, alternatively, as in the case of the Michelangelo's David that is representing Italy at the World Expo in Dubai in 2021, the original artefact (a colossal statue kept at the Accademia Gallery in Florence that is 5 meters and 17 centimeters high, five tons and 600 kilos of Carrara marble) didn't leave the Italian museum and, in its place, it will be exhibited a perfect reproduction printed with the largest existing 3D printer. On this point it is interesting to consider that also for the transport of the artefacts, 3D printing can be very helpful both to create custom-made housings that will more effectively protect the original that will be transported, and for insurance purposes, since it will be possible to compare the artefact at its return from the loan not with the photographs of the same before the transport, but with a three-dimensional reproduction of it. Furthermore, in terms of valorization, the lockdown we experienced during the CoViD-19 emergency, taught us how cultural heritage enhancement can be accomplished outside of art sites. 3D printing, in this sense, can help reverse the process of buying souvenirs, which generally involves first visiting the cultural heritage and then buying a reproduction to carry the memory of the visit. Well, this process can be reversed because 3D printing can allow the world to appreciate cultural heritage through a faithful representation that might then entice people to visit the site that hosts the original artefact.

When it comes to the role of state-owned companies in the market of 3D printed reproduction, Dr. Di Bennardo states that it would be desirable a greater involvement of the state in the valorization and exploitation of cultural assets, also from an economic point of view. However, he mentioned that this process should be entirely under the control of the Ministry of Culture. This may also lead to a better promotion of the Cultural heritage because, not responding to eminently or exclusively financial logics, the state could push the sale of different gadgets, reproducing artefacts other than those most commonly sold in bookshops and specialty stores (for example, in Pompeii is typically sold the "cave canem" image) and thus promote a diversification in sales and then in the valorization of the Cultural heritage. Moreover, this would allow a greater control of the state in the reproduction process, also in terms of faithfully respect the shapes of the original manufacts.

Finally, Dr. Di Bennardo has focused on the professionals involved in the production process and has highlighted how it is extremely difficult to find trained enough people in this field. "Digital Sculptors", who may or may not coincide with scanners (who are in charge of scanning the original artefacts), are professionals, whose works begin after the scanning phase, that must be able to combine both computer skills and artistic sensibility (if we want it is not so different from the past, since also Michelangelo used chisel and hammer, but he was able to combine the use of tools with his innate artistic genius) and this is pretty rare because these two competencies are basically very far from each other. Employees who are in charge of setting and monitoring the printing process must have competencies that enables them to manage both printers softwares and hardware.

Of course, the entrepreneur should be able to organize the production factors and his works is determinant since the initial selection of the artefact to be reproduced. Moreover, the entrepreneur

should be able to appropriately choose the right distribution channels, adequately promote the activity and setting the right price which can be positively accepted by the market, according to a given value proposition. Therefore, Dr. Di Bennardo highlighted that technical skills, inventiveness, artistic sensibility and the ability to organize the business are the main elements that may help a young entrepreneur to succeed in this business. Some of these characteristics can be developed through initiatives like this Erasmus+ project and his company will be very happy to illustrate to students their activities and collaborate with schools in the area of transversal competencies and orientation.

Case Study 2: 3DnA

The mission of 3DnA (https://www.3dnasrl.it) is guiding its customers in the adoption of additive manufacturing in their production cycle by choosing the most appropriate and innovative technologies and materials. 3DnA is an engineering company focused on additive manufacturing technologies that offers an integrated service of design, optimization, simulation, prototyping and production using industrial 3D printing systems.

Their business model is composed of six different activities. The design and reverse engineering business unit aims at providing support to the client from the development of the idea (co-design / re-design) or starting directly from a physical object (reverse engineering). The rapid prototyping business unit is focused on printing functional prototypes by using additive technique with a wide range of materials and minimizing time and costs. The production activities deal with pre-series, mini-series or series production in additive manufacturing. Of course, they also have an intense research and development activity focused both on materials and geometries optimized for additive manufacturing and on the re-design of components from an additive manufacturing perspective. Finally, their business is completed by 3D printing selling and assistance activity and by the provision of different types of training courses on 3D design and painting (basic, advanced and professional).

The company provides these products and services to a variety of industries, such as: aerospace, automotive, biomedical, railway, mechatronics and, of course, also Cultural heritage.

When it comes to technology, 3DnA employs 2 scanners and 13 different 3D printers. Each scanner costs around 70 thousand euros. Each 3D printer has different size and characteristics, such as speed and accuracy, and not all of them can be used with the same materials. For example, Fused Filament Fabrication and Fused Deposition Modeling printers employ the most commonly known printing process (a similar process to the one also seen in the first case study) with standard polymers [PLA – ABS – Nylon] or technical polymers [Onyx] for prototyping and small production at low cost, or Super Polymers [Peek – Ultem] or Composite Materials [Carbon PA – Carbon Peek] for prototyping and production of structural parts or assembly equipment. Other printers, such as Laminated Object Manufacturing, employ a green technology for laminating sheets of 100% recyclable paper which recreate full color objects with wood texture. Finally, they also have 3D printers, such as the Selective Laser Melting, whose process, through the laser sintering of metal powders (aluminum, steel, titanium, nickel, cobalt, chromium and copper) allows the realization of complex geometries with high performance for industrial applications aimed at prototyping and production mainly in the automotive and aerospace sectors.

When it comes to products, as aforementioned, 3DnA provides products for several industries. They have produced a molded contouring and drilling template for the aerospace sector, a trolley head for trolleybus in the railway sector, a stomach with printed and colored by-pass in the biomedical sector, a prototype of internal bodywork structural parts for the automotive industry and, finally, the Ercole Farnese (printed in scale in LOM technology) and the Venus Callipygian (printed to scale with synthesized powders) for the Cultural heritage sector.

Even though the company began its activity dealing with the aerospace industry, since 2016 it has developed a cross-sectorial knowledge and technology which have also allowed it to carry out important collaborations and orders in the field of cultural heritage. The company's first commitment to the cultural heritage sector dates back to July 2019, when the National Archaeological Museum of Naples (MANN) hosted an exhibition entitled "Assyrians in the shadow of Vesuvius," a cultural journey aimed at raising awareness of the glorious civilization of the

Assyrians through casts and 45 ancient artifacts coming from multiple international institutions (including the British Museum, the Ashmolean Museum in Oxford and Vatican Museums). In the context of this exhibition, the Director of the Museum, Paolo Giulierini, under the supervision of Professor Ludovico Solima (one of the most important international expert in the field of cultural heritage management studies) had the idea of creating an immersive multimedia and technological environment, which could bring the visitor closer to this ancient cultural world. Subsequently, many other activities have been carried out in the field of cultural heritage, both on behalf of museum organizations and at the request of private individuals. This is the case of the initiative "the archaeological chess of the MANN" (2021) where the pieces of the game are made up of images of the Museums' artifacts. Also in this case, as in that of the Assyrian exhibition, a tactile prototype with captions in Braille was presented by the Educational Services of the MANN. The project proposal, also in this case, was carried out by Prof. Ludovico Solima. Still with reference to the collaboration with the National Archaeological Museum of Naples, 3DnA has lent its work in the reproduction of some statues

of international importance. The MANN hosts, in fact, one of the most important collections of sculptures in the world, many of which belong to the "Farnese collection". The Farnese Hercules and the Farnese Bull, for examples, are a symbolic work for the entire history of art. The 3DnA first scanned and then reproduced (in 25 cm size) these statues that the Museum wanted to donate to institutional visitors. Moreover, 3DnA has also had a collaboration with the Museo Archeologico dei Campi Flegrei for the reproduction of statues and artifacts temporarily on loan for exhibition purposes at a German museum. On this point, Dr. Elia highlighted that European projects like this one are welcome, as they have the merit of combining elements of technological avant-garde with the protection and enhancement of the history of our countries. Fully embracing this purpose, 3DnA declares itself available to participate in a possible training course to be created in collaboration with schools and to show students its projects.

Finally, they also scanned and reproduced statues commissioned by private individuals (of American origin) who wanted to enrich their furniture with faithful reproductions of original pieces of Italian cultural heritage.

Today the company has several collaborations with national and international institutions, such as universities and companies, and over 7-million-euro investments in plants, machineries and software, partially cofounded by the European Regional Development Fund ("Campania Start Up") which believed in the development of the project named "Development of an innovative business model in the Additive Manufacturing sector". Still with reference to the technology, given the importance of the orders, compared to the previous case study, Dr. Elia highlighted that their investments included energy generator groups of continuity that would allow the printers to continue their work even in case of momentary power outages. From the point of view of the process and the necessary technologies, on the other hand, Dr. Elia substantially confirmed what had already been seen in the examination of the Museum Shop case, emphasizing how, clearly, the market is extremely varied and characterized by instruments that vary their price and performance radically. Just think that there are

also 3D printers on the market that can cost 4 million euros. It's clear that between the 150-euro machine and the 4 million euro one there is the same difference that passes between a handicraft production and an industrial one.

Clearly, this difference is reversed on the professionals involved in the design and manufacture of objects using this technology. The more complex the industrial process and the use of technology, the greater the skills required of the professionals involved. In this sense, Dr. Elia pointed out that there is a significant gap between the demand for specialized skills from the manufacturing world and the education sector. The problem is not insignificant because in the near future (maximum in 30 years) industrial production as we conceive it now will no longer exist and will be entirely supplanted by 3D printing technology. It would be a good idea to start, therefore, right from the school years to increase the knowledge and familiarity of young people with this trajectory of development. In this sense, schools could already do a lot in order to create a professional figure to be quickly inserted in the working context. It is clear that the professionalism required in this field changes a lot with the type of work to be done and therefore, in addition to the school system, the university system should also be involved with the creation of highly focused training courses in engineering studies.

The sensitization of the new generations, in this sense, appears extremely simple in a period like this one characterized by an increasing attention to the environmental safeguard. In fact, Dr. Elia pointed out that, unlike traditional production logics, those using 3D printing technology avoid the melting of materials for production with an obvious advantage in terms of energy consumption and production waste, since the production itself does not take place by subtraction but by addition.

Throughout their industrial experience, they have therefore been very attentive to the issue of training, actively participating in school-to-work alternation plans and hosting university internships. From their point of view, with reference to the school system, it is clear that institutes should equip themselves with the necessary technologies and training courses should be created for teachers first. Already a training course of about twenty hours could be enough to support the initial phase of teaching and make students curious.

So, in this sense, European projects like this one are welcome, as they have the merit of combining elements of technological avant-garde with the protection and enhancement of the history of our countries. Fully embracing this purpose, 3DnA declares itself available to participate in a possible training course to be created in collaboration with schools and to show students its projects.

7. Conclusion

Although this document does not have the ambition to represent an exhaustive guide to develop entrepreneurial activities using additive manufacturing technology in the field of cultural heritage, it is possible to draw some synthetic considerations of absolute relevance. These come from three main sources of information. First of all, from the desk analysis presented in the first two sections of the document and concerning technologies and processes as well as the application fields in the cultural heritage sector. Secondly from the analysis of the business model canvas for entrepreneurial activity aimed at the production and marketing of gadgets and products inspired by the images of cultural heritage itself. Thirdly from the analysis of case studies reported in the previous section of the document.

The first consideration is related to technologies. We are analyzing a field in continuous evolution and in which the development of new materials, equipment and machinery, as well as new software, is constantly changing the competitive levers. It is expected that soon, additive manufacturing will be able to bring about an upheaval in the entire global manufacturing process, effectively replacing most of the current production. It is clear that this will push research and development in this sector even further, eventually reducing the costs of the less sophisticated equipment, that can be used for productions such as those covered in this paper. The second important aspect concerns the relationship between the use of this technology and the effects on the environment. Since, both in terms of the possibility of recycling the production materials (PLA in particular) coming, for example, from corn starch, and above all in terms of their waste (given that through these productions waste is essentially reduced to zero), additive manufacturing is perfectly in line with the objectives of the U.N. 2030 Agenda and with the European Green Deal, it is both desirable and probable to expect that there will be further funding to encourage entrepreneurial investment in these technologies. With reference to the scope of this guide, which was analyzing the entrepreneurial possibilities in this field, some strengths and some weaknesses have quite clearly emerged. From the point of view of strengths, the first thing that should certainly be pointed out is the application versatility of this technology, which can be used both in restoration and conservation, as well as in the marketing and research in the cultural heritage. Although the quality guaranteed by additive manufacturing in replicating the perfect forms of cultural heritage through the scanning of the originals is perhaps the most important strength in terms of the study and valorization of the heritage, from the point of view of commercial exploitation, the personalization of production assumes the greatest importance. Personalization, however, at least at the present time, suffers from a problem related to production lengths that are difficult to reconcile with the generally very tight schedule of cultural heritage visitors. To hypothesize, indeed, a personalized production inside a museum bookshop is today rather unrealistic. Personalized production could more likely be realized in stores located in historical centers or, even better, online. The cost of equipment for mass production continues to be prohibitive today; therefore, the exploitation of economies of scale cannot represent the main source of competitive advantage in this field that, rather, is believed to be found in the creativity of digital designers and co-creative processes to be put in place through an effective customers relationship management. In this sense, not only the color or shape of the gadget to be produced, but also its usability assumes relevance. Products inspired by cultural heritage but with a not merely decorative function of use, as in the case of cookie cutters, refrigerator magnets, pen holders, etc., may be examples of creativity to focus on. From this point of

view, the main key resources to start an entrepreneurial activity in this sector, although anti-intuitive, it may seem, are the human resources. From this point of view, it is easy to understand the centrality of a project such as ST.A.R.T.UPtoEU, which has the fundamental merit of stimulating European citizens, starting from school age, to understand the probable evolutionary trajectory of production systems and to evaluate an educational and then entrepreneurial path in this field.

8. Reference list

Anastasiadou, C., & Vettese, S. (2021). Souvenir authenticity in the additive manufacturing age. Annals of Tourism Research, 89, 103188.

Ballarin, M., Balletti, C., & Vernier, P. (2018). REPLICAS IN CULTURAL HERITAGE: 3D PRINTING AND THE MUSEUM EXPERIENCE. International Archives of the Photogrammetry, Remote Sensing & Spatial Information Sciences, 42(2).

Balletti, C., & Ballarin, M. (2019). An application of integrated 3D technologies for replicas in cultural heritage. ISPRS International Journal of Geo-Information, 8(6), 285.

Balletti, C., Ballarin, M., & Guerra, F. (2017). 3D printing: State of the art and future perspectives. Journal of Cultural heritage, 26, 172-182.

Bašić, A., Mladineo, M., Peko, I., & Aljinović, A. (2018). 3D Scanning, CAD Optimization and 3D Print Application in Cultural heritage: An Example on Statue from the Ancient Salona. In International Conference "Mechanical Technologies and Structural Materials".

Cronin, C. (2021). Intellectual Property Implications of 3D Printing of Cultural heritage. Available at SSRN 3849013.

Du, Y. (2020, January). The Promotion of Intangible Cultural heritage Tourism Creative Products' Development Through 3D Printing Technology. In 4th International Conference on Culture, Education and Economic Development of Modern Society (ICCESE 2020) (pp. 354-357). Atlantis Press.

Fatta, F., & Fischnaller, F. (2018, October). Enhancing cultural heritage exhibits in museum education: 3D printing technology: Video mapping and 3D printed models merged into immersive audiovisual scenography (FSJ-V3D printing+ MM installation). In 2018 3rd Digital Heritage International Congress (DigitalHERITAGE) held jointly with 2018 24th International Conference on Virtual Systems & Multimedia (VSMM 2018) (pp. 1-4). IEEE.

Greggio, I. (2017). La stampa 3D nei Beni Culturali. Analisi e caratterizzazione di materiali per la fabbricazione digitale di Beni Culturali. Tesi di laurea magistrale in scienze chimiche per la conservazione e il restauro. Università Cà Foscari Venezia.

Kent, T. (2010). The role of the museum shop in extending the visitor experience. International Journal of Nonprofit and Voluntary Sector Marketing, 15(1), 67-77.

Neumüller, M., Reichinger, A., Rist, F., & Kern, C. (2014). 3D printing for cultural heritage: Preservation, accessibility, research and education. In 3D Research Challenges in Cultural heritage (pp. 119-134). Springer, Berlin, Heidelberg.

Osterwalder, A., & Pigneur, Y. (2010). Business model generation: a handbook for visionaries, game changers, and challengers (Vol. 1). John Wiley & Sons.

Vasiljević, I., Obradović, R., Đurić, I., Popkonstantinović, B., Budak, I., Kulić, L., & Milojević, Z. (2021). Copyright Protection of 3D Digitized Artistic Sculptures by Adding Unique Local Inconspicuous Errors by Sculptors. Applied Sciences, 11(16), 7481.

Appendix: Case Studies Interview Protocol

The two case studies discussed in the seventh section of this document have been developed by administering a questionnaire consisting of 18 questions, the contents of which are as follows:

1) How did the idea of employing 3D printing in the contest of cultural heritage develop in your company?

2) What 3D printing projects for cultural heritage has your company done? And what kind of gadgets have you produced?

3) Does your company do both 3D modeling and 3D printing? Which instruments are used to realize reproductions of artifacts and/or art objects?

4) In this phase of great attention to the environment, do you think 3D printed cultural gadgets production can respond to principles of sustainability?

5) New technologies in the field of the cultural heritage are increasingly representing an instrument of valorization. How can 3D printing contribute to a better fruition of cultural heritage?

6) How are 3D scanning and 3D printing technologies introducing novelties in the field of conservation, valorization and dissemination of the cultural heritage? Do you think they will revolutionize the fruition of the cultural heritage?

7) The reproduction of art objects and the realization of gadgets can be considered a tool to raise awareness of our vast heritage and help strengthen the cultural awareness?

8) Can the application of 3D printing in the field of cultural heritage create new opportunities and new tools for those who work in the field of cultural heritage?

9) Which professionals are involved in a company that creates gadgets for museums?

10) To reproduce 3D cultural heritage can be considered a new work channel for professionals and experts in the field of cultural heritage protection and why?

11) Entrepreneurship and cultural heritage are becoming an increasingly consolidated pair. What could be the future developments?

12) How can marketing needs be combined with the protection and enhancement of cultural heritage?

13) In reproducing cultural heritage objects for commercial purposes, how important it is to respect the original shape? Have you had any indications from competent institutions?

14) "Selling Pompeii lapils as a project of valorization", as provocatively stated by Massimo Osanna, General Director of Italian Museums and former Director of the Archaeological Park

of Pompeii, or other artifacts of the past, can be a way for reaching the valorization of the cultural heritage? In this view, can the use of 3D reproduction represent a surrogate for the mass public who wants to take a sign of the past with them?

15) The additional services to the fruition of cultural heritage, such as the production and sale of gadgets, have so far mainly been delegated to privates, but it seems that the Italian state intends to involve Ales SpA, a 100% state-owned company, in managing this business. Accordingly, what changes would you expect and what will be the added value that a state-owned company may bring to the cultural heritage sector in this way?

16) St.A.R.T.UPtoEU (Storytelling Ancient Roman Traces up to Europe) is an Erasmus+ project which includes, among its activities, the 3D printing production cultural gadgets. Based on the experience of your company, by developing such a path and involving students, will it be possible to have a positive educational impact in the long term and to contribute to raise the cultural awareness by encouraging the development of new professional and local entrepreneurial activities?

17) Would your company be willing to present its projects in the context of schools and to collaborate with schools in the field of education?

18) What advice would you give to students interested in pursuing a youth entrepreneurship project in the cultural heritage sector? Can you suggest three essential personal qualities to start up a business in this sector?