Academic heritage between digitization and dissemination

Academic Heritage Between Digitization and Dissemination

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Abstract

The study explores the educational applications of 3D modeling and rapid prototyping to enhance participatory learning of cultural heritage, focusing on public engagement and academic dissemination. Conducted within the Politecnico di Torino's Geometric Modeling in Architecture course, it emphasizes the analysis and communication of architectural facts through interdisciplinary geometry. The research aligns with growing European recognition of academic heritage's cultural value, tracing its roots to the Halle Declaration (2000) and subsequent recommendations. This heritage spans tangible and intangible university assets, with an emphasis on their role in scientific research dissemination. Structured into six steps, the project began by identifying valuable academic heritage, focusing on Giovanni Curioni's 19th-century wooden models of vaulted surfaces. Nine models were digitally analysed and reproduced by students using rapid prototyping methods like 3D printing. These physical artifacts were tailored for public engagement, specifically during the European Researchers' Night 2024, showcasing their potential for inclusive communication with diverse audiences. Challenges included inaccuracies in physical reproductions, fragility of prototypes, and limited interaction with complex geometries. Nonetheless, the integration of digital and physical modeling demonstrated its educational impact, fostering engagement beyond academic circles. This approach highlights the potential of academic heritage as a bridge between scientific knowledge and public participation, promoting inclusive learning experiences within the polytechnic culture.

1. Introduction

The contribution exposed a series of critical reflections on a research study dedicated to the educational applications of 3D modeling and rapid prototyping aimed at facilitating participatory learning of and active interaction with the cultural heritage/legacies of universities.
The research addresses the issue of mediating between the operational modes and tools for research, architectural heritage education and academic heritage dissemination. One of the main objectives of the research is to critically examine the possible impact of academic heritage on its knowledge dissemination in public engagement actions, which falls under the Third Mission of the University (Compagnucci, Spigarelli, 2020).
The theme here discussed is a *tessera* of a mosaic, since it is a part of a research project named Geometry and Representation: Accessibility and Inclusion (GR.AI). This is dedicated to enhancing the accessibility of architectural and academic heritage by means of the Science of Drawing and Representation (Camerota, 2020; de Rubertis, 2018) and its application with the goals of social inclusion and disclosure of architectural/geometrical knowledge and culture.
The research is developed within the bachelor's degree in architecture from the Politecnico di Torino, specifically in the Geometric Modeling in Architecture elective course (MGA) (Pavignano et al., 2022). This course is dedicated to the themes of digital and physical modeling for the analysis and communication of architectural facts through an interdisciplinary interaction of the language of Geometry (Cumino, Pavignano, Zich 2020). The course is focused on a piece of proper tangible academic heritage of this institution, the Curioni Collection (Bocconcino, Vozzola, Pavignano, 2024). This set of 19th-century artefacts can also help us in framing the multifaceted roles of the academic heritage within the triple mission of universities and can also suggest some examples of best practices in the intertwining of Didactic, Research and Third Mission with a specific goal on knowledge dissemination.

2. State of the art

The research is based on the scientific framework of the Science of Drawing and Representation. It looks at the specific theme of Academic Heritage – as defined by the Declaration of Halle (2000) and specified by the Council of Europe (2005) – within the context of the triple missions of universities.

2.1 The Science of Drawing as a scientific framework

As indicated in the Introduction, we operate our research into the scientific framework of the Science of Drawing and Representation (SDR). We propose critical and creative applications of its principles as analytical tools for the representation and subsequent visualisation of the studied Academic Heritage. In other words, the study presented here allows us to engage with the merits of the issues addressed through specific declinations of the visual grammar of drawing (Piedmont-Palladino, 2019). It is therefore appropriate to specify from the outset that drawing, thanks to its statutes and tools, can be considered a true language of a purely visual nature, that is, a mode of interpersonal communication based on the constructive use of graphemes and iconemes that might give birth to both graphic and tangible representations.
From an epistemological perspective, we can find an initial definition of the Science of Drawing and Representation in the theoretical formalisation of the projective concept of perspective (Camerota 2020). In this sense, the perspective construction guided by geometry is brought closer to the concept of human vision, and the mathematical rules that support its structure are provided. It is evident that this initial association of representation with the concept of science can be attributed to the primary recognition of the interdisciplinary value of representation as the expression of a codified and codifiable language capable of unveiling the procedural nexus that connects the eidetic world with the phenomenal world. From a procedural point of view, the science of drawing is what was defined by H. Speed (1920), i.e. the interaction between vision, perception and

artistic techniques applied to the creation of graphic representations that also have the value of visual memory. In the wake of this second interpretation is the view of drawing (as one of the possible declination of representation) as a place for learning to observe, investigate, analyse and compare, i.e. as a moment of knowledge stimulated by the 'drawing' of mental models and/or the phenomenal world (Petherbridge, 2010) or as a tool for educating thinking (Ravaisson, 2016).
A third interpretation of the concept of the science of representation has been clarified by the holistic view that understands it as the set of those complex interactions between ideas and images made explicit in an accomplished sense through representational operations (both intangible and tangible, digital and analogue) (Docci, Gaiani, Maestri, 2017). It seems clear that this third declination is inclusive of the first two and reveals their general and specific characteristics in a single place, that of representation.
Thanks to these epistemological interpretations, we can clearly define the cultural framework of the research presented as that of the science of representation (or the science of drawing). It allows any problem of any nature to be investigated graphically, all the characteristic aspects of the phenomenal world. This desire for representation has often been observed as the outcome of a necessity linked to those «communicative opportunities» that through the application of the practices of representation to all human activities pertaining to the use of the image both as a qualified objective of aesthetic communication and information and as a design tool for all sorts of artefacts (de Rubertis, 2018). Hence, any operation of analysis and communication of the results of research of a purely visual nature, i.e. aimed at the definition of tangible and intangible images (Cicalò, 2016), cannot disregard the necessity of its graphic representation, carried out thanks to the critical and creative interpretation of the statutes of representation.

2.2 The triple missions of universities

Starting from the 1980s, the universities all around the world have been facing "remarkable structural and functional changes" (Sánchez-Barrioluengo, 2014). Among them, the formal recognition of their triple missions emerges. Those missions were framed in: 1) Teaching/Didactic/Education; 2) Scientific Research; 3) the so-called Third Mission (TM) (Taliento, 2022).
The first one has been the driving force for the very concept of 'universitas' since its foundation in the 13th century (Cavaller, 2014; Fernández et al, 2019). The second one followed and always characterised the academic institutions as well (Sánchez-Barrioluengo, 2014). The highlighting of the existence of the TM has been an essential statement for universities, since this concept subsumes a variety of 'actions' and 'interactions' between academies, industries, policy makers, and the public society (Sabatini, 2022; Gaffaro Garcia, 2025). In this sense, the TM comprehends all the aspects of knowledge transfer and knowledge dissemination, both via outreach actions and public engagement activities. A foundational interpretation of this topic was provided by Etkowitz and Leydesdorff (2000) who established the concept of the Triple Helix where the search for innovation must be the result of a close debate between universities, industries, and governments. Another important statement comes from Touriñán (2020), who clearly highlighted the key component of the TM to be the transfer of knowledge at all levels.
Starting from personal research interest oriented toward the study of our academic heritage, here we operate on the first mission with the goal of transferring knowledge to our students to help them shape their critical analysis-related skills. This step is directly intertwined with the Third Mission, since we guide our students toward a public engagement action (conducted based on their personal research within the frame of MGA course).

2.3 The Science of Drawing in the triple mission of universities

Before entering the core of the paper, it is important to frame the Science of Drawing and Representation within the triple mission of universities, with specific regard to the architectural studies and research. The first mission of universities deals with the Science of Drawing in two main ways, since SDR is a subject of teaching actions but can also provide a powerful set of tools that can support other subjects by creating visual/graphic/tangible representations of complex concepts/issues. Following this idea, the second mission of universities can also benefit from the visual support of the SDR. Nonetheless, SDR is a subject of study, with its statutes and applications. Still, the SDR can enter the TM since it provides analogue and digital support for most of the activities related to the TM. In this case, we focus our attention on the so-called public engagement.

2.4 Academic heritage and dissemination

In the European context, there has been a marked increase in the scientific community's attention towards academic heritage (AH) over the last 25 years, for which the Halle Declaration (2000) provided an initial framework. Then, the Council of Europe's Recommendation (2005) established the definition of university heritage as that set of tangible and intangible witnesses of the history of university institutions and the scientific research conducted in them (Soubiran, 2008). Thus, it can include not only archival and bibliographical documents, but also every kind of scientific instrument or specific tool once used for research and educational purposes. By now, this heritage has been recognised as both a testament to the critical exploration of the scientific method and a potential tool for the promotion of scientific research through its dissemination to a broad and non-specialist public in the context of the TM of universities (Bernabè, Tinti, 2020). A growing awareness of the cultural potential of academic heritage has emerged, facilitating its study and dissemination beyond the confines of university museums and archives (Suárez Menéndez, 2024), thus inserting the AH within the triple missions of universities (Fig. 1).

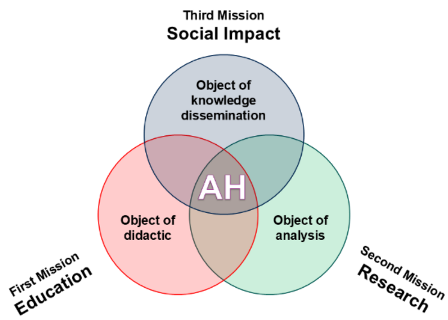

Fig. 1. The AH and the triple missions of universities (Graphic elaboration by MP).

3. Methodology of the research

As already stated, the research is based on the application of the SDR to the academic heritage within the context of the triple mission of universities. To this extent, the research is structured in six steps:

Step 1, recognising the cultural value of the academic heritage of our institution as a founding element for the polytechnic culture that supports all our teaching, research, and third mission.
Step 2, identifying the parts of the academic heritage that can be useful for education and disseminating the architectural facts of our interest.
Step 3, analysis of artefacts through redrawing from graphic sources, direct surveying, and digital modeling (MGA course).
Step 4: design tangible artefacts suitable for the inclusive communication of the analysed academic heritage for a specific audience, namely the European Researchers' Night One (ERN).
Step 5: verification of the effectiveness of the artefacts during ERN 2024, with heterogeneous and non-heterogeneous audiences, also involving high school classes with students with Children with special educational needs and disabilities (SEND).
Step 6, critical analysis of the results obtained and re-proposal of the course to a second group of learners.
Step 1 and Step 2 have already been discussed (Bongiovanni, Angelini, 2019; Bocconino et al., 2024; Bocconcino, Vozzola, Pavignano, 2024). They defined the subject of the research, the Curioni Collection of tangible artifacts, as a good example of the Academic Heritage of our institution (Bocconcino et al. 2023), thus providing a structural framework for its dissemination. The collection includes more than 140 artefacts created in the second half of the 19th century for the teaching of Building Mechanics and Construction Science. Both Steps are at an advanced development but are not the focus of this paper.

4. Materials of the research

4.1 The Course Geometric Modeling in Architecture (MGA)

Step 3 and Step 4 of the research has been implemented in the Geometric Modeling in Architecture course (MGA). It is a multidisciplinary course of the third year of the Bachelor Degree in Architecture. It involves the disciplinary sectors of Drawing (CEAR-10/A) and Geometry (MATH-02/B). The focus revolves around Geometry understood as a shared language between the two disciplines and, therefore, the incipit of an approach that, in practice, becomes interdisciplinary.

4.1.1 Course structure. The course, of the student-selected type, is structured in theoretical lectures, multidisciplinary exercises, interdisciplinary educational field trips, and consequent personal development of a physical and digital model descriptive of architectural geometries.
In the last two academic years, we identified some models from the Curioni Collection as possible objects of study, with a specific attention to the 25 artifacts representing vaulted surfaces (Fig. 2). This allowed our students to investigate the academic heritage as a cultural heritage and to rediscover its ancient value as a training tool for the school of engineering and architecture.
The models from the Curioni Collection were devices for technical-scientific knowledge and are today a heritage that is difficult to share because it is protected and therefore not freely usable. The study of the Curioni Collection is proposed as a stimulus to propose new forms of accessibility in compliance with its conservation and inclusion, with the aim of opening it to a non-specialist public in contexts of the TM of universities, such as the European Researchers' Night (ERN) activities.
We guided our students to develop their own sensitivity regarding the accessibility of information by directly exploring different communication methods, especially through choral experiences. Our intention was to lead students to develop their spatial prefiguration, representation, and modeling skills for sharing both the object of study and their entire cognitive process.
The multidisciplinary nature of the theoretical lessons allows the architectural geometries to be narrated with different tools and languages to educate the choice of the most suitable tools for Representation/modeling in compliance with the expressive purposes. In fact, the course illustrates different methods of tangible/haptic and digital modeling with particular attention to the interpretation of the mathematical contents that are intended to be conveyed through the design of new prototypes.
The focus of the course is not to produce a copy of the existing models but to reinterpret them to explain their geometry and therefore identifying the correlation between the descriptions proves to be an essential requirement (Fig. 3).
The guided exploration of existing models included in permanent exhibitions was an integral part of the course, being preparatory to starting work on the Curioni collection. Moreover, students could evaluate their communicative effectiveness in relation to the type of users. Specifically, we proposed a visit to the Cinema Museum of Turin located in the Mole Antonelliana. This has been an opportunity to seek answers to many of the questions proposed during the theoretical lessons.

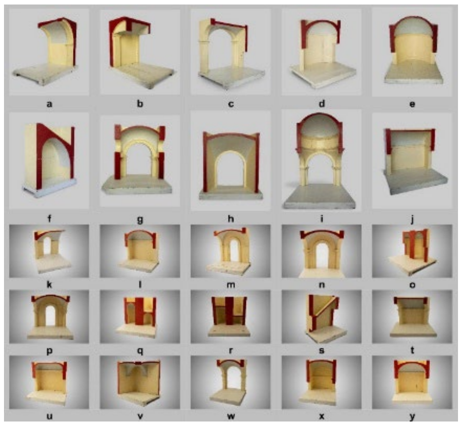

Figure 2. Vaulted surface models of the Curioni's Collection (courtesy of M. Bongiovanni, Politecnico di Torino, ARIA. Graphic elaboration by MP).

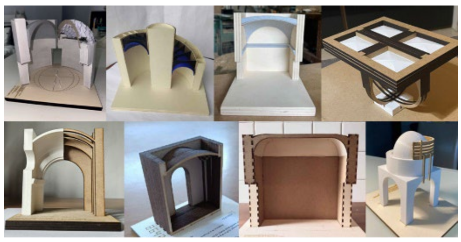

Figure 3. Examples of students' works, by RC, AG, FM, BI, BR, EI, a.y. 2023/24 (Graphic elaboration by UZ).

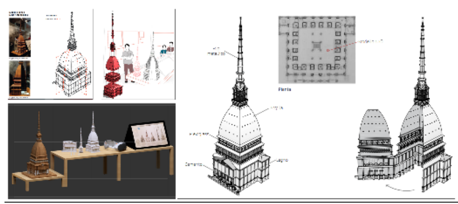

Figure 4. The Mole Antonelliana. Working on site. Observing models, proposing models, students' works, a.y. 2023/24 (Graphic elaboration by UZ).

There, we analysed a wooden model of the Mole Antonelliana, which is cut to allow for viewing of the interior. It is positioned at eye level so that it can be explored by touch and included in a tour itinerary designed for the visually impaired. The choice to show it to students has a double value: direct, in being able to explore the model firsthand and verify the quality and quantity of information in relation to the scale of representation, prototyping techniques and materials, accessibility and effectiveness in communication; indirect, in being able to observe other visitors, their approach and the resulting dynamics of comparison with the model (Fig. 4).
To complement the individual experience, we asked students to try to look for those elements in the real architecture that the model had emphasized and to look for the optimal points of view to read them best. Subsequently, divided into groups, they were asked to make a review of the observed model, identifying its strengths and weaknesses, analysing the model as a single object and/or as an element of a system. The subsequent debate was introductory to the work on the Curioni Collection.

4.1.2 From model to model. The request to create descriptive models of the Curioni artifacts was supported by the illustration of the *modus operandi*, starting from the multiple sources that can be consulted: graphic, textual, and material approach (Fig. 5).
Between signs and drawings, conventions and graphic codes, the graphic sources reveal the process of synthesis typical of each inevitably non-exhaustive representation that the comparison with the textual description emphasizes.

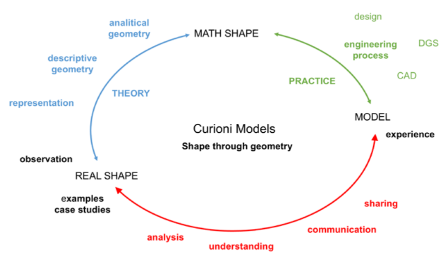

Figure 5. Curioni Models through geometry (Graphic elaboration by UZ).

The students were asked to develop the information acquired from each source in parallel, compare it, and critically evaluate how and whether to integrate it before starting the digital modeling. The additional opportunity given by being able to interact with the physical object has increased the variables around the shape to be represented: the survey operations, direct and/or indirect, in fact offer concrete information that differs from the theoretical model drawn and/or narrated. As in any survey, at any scale of representation, the comparison between the sketches and the acquired data, between restitution and rectification, leads to interpretations that necessarily distance themselves from the theoretical form, typical of the purely geometric approach (Fig. 6). The critical process of integration between the sources supports the creative process of the physical model with the intention of narrating its geometric specificities.

Figure 6. Survey of some Curioni's models, a.y. 2023/24 (Graphic elaboration by MP).

4.1.3 How to model. The path that leads to the realization of tangible artifacts is underpinned by a digital modeling workflow (Fig. 7). In fact, this workflow is based on a systematized approach to geometrical modeling via proper software, like Rhinoceros 3D. The described procedure is based on consolidated approaches (Spallone, Bertola, 2020). To achieve a digital representation of Curioni's artifacts, first, we guided students across the interpretation of Curioni's graphic representation via a 2D redrawing process. This first digital step supported students' comprehension of Curioni's written description and graphic illustration and was the base for the second step, dedicated to 3D reconstruction of Curioni's ideal models and their geometries. This step created a set of digital copies of the original artifact. Those copies could then be used to design tangible artifacts and their prototyping strategies. In this sense, we explored, for example, laser cutting (Tagliari, Florio, 2013), 3D printing (Bertola, 2021), paperworks, and origami (Cumino, Pavignano, Zich, 2020). Nonetheless, we let students experiment with many types of prototyping techniques: some of them used 3D printing to realize moulds for pouring gypsum/concrete to obtain heavier models.

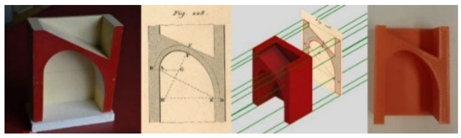

Figure 7. Example of the geometrical modeling workflow, a.y. 2023/24 (Graphic elaboration by MP).

4.1.4 Which model? The multiple variables inherent in the path just described offer infinite possible declinations. How many and what contents can be shared? How? And with whom? Dynamics with different purposes and users were illustrated within the course. Here we discuss two artifacts of the very last a.y. Even though the request was to model a vaulted structure among the many illustrated by Curioni, one hypothesis was to narrate only the theoretical surfaces and not their application.
This is the choice made by the student NF in analyzing the vault with splays. An initial process of comparative reading of all the available sources suggested a comparison between the consequent digital modeling to highlight the non-exhaustiveness of each of the descriptions analyzed individually (Fig. 8).

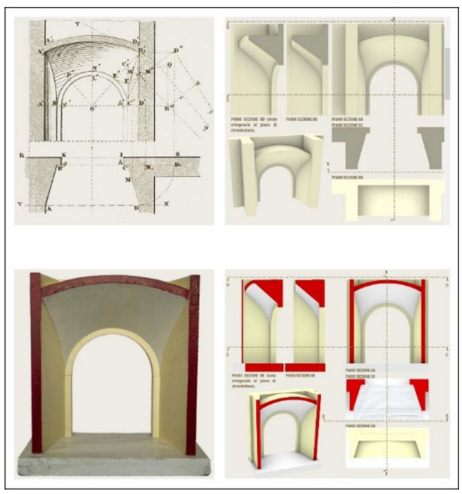

Figure 8. Vault with splays. Analysis and digital modeling from sources. Above, from graphic and textual description, below from direct survey of the physical model. NF, a.y. 2024/25 (Graphic elaboration by UZ).

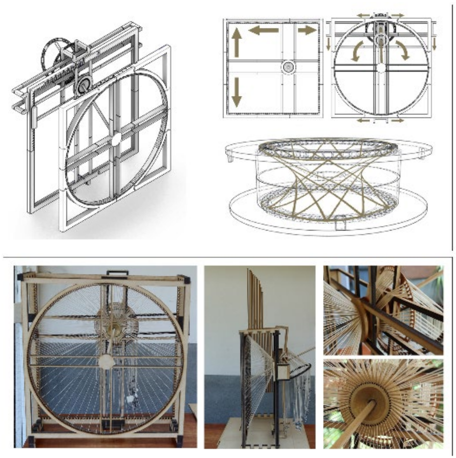

Figure 9. Wire model, laser-cut structure and 3D printed elements, NF, a.y. 2024/25 (Graphic elaboration by UZ).

Subsequently, referring to the theoretical lesson dedicated to the catalogs of mathematical surface models, NF believed that the most effective way to describe the geometry of this vault, invisible to many in the Curioni model but very present in its graphic and textual description, was to model it as a tangible description of the theoretical surface. How then to narrate in an accessible way the surface of the cone with a defined base and dynamic vertex to a non-specialist audience? In her examination work, making explicit reference to Schilling’s wire models (Schilling, 1911, pp. 112, 113), NF ranges between graphic, analytical, and tangible theoretical descriptions, proposing a modern version that integrates wires, 3D printing, and laser cutting (Fig. 9).

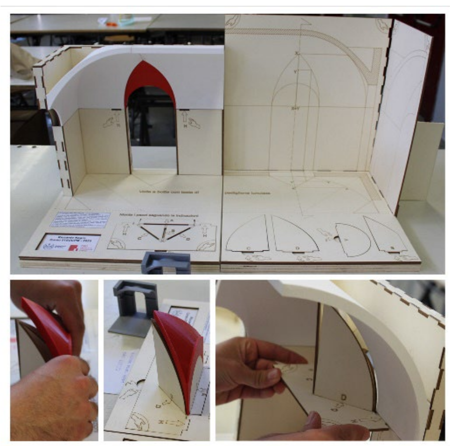

Figure 10. Barrel vault with lunulated cloister head. Model and sources for geometric analysis. RN, a.y. 2024/25 (Graphic elaboration by UZ).

The design exercise of the model clashed with its feasibility: from an initial idea entirely made with wires and a 3D printed structure, in 1:1 scale, with unmanageable times and costs for a didactic experience, its declination with the structure optimized to be prototyped with laser cutting highlighted the need for a further design phase for the resolution of specific problems in its dynamic dimension for the movement of the vertex of the cone. Its communicative effectiveness is a consequence of its geometric nature, visible and tangible at the same time; it is an expression of concrete geometry (Zich, 2023).

ERN’s approach is different, representing the object described by Curioni while maintaining an explicit relationship with the sources: it proposes a dihedral with laser-cut orthographic projection planes on which the incomplete tangible model is inserted. In the support base, there are elements and instructions to complete the assembly of the different parts and to be able to directly verify the constituent geometry. The possibility of reading the 3D object together with the graphic and textual sources proves to be extremely effective and exemplary of the procedural model of teaching dynamics (Fig. 10).

4.2 Dissemination

Step 5 benefits from the focus of the course: sharing the Curioni Collection with physical models as a means of communication. In this Step models produced by students become both an end and a means. In this sense, the entire prototyping process, if conveyed to the user, also becomes part of cultural dissemination.
The dissemination process, therefore, begins in the design phase when approaches, tools, activities, and languages are chosen based on users and context.
The ERN context is the ideal context in which to experiment because it presents the work of researchers in unconventional places and therefore the way in which the activities are designed and shared becomes fundamental. ERN is in fact the opportunity not only to present a work but to share and actively involve in the knowledge process.
Inserting cultural dissemination activities into the 2023/24 course program was a challenge: when we proposed to the students to participate in the event, go to the square and personally verify how the public welcomed their proposals, we did not know what the outcome would be. Participation was free and not tied to taking the exam, which represented only a simulation of the same, with the possibility of presenting one’s model to a colleague in the course (Fig. 11). Today, we can say that the response from both students and the public was remarkable: many participants on both sides, interesting critical feedback, and stimulating interaction with the user. Relaunching the experience this year was a natural evolution of the project.

Figure 11. ERN 2024, dissemination of Curioni’s Collection (Graphic elaboration by MP).

Although the design path of the tangible model was immediately directed towards accessibility and inclusion, when used by an unaware user, the limits of many projects emerged. The physical models, designed to communicate the latent geometries of the artifacts to a heterogeneous audience, have not always been effective because they are mostly static and/or complex in wanting to be exhaustive. Some, designed to convey only certain information related to theoretical surfaces, have involved the public more, so much, to encourage interaction with students and, in this way, to get closer to objects previously considered more

complex. The possibility of exploring physical and digital models in parallel has conveyed a variety of languages with common intentions. Through this experience, students have also verified their specific linguistic and descriptive skills, essential for a scientific communicator.
It is interesting to observe how the users, heterogeneous in age and education, have sought interaction with students intrigued by this opportunity.
The possibility of telling one's own path, from having manipulated an object normally inaccessible to having designed an interpretation to share its educational value, has proved to be a precious moment of applied training so much so that it has been proposed again in the current academic year as the objective of the course and method of discussion of the exam.
Observing a generic user manipulating their models is an opportunity to verify their effectiveness by introducing the need to distinguish different modes of use: autonomous, assisted, guided. Curioni's models, also through the 'different twins' resulting from the students' interpretations, have reclaimed their identity as training tools, encouraging the sharing of experience. Furthermore, on this occasion, the models of the Curioni Collection have offered a concrete opportunity for comparison between theoretical and tangible geometry, between the project and the survey of an artefact.

4.2.1 New perspectives of the course and first results awaiting validation. Given the feedback from the experience at ERN 2024, the 2024/25 course was entirely dedicated to the design of teaching aids dedicated to ERN 2025 with greater awareness. Furthermore, having had parallel experience of working with users with SEN (Zich et al. 2025) further oriented the teaching of the course.
Based on the experiences shared by students who presented their work at ERN 2024, some of this year's students decided to propose semi-guided activities for the discovery of the concrete geometry of Curioni's models. SD, for example, proposed the activity of decomposition and recompositing of simple volumes to build the complex system of spandrels, drum, and dome, starting from a cupola, a cylinder, and a sphere with the operation of adding and subtracting volumes.
The activity, illustrated simply through a diagram that summarizes which solids are at the base of which part of the model, proves to be accessible; furthermore, the introduction of a color code facilitates the task making it accessible even to the youngest and the presence of magnets to aggregate the parts is of immediate use. The use of a mirror allows you to verify the presence of symmetries and interact more with the model, arriving at seeing the complete shape, even with only half the model (Fig. 12).
Similarly, PG chooses to have the individual parts of the model compared with the theoretical forms but identifies a different activity: the theoretical forms are static and created as a sequence of section planes cut with the laser cutter, the parts of the vault to be compared are created with the 3D printer and the assembly methods of the parts are intuitive (Fig. 13).
Comparing the two activities, it is clear how PG believes it is possible to describe the theoretical forms without directly modeling the surfaces, leaving the user to complete the meaning of what he observes and explores. The fact of being able to move the printed element on the theoretical surface makes the geometric description extremely effective.

5. Results and discussion

As recalled, Step 1 has already been the subject of investigation and is currently undergoing advanced development, having identified the Scientific Collections of the Politecnico di Torino as ideal activators of scientific research dynamics on the history of the institution and the value of the academic heritage within the polytechnic culture (Bocconcino, Vozzola, Pavignano 2024). Step 2, which has been completed, enabled the selection of Giovanni Curioni's Collection of wooden models (second half of the 19th century) within the various scientific collections. This step, in particular, focused research attention on the 25 artefacts dedicated to studying vaulted surfaces that had become the object of study for the subsequent step.

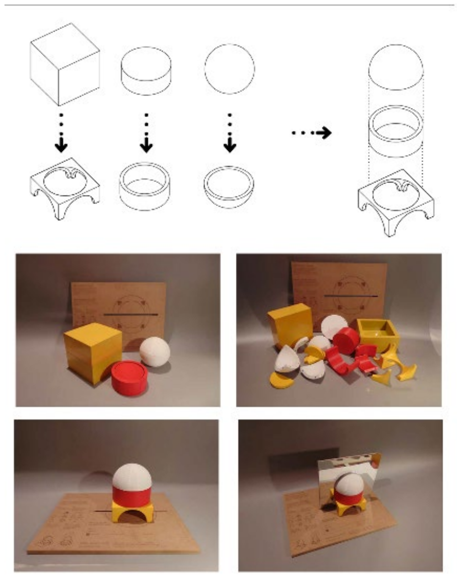

Figure 12. Break down and reassemble the pieces to build the dome on its drum and pendentives, SD, 2024/25 (Graphic elaboration by UZ).

Figure 13. Build the dome and compare its geometries, PG, 2024/25 (Graphic elaboration by UZ).

Step 3 involved the selection of nine models from those chosen in the previous step. These artefacts were submitted to the course students, who were tasked with creating digital reproductions from drawings published by Curioni in his *L'arte di fabbricare* (1866). Then, direct verifications were to be conducted on each model.

In Step 4, the students were tasked with the development of a communication project for the models that had been studied. This project was to be designed with the ERN 2024 audience as the intended users. To this end, the students were required to devise a prototyping strategy for their artefacts, drawing upon the digital models they had developed. This strategy encompassed the most prevalent rapid prototyping and additive manufacturing systems, such as laser cutting and 3D printing. The project focused on communication, and the expected models were designed to explain the geometries recognised and detected on the individual artefacts. This resulted in the design and prototyping of 36 artefacts during the a.y. 2023/24 and 27 for the a.y. 2024/2025. The latest will be presented during the ERN 2025.

Step 5 enabled the direct observation and verification during ERN 2024 of the models prototyped and will be repeated on ERN 2025. Here, students engaged in a public showcase of their individual communication projects, thereby highlighting the strengths and weaknesses of the various artefacts. The event played a pivotal role in the students' education, as it compelled them to illustrate their work to a diverse audience, extending beyond the confines of the course faculty and their colleagues. Furthermore, it facilitated the dissemination of a part of the academic heritage of the Politecnico di Torino to the wider community, thereby transcending the prevailing accessibility constraints, primarily attributable to the inadequacy of adequate premises for the exhibition and narration of this heritage. The verification process was conducted through diverse methods of public engagement, encompassing heterogeneous users and the high school classes participating in the project to share and discover the academic heritage.

Step 6, currently underway, involves ex-post evaluation of the research results and paths. The critical issues that have been identified at this stage, thanks to ERN 2024 experience, are as follows:

- The use of physical artefacts that did not always respect the geometries of the artefacts belonging to the Curioni Collection.
- The fragility of some artefacts whose prototyping did not provide for prolonged public handling.
- The difficulties in interacting with a physical model and communicating its latent geometries.

To face such issues, we will organize a pre-ERN 2025 workshop for the students who will to participate, in order to help them to improve their communication skills before the ERN actions.

Still, this research allows us to better understand the value of the Academic Heritage of our institution. Moreover, this research could frame, probably for the first time, the triple role of the AH within the triple missions of the university. In this sense, whichever piece of AH, tangible or intangible, could assume different values when related to each of the three missions, even from an epistemological point of view. The Curioni's models changed their status from being tangible aids for 19th-century education to being witnesses of such procedures.

6. Conclusions and future developments

The research presented herein offers several points for reflection. Firstly, it is demonstrated that the contribution of heritage digitization should not necessarily aim at its mere dematerialisation and reproduction in virtual environments but can provide the basis for a return to the analogue artefact, which is by nature finite and tangible (Smith, 2004). However, the experience revealed the need for greater integration between the virtual and physical worlds, suggesting possible evolutions of the research project. These evolutions would involve implementing AR and XR interactions between the artifacts of Curioni Collection and its tangible representations. This will be facilitated by the 'ongoing' developments of Step 2. This integration may also contribute to defining a set of distinct digital twins of the same object, targeting different audiences and dissemination moments.

The dissemination of the academic heritage of our Politecnico can also serve as a valuable opportunity to promote scientific knowledge related to the construction field. The physical model has already demonstrated its efficacy as a flexible medium for engaging users with diverse cognitive abilities, facilitating participatory educational experiences within the polytechnic culture.

Credits

While the research is the result of the collaboration between the authors, M. Pavignano wrote paragraphs 1, 2, 2.1, 2.2, 2.3, 2.4, 3, 4.1.3, 5; U Zich wrote paragraphs 4, 4.1, 4.1.1, 4.1.2, 4.1.4, 4.2, 4.2.1. Both authors wrote paragraph 6.

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