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Finding the Lost 16th-Century Monastery of Madre de Deus: A Pedagogical Approach to Virtual Reconstruction Research

Jesse Rafeiro [1,*] and Ana Tomé [2]

[1] Tokyo College, University of Tokyo Institutes for Advanced Study (UTIAS), Hongo, Tokyo 113-8654, Japan
[2] Civil Engineering Research and Innovation for Sustainability (CERIS), Department of Civil Engineering, Architecture and Environment (DECivil), Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal; anatome@tecnico.ulisboa.pt
* Correspondence: jesse.rafeiro@mail.u-tokyo.ac.jp

Abstract: This article outlines a pedagogical approach to the virtual reconstruction of the 16th-century Monastery of Madre de Deus, Lisbon, Portugal. The monastery was built upon a former palace in 1509 by Queen D. Leonor. After her death, it underwent several modifications until its present function as the National Tile Museum. These modifications have obscured its history as one of the most significant religious buildings of the Portuguese Renaissance. To recover this lost history, the research uses a pedagogical approach combining previous scholarship, a laser scanning survey, archaeological survey data, written and graphic historical descriptions, and discussions with historians. The article has two principal aims: firstly, to concretize the results of the eight reconstruction projects produced by students using a Historic Building Information Modeling (HBIM) methodology. Secondly, to present an alternative model of teaching history and digital technologies. Our research suggests that extending virtual reconstruction research into pedagogy can provide highly original interpretations of complex and contradictory architecture. The approach promotes meaningful collaborations between researchers and cultural institutions while immersing young professionals in the digital tools and current philosophies of architectural heritage.

Keywords: Historic Building Information Modeling (HBIM); virtual reconstruction; digital modeling; digital surveying; laser-scanning; 3D-printing; architectural pedagogy; e-learning; Manueline architecture; Mudéjar architecture

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1. Introduction

1.1. Finding the Lost 16th-Century Monastery of Madre de Deus

Since 2019, we have undertaken research for a virtual reconstruction project with the National Tile Museum (Museu Nacional do Azulejo), Lisbon, Portugal. So far, the main objective has been to develop digital models to visualize and examine various hypotheses about its historic foundation as the Monastery of Madre de Deus in the 16th-century until today. The work will play an important role in demonstrating the underappreciated and lost history of the building in the present. This includes a deeper understanding of the life of the Colettine nuns who resided there and, for the first time, visualizing the unique hybrid of Manueline and Mudéjar architecture that once coexisted there.

Today, the National Tile Museum holds immense cultural significance through its active preservation and education of the Portuguese tile painting tradition and its permanent collection of Portuguese tiles from across history. Despite this important function, visitors are rarely aware of the building's rich history and former significance as one of the most important religious sanctuaries of the Portuguese Renaissance. Here, sanctuary is defined as any form of chapel, hermitage, or church with continual attraction to religious communities beyond the local community [1] (p. 71). These kinds of sacred spaces were often sought because of their curative properties, miracles, or other devotional dimensions. The

Monastery of Madre de Deus was not simply a privileged space for nuns of the Colettine Order, it was a site filled with relics that inspired many pilgrimages and religious festivities.

Prior to its present function as the National Tile Museum, the Monastery of Madre de Deus was founded in 1509 by Queen D. Leonor and took the place of a pre-existing Mudéjar palace on the coast of the Tagus River in Lisbon, Portugal. It is the second oldest of the reformed Clarissa's in Portugal, with the original seven nuns having previously founded the Monastery of Jesus in Setúbal in 1491. However, it is very difficult to imagine how the Monastery of Madre de Deus would have looked at its founding. No single historical source describes the building in its entirety. Adding further to this difficulty is the fact that the 16th-century configuration of the monastery would have only existed for a short window of time.

Soon after the death of Leonor in 1525, the building underwent expansion work by King D. João III around 1555 which greatly increased the original footprint of the monastery. This was a response to complaints about the small size of the monastery and the consistent flooding of the first church due to rising waters from the Tagus River. The expansion, consecrated in 1624, included a new church, cloister, refectory, infirmary, and bell tower as well as a private royal balcony within the church. This intervention largely defines the building's footprint today.

In the 19th-century, following the extinction of religious orders in Portugal (1834), the monastery was adapted to house the D. Maria Pia asylum by the architect José Maria Nepomuceno, with works beginning in 1871 and carried to completion by the director of public works, Liberto Telles, in 1899. In this conversion, considerable effort was made to retrieve the lost Manueline architectural elements of the 16th-century which had been erased during the expansion by King D. João III. The building that exists today is thus primarily a result of this 19th-century Neo-Manueline conversion attempt to retrieve a stylistic memory of the original monastery. In the 20th-century, a new space-functional reconversion took place with the installation of the National Tile Museum in 1965.

While the long-term aim of the project is to virtually reconstruct all these phases of history, the project presented in this article focuses primarily on the initial period of the building's transformation from a palace to a monastery in the 16th-century—a period of history that is the least understood by experts today. The spaces discussed relate to the foundation of the original nucleus which includes the original church, the low choir, the chapel (known as the Arab Room), and the small cloister. Due to the lack of historical information, no effort was made at this point to reconstruct living spaces such as the refectory, kitchen, and dormitories of the nuns. In order to understand this 16th-century nucleus, punctual modeling tasks related to the 17th-century, 19th-century, and present state of the building were also introduced.

1.2. Why HBIM? A Theoretical Background

In recent years, Historic Building Information Modeling (HBIM) has been applied to a variety of similar research aims such as virtual reconstruction, rehabilitation and conservation, building management, and the documentation and public dissemination of architectural heritage [2–6]. HBIM applies a Building Information Modeling (BIM) methodology to historic buildings—usually using point cloud data from laser scanning surveys—to produce millimeter-precise models. In some cases, these models also incorporate historical drawing sets or other historical knowledge to speculate on the past phases of a building's history or to understand the material composition of a building in cases where physical interventions are not permitted [4].

We believe that adopting an HBIM approach is important to meet the integrated demands of scientific accuracy, current conservation practices, and the long-term accessibility of digital heritage. With the possibility for the digital model to be populated with non-geometric information, ranging from historic data to levels of uncertainty or deformation analysis [7], it can serve as a functional archive and research artifact for the dissemination of heritage [8,9]. This is especially important to manage information about the past. Digital

models created through this approach can also contain important information regarding the way a digital record was created, the accuracy of modeled geometry, the scientific validity of the reconstructed elements, and textual reference material [10]. Through this, they contain all the data necessary to meet the rigor of current international standards for virtual reconstructions outlined in the London Charter (2009) [11] and the recent Principles of Seville (2017) [12]. Furthermore, the process utilizes millimeter-accurate digital surveying techniques such as terrestrial laser scanning and photogrammetry which are fundamental in current practices of rehabilitation and conservation [13]. The Industry Foundation Classes (IFC) data model built into the software ensures long-term accessibility. The files are open-source, platform-neutral, and software interoperable [14]. In the face of BIM obsolescence, the format specification would allow the data to be recognized and accessible.

Usually, the tool of choice is Autodesk Revit, however, there is also growing competition from other tools such as ArchiCAD and BricsCAD which are lower-cost alternatives. Regardless of the specific tool, BIM is a growing industry standard digital modeling process used in the architecture, engineering, construction, and operation industry (AECO). Considering that the European Commission predicts that 85–95% of existing buildings will still be standing by 2050 [15], it seems even more imperative that architects have the skills to use BIM to document existing buildings and heritage, especially when governments across the world continue to mandate BIM for public and private projects [16].

Despite these observations, few examples can be found for HBIM pedagogies that address cultural heritage through an HBIM approach. The approach outlined throughout this publication is the only known course of its kind to use HBIM as a tool for collaborative learning which combines historic research and virtual reconstruction. To the best of our knowledge, this is innovative—in terms of the HBIM courses offered both within Portugal and internationally. The existing offers range from courses for professional training or recent graduates, with a short duration [17–19], to specialization courses or masters, with longer durations, typically up to 12 months [19–21]. These existing examples emphasize technological training with data acquisition, modeling, or both. The intersection of HBIM modeling with point cloud modeling, historical research, virtual reconstructions, and digital storytelling is not at all common.

One of the topics that has been recently debated in academia is precisely the contribution of digital content to the public knowledge of heritage. Such models, sometimes constructively very detailed and complex, remain closed within architecture and engineering offices. The complexity of the software and its operating costs constitute barriers that are difficult to overcome. These barriers raise ethical questions about the dissemination of knowledge and, ultimately, the very preservation of heritage insofar as the latter depends on the former. The democratization of culture means, broadly speaking, creating culture available to all [22]. The case of the virtual visit to the Canadian Parliament buildings is an interesting example of these concerns which leverages an HBIM and the data used to create it into a virtual tour to maintain the public engagement with heritage during a rehabilitation campaign set to endure for several decades [23].

The HBIM pedagogical approach to virtual reconstruction research outlined in this research was implemented in the HBIM (Historical Building Information Modelling) course of the last year of architecture. It is a recently created course (2021–2022) in the Integrated Master's in Architecture, at Instituto Superior Técnico, Lisbon University (Lisbon, Portugal).

2. Materials and Methods

2.1. Designing a Pedagogical Model for HBIM

Designing an appropriate pedagogical model to address the complex research questions involved was challenging for several reasons. Firstly, little to no remains of the 16th-century are currently intact. Secondly, the process of virtual reconstruction bridges history and digital modeling, which are normatively two separate domains of architectural pedagogy. Instead of a rote multiple choice or date identification, how could an HBIM

course introduce history through a project-based mode of learning? Instead of a step-by-step modeling course, could HBIM be integrated into research to accurately visualize the past?

Four initial lectures provided context to the types of work currently going on within the field of digital heritage and virtual reconstruction. Differing uses and definitions of HBIM were presented as case studies. Basic concepts such as the level of detail, level of accuracy, and level of information were introduced along with strategies of parametric modeling with point cloud data. The technical processes of data acquisition were also introduced.

To stimulate awareness of their role as active participants in a field of research, questions were introduced during the initial weeks of the course and were continuously asked throughout the learning process. The repeated questions were: How do we visualize and compare the past and present? What is too much, or too little detail? How should we define intangible heritage? How can we model something which only exists in 2D? How can BIM be a tool for historic research and conservation? How do we translate a painting into a spatial experience? How do we represent uncertainty and partiality? What criteria justify the use of case studies for virtual reconstructions? How do we communicate historical inaccuracies? What can this form of virtual reconstruction contribute to revealing complex architectural histories? How can we represent our speculations of both the possible and impossible? How can our findings be communicated to diverse publics in engaging ways? These questions did not have definitive answers and each group approached them differently. Contrary to normative pedagogical models in the university, the "answers" could not be known prior to the activity of learning because they could come only through the process of reconstruction.

Because the modeling procedures for BIM have been exclusively intended for modern construction composed of standardized building elements, it is often difficult to adapt the tool to suit the specific requirements of historic buildings which are often built according to the irregularity of local materials and the human hand. Furthermore, it is difficult to find learning resources for modeling historic buildings from point clouds since Autodesk Revit and other companies do not formally acknowledge the use of their program for these purposes.

Prior to the start of the course, we developed an e-learning course through our website and research venture, Investigation in (cultural) Patrimony: Tangible and Intangible (IPTI). The course, titled "HBIM—Basics", was developed so that students and practitioners could learn basic modeling methods [24]. The course was accessed individually by all students through individually assigned accounts. In this way, students could independently reach a common understanding of modeling in Revit from point cloud data during the initial three weeks of the course (Figure 1). The e-learning course was divided into several modules and provided step-by-step videos allowing students to learn at their own pace from any location while tracking their own individual progress. Each of the modules corresponds to an architectural building element or condition that is commonly found within any historic building. Additional videos about project set-up, data verification methods, and historical phasing were also given. In addition to a numbered sequence of steps, several tips were inserted throughout each video to explain how to overcome common difficulties.

While most of the students had some previous experience in Revit from a modeling course in their second year, the use of point clouds to model historic buildings was a novelty common to all. Despite this, all students were able to obtain substantial modeling skills with little supervision from instructors. This allowed much more time within the classroom to be dedicated to the research questions instead of modeling methods. With the videos accessible throughout the duration of the course, students could return to re-watch tutorials according to new modeling problems encountered in their work. In this way, the technology took the backstage while the primary focus remained on the research questions and communication efforts.

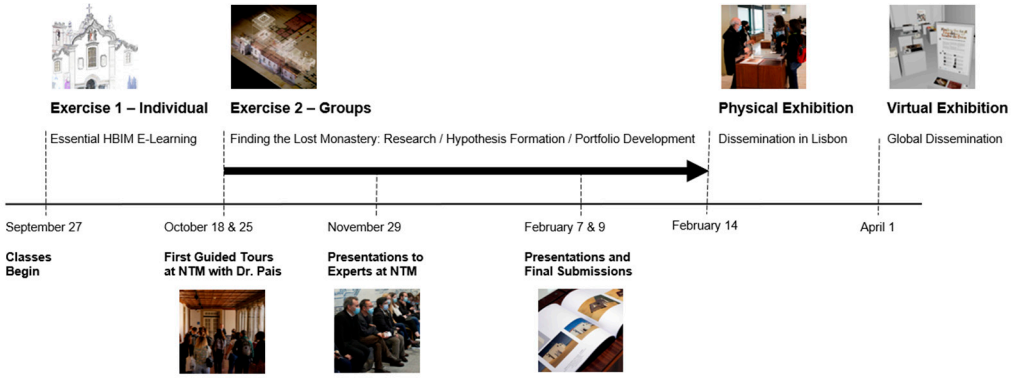

Figure 1. Calendar map of the semester from the first day of class on 27 September 2021 to the launching of the Virtual Exhibition on 1 April 2022.

After learning digital modeling from point clouds in Autodesk Revit, students were divided into eight research projects. Each space of the monastery was taken as a separate research project. Although there are flaws in reconstructing each space individually, this workflow was adopted for three main reasons. Firstly, the available references are normally given space by space and we are rarely able to understand the interrelations between spaces. Secondly, this method allowed a non-hierarchical interpretation of the historical evidence to ensure that any single space was not prioritized over another. Thirdly, at the pedagogical level, it was easier to divide the work among students in such a way without an excessive overlap between many students working in the same space.

Within the second month of the semester, an introductory tour of the National Tile Museum was given by the director. Students walked throughout the spaces of the museum to learn about the changing functions of the spaces and the present research hypotheses. By this point, students had already selected their topics and were able to ask questions about their specific reconstruction tasks as well as to clarify anything about the spaces that could not be understood from the datasets. During the third month, presentations of work in progress were given to experts at the National Tile Museum to receive feedback about the plausibility of their reconstructions. This was an opportunity to gather references and examples of similar buildings as well as to better understand how monastic life functioned within the 16th-century.

Following this round of feedback, students continued to develop their reconstruction proposals until the end of the term, using the classroom time as an opportunity to present updates to the work and receive comments from the professors and other students. In the end, the results were turned into a physical exhibition, "Finding the Lost Monastery of Madre de Deus", which took place in the Civil Museum of the Department of Civil Engineering at Instituto Superior Técnico. An A3 portfolio of each group communicated the use of different historical sources, references, decision-making, and modeling processes (Figure 2). Each group also prepared a large poster that summarized their work in a single compelling image to entice viewers to read their portfolios.

To achieve valuable results, it was important for students not only to be able to visualize historic architectural configurations but also to justify their visualizations according to historic sources and to present a compelling argument for their decision-making process. In addition to this blend of history and technology, a third requirement, focused on the communication of research methods and results, was introduced. This comes in recognition of the growing importance of virtual reconstruction projects to make the decision-making process and research methods transparent. This gave students a critical awareness of how their work is situated within a larger domain of research. A portfolio was made with documentation of each student's individual contribution to the group project. In this portfolio, all novelties in modeling methods that were discovered throughout the process were recorded in brief tutorials for future students to learn from. This was a great opportunity to observe what was learned within and without the framework of the initial IPTI e-learning

course. The portfolio comprised compelling visuals of the finished work to compare the past and present uses of the spaces together.

Figure 2. Examples of final exhibition materials include an A3 portfolio, poster image, and 3D-printed historic source.

A 3D-printed identifier related to an important historical source for each group's project was provided by the professors. These were created using the heightfields of the digital image of the paintings and historic drawings, among others. They served as wayfinding devices to guide visitors within the room. Some students chose to create 3D printings of their final models. Cumulatively, these 3D models contribute to the research agenda of the National Tile Museum to create accessible exhibition materials for the visually impaired.

A virtual online version of this exhibition was created to make all the material accessible to a larger audience (Figure 3). The D. Manuel Room of the National Tile Museum was chosen as the virtual location of this experience since it is thought to be the original church from the 16th-century. Now, researchers, educators, and even visitors to the National Tile Museum who want to learn more about the history of the building can see the results of the students' work from any location. The online exhibition showcases downloadable 2D posters, 3D-printed identifiers, and the HBIM models themselves.

Rather than reconstructing absolutes, the students frequently revealed new questions about the 16th-century nucleus of the monastery. The projects do not achieve a single finite state as much as highlight many possible configurations of the 16th-century monastery. Finding new questions through the process of modeling is essential to virtual reconstruction projects because it reveals all the gaps in the present knowledge and allows the process to continue faithfully without ignoring the evidence. The results of these eight projects are shared in Section 3 Results below.

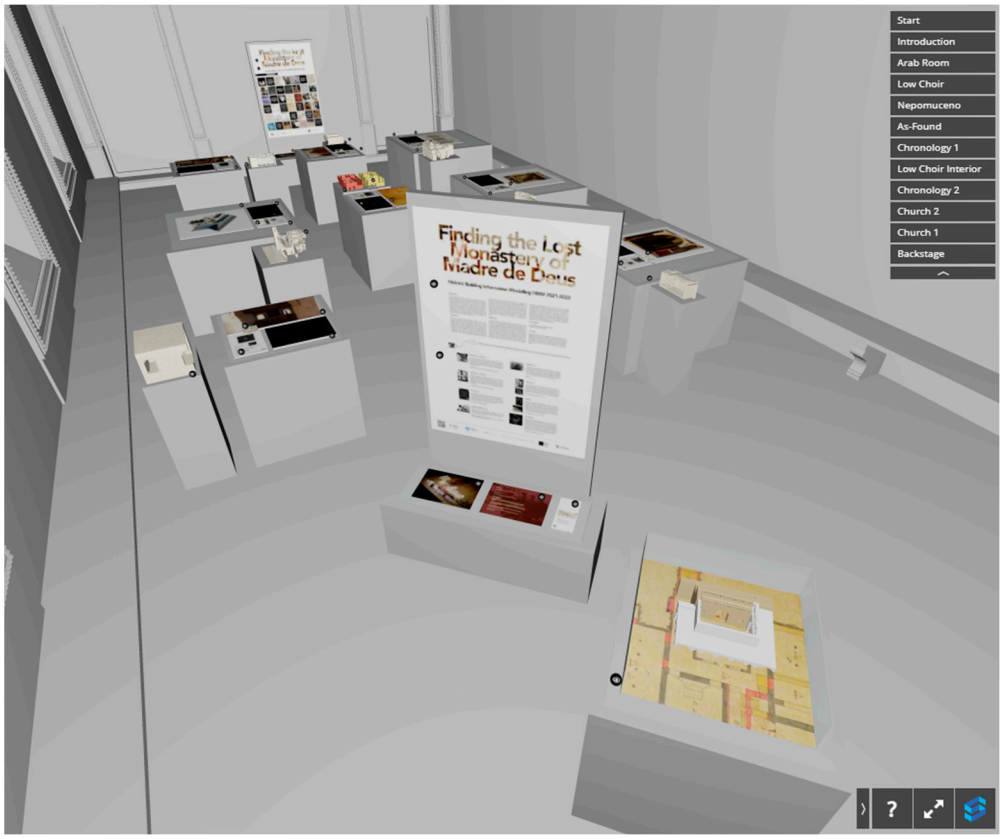

Figure 3. "Finding the Lost Monastery of Madre de Deus" virtual exhibition accessible online through: https://ipti.pt/finding-the-lost-monastery-virtual-exhibition/ (accessed on 4 April 2022).

2.2. Research Materials

2.2.1. Historic Data

- A chronicle known as *News of the Founding of the Madre de Deus Convent of the Barefoot Religious Women of Lisbon (Noticia da Fundação do Convento da Madre de Deos das Religiozas Descalças de Lisboa)*, 1639 [25]. The text provides a chronicle of the origins of the Monastery of Madre de Deus from the 16th to 17th-century. The text combines conjunctures, material evidence, and oral traditions passed down within the monastery to concretize aspects of daily life and spaces of the building. While the authorship of the text is attributed to Maria do Sacramento between 1639 and 1652, it is written in the form of dialogues supposedly composed of real conversations that follow the structure of questions and answers. Fortunately, at this point in history, some religious chroniclers in Portugal had become increasingly interested in historical representation out of fear that the memories of their monastic communities, origins, and architecture would be lost [26] (8–9). It is a fortunate document to have survived for much of what we know today would not be possible without it.
- A historic painting (Appendix A, Figure A1) by an unknown author called *Arrival of the Relics of Saint Auta to the Church of Madre de Deus (Chegada das Relíquias de Santa Auta à Igreja da Madre de Deus)*, c. 1522 [27]. This is the earliest known visual depiction of the Monastery of Madre de Deus, providing us with crucial historical information about the original façade. There is much debate about its historic accuracy and there are numerous possible interpretations of how it relates to the building today. Each radically transforms our understanding of the original 16th-century building. The painting is originally from the *Santa Auta Altarpiece (Retábulo de Santa Auta)*, a polyptych of five oil paintings on oak wood from around 1520–1525.
- A historic painting (Appendix A, Figure A2) by an unknown author called *Saint Francis Delivering the Statutes of the Order to Saint Claire (S. Francisco Entregando os Estatutos da*

Ordem a Santa Clara), 1515 [28]. To the far left, Queen D. Leonor can be seen dressed in her black Clarissa gown. She observes St. Clare receiving the rule from St. Francis. Across different groups, the students used the image to speculate on various aspects of the interior reconstruction, including the columns, flooring, altar, and other details. The painting was likely part of the *Polyptych of the Convent of Madre de Deus (Políptico do Convento da Madre de Deus)* [29], c. 1515, though this cannot be said for certain.

- A historic painting (Appendix A, Figure A3) called *Tryptic of the Presentation of the Child in the Temple (Tríptico da Apresentação do Menino no Templo),* c. 1501–1525 [30]. The painting is by the Flemish painter Goswin van der Weyden. It was commissioned to decorate the church of the Monastery of Madre de Deus. Although it is uncertain whether the painting depicts the actual interior of the church, the heraldic symbols on the left panel suggest it was of royal origin, painted specifically for the monastery, around the time of its founding.
- A contract signed between D. Joana de Ataíde and the masons Rodrigo Afonso and Pêro de Bruges for the architectural work of the Church of the Monastery of Nossa Senhora da Rosa, in Mouraria, 1517 [31]. The contract compares the church of Madre de Deus to the church of Nossa Senhora da Rosa in Mouraria and provides a list of dimensions of the original church.
- 19th-century floorplans (Appendix A, Figure A4) and elevations (Appendix A, Figure A5) by the architect José Maria Nepomuceno when he repurposed the building from a monastery to the Maria Pia Asylum [32]. The plan drawing is important because it contains various historical layers involved in the intervention work, some believed to date back to the 16th-century. The drawing is color-coded, including elements in dark grey (elements that were found and kept), yellow (elements that were found and demolished), and red (new interventions).
- Historic photographs of the main cloister and Arab Room of the National Tile Museum [33]. The photos are from the SIPA Thesaurus, an archival system for architectural heritage by Direção-Geral do Património Cultural–DGPC at the Forte de Sacavém, Lisboa, Portugal.
- Five illustrations of the building's façade from across history. (1) An engraving, "Vista do Convento da Madre de Deus" by Dirk Stoop, c. 1662 [34]. (2) A tile panel from the Consistory Room of the Church of the Third Order of São Francisco in São Salvador da Baía, Brazil, 18th-century, with the primitive church of Madre de Deus seen from the south [35]. (3) A tile panel from the *Large Panorama of Lisbon*, c. 1700, by Gabriel de Barco [36]. (4) A drawing, "N.S. Madre Deos" by Luiz Gonzaga Pereira, 1833 [37]. (5) An engraving, "Convento da Madre de Deus" by Barbosa de Lima, 1862 [38].

2.2.2. Laser Scanning Survey

To model the building in its present state, a laser scanning survey was made using a terrestrial laser scanner (Leica BLK 360) [39]. The scans were collected prior to the start of the semester in a span of 4.5 days. The data comprise 145 scan stations, 131 of which feature high-resolution data with HDR photography, 14 with medium resolution and HDR, and 8 with medium resolution and LDR photos (Figure 4). The scanning was undertaken previously by the authors of the paper in anticipation of the course, not by the students. To avoid scan registration errors, we conducted an abundance of overlapping scan stations at short distances (less than 6 m) using the highest density scan option (5 mm @ 10 m) for the majority of scans. Numerous scans over balustrades allowed us to easily connect the spaces between the three levels of the small cloister (Figure 5). All other scans were conducted on the same level, moving from space to space. In these cases, scans within door frames allowed us to register scans between spaces and between the interior and exterior. The scan stations were registered using Cyclone REGISTER 360 which provides several targetless registration options. The option we used was the cloud-to-cloud function which matches two scan stations based on geometric and visual features. In cases where scans would not align, we used the visual alignment tool combined with a manual elimination of redundant

points. The individual errors between scans are automatically recorded in the software. Within the entire point cloud bundle, the software reported a cloud-to-cloud absolute mean error of 2 mm.

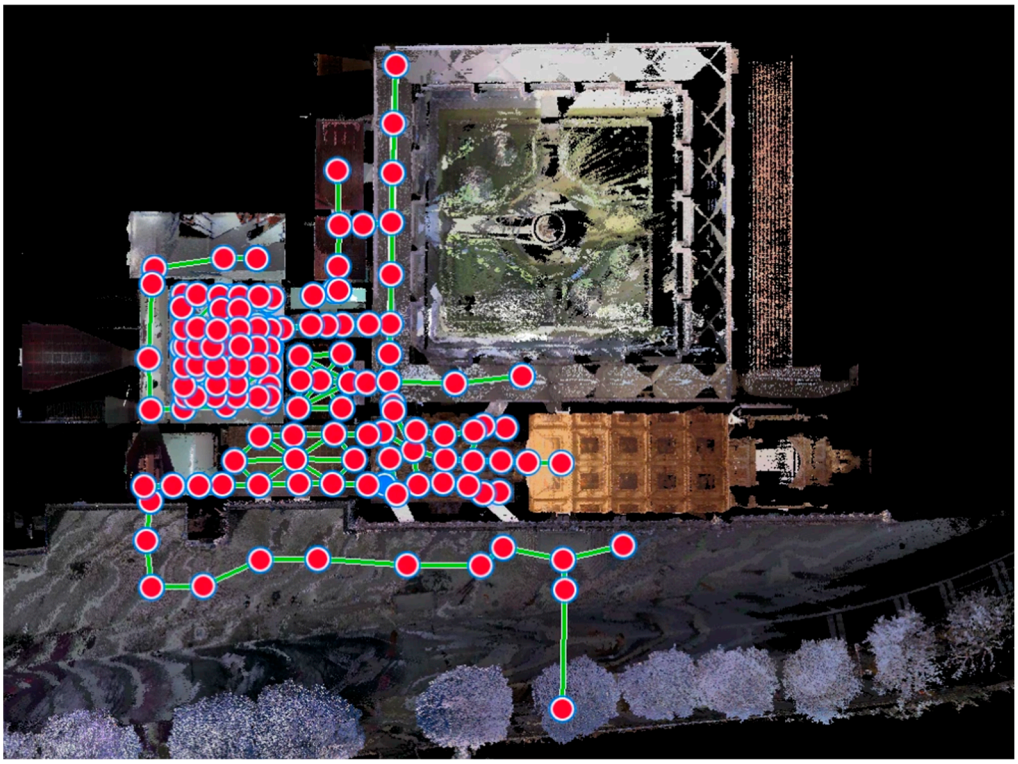

Figure 4. Map of the laser scanning survey including all 145 scan stations.

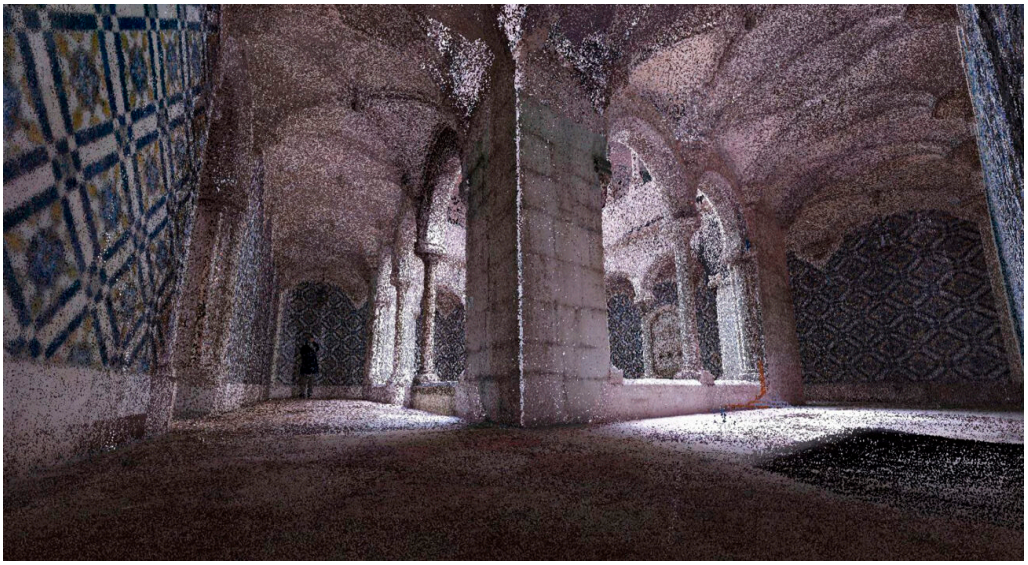

Figure 5. View of the laser scanning survey of the small cloister.

2.2.3. Previous Research

- Report and photographs on the archaeological monitoring of the work to rehabilitate the D. Manuel Room of the National Tile Museum, by Maria Antónia de Castro Athayde Amaral, 2014 [40].

- Three hypotheses of reconstruction found in previous research: (1) José Ribeiro Guimarães, 1874 [41], (2) Alexandre Pais and Alexandra Curvelo, 2009 [42], and (3) João Miguel Simões, 2009 [43].
- A recent publication about the monastery found in: *Igreja Da Madre De Deus: História, Conservação e Restauro*, 2002 [44].

3. Results

3.1. Modeling the National Tile Museum "As-Found"

Every virtual reconstruction project must consider what is known about the present. Using the point cloud data of the building today, this project focused on digitally modeling the National Tile Museum building "as-found" (Figure 6). Its goal was to create accurate models of all the individual spaces believed to be related to the original nucleus of the Monastery of Madre de Deus. In this way, the model of the present could be compared against the 16th-century reconstruction.

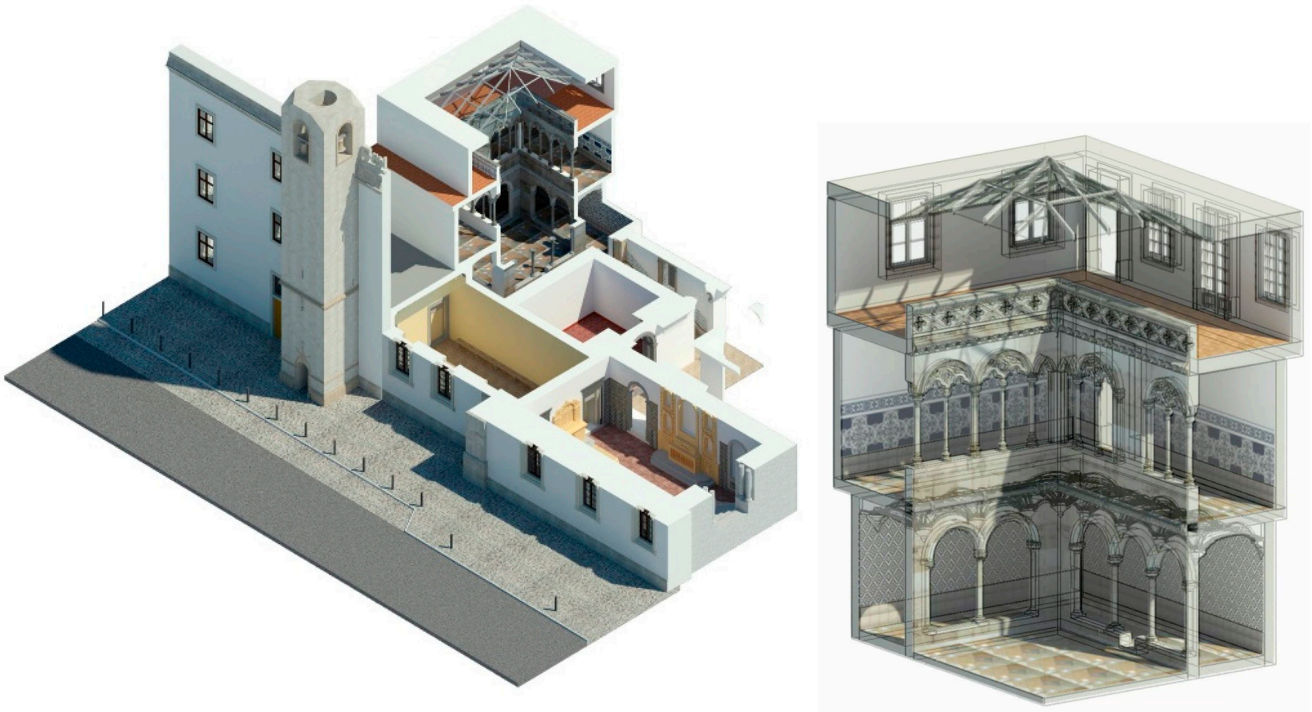

Figure 6. Modeling the National Tile Museum "As-Found." (**Left**): The combined model of all student work. (**Right**): Point cloud overlayed onto the model of the Small Cloister. Credits: Bianca Cordeiro, Catarina Brás, Daniela Pereira, Joana Silva, Maria Nazário, Miguel Vasco, and Mariana Camilo.

For this project, students were subdivided into seven individual spaces defined by reference planes in a shared Revit file. In this way, the individual projects could be easily combined at the end of the term. This required close collaboration to ensure no overlapping geometry was present in the final model.

The modeling advanced from point clouds to photographic surveys of differing spaces. Photographic surveys were needed in areas that could not be scanned or that were not clearly visible in the point cloud data. Throughout the semester, students were given free access to visit the building at any point, which greatly facilitated this effort. With access to the physical spaces, the group could better identify building materials and interpret ornamentation that was obscured in the point clouds. The site visits proved necessary to accurately trace some of the intricate tile patterns covering the walls of the building.

In some spaces, Revit families were directly transferable to 16th-century reconstructions of the same space. For instance, the 16th-century chapel (or Arab Room) contained a Mudéjar rope ceiling which remains intact to this day. While the modeling of the space

itself was straightforward, the intricate rope detailing took considerable modeling effort. After analyzing the geometry, the students realized that a repeating ceiling-based family could make up the entirety of the ceiling. Several attempts were made to model it before arriving at the final model which was shared with the modelers of the 16th-century version of the same space.

One of the greatest difficulties was defining the level of detail throughout the different projects. For instance, there are extremely detailed motifs or bronze-plated carvings that could only be captured with a detailed photogrammetry survey. While the process would have created accurate meshes, these would have taken considerable effort and would have increased the file size immensely. It was decided that this was beyond the scope of the HBIM course. Instead, furniture was modeled generically so that it could be replaced at a later point in the continuation of the project.

3.2. Original Church—Hypothesis 1

This theme focused on the early church of Madre de Deus. Using historic texts and paintings, the hypotheses developed by previous historical work were challenged. For Pais and Curvelo, the site of the original church was located in what is known today as the D. Manuel Room [42]. This hypothesis is based on two premises: firstly, the literal interpretation of the *Arrival of the Relics of Saint Auta* [27] painting of the 16th-century which depicts the river to the right of the church façade and secondly, the possibility that the church portal depicted in this painting was moved to its location today from a previous location.

While it was commonly understood that the location of the Tagus River in the painting was depicted incorrectly due to the orientation of the current church portal, the student's hypothesis contested this assumption. Instead, the students discovered a previously unconsidered arrangement based on the excavation of part of the exterior wall of the Low Choir wall found in Nepomuceno's drawing from the 19th-century [32]. This excavation space corresponds to the width of the portal today, as measured from point cloud data. This suggests that the original portal may have been buried within the wall during the 17th-century expansion of the church. A similar hypothesis is mentioned by Pais and Curvelo [42], though the location in Nepomuceno's drawing was not detected. The shift in location of the portal would also explain its lack of deterioration as compared with other façade elements dating to the 16th-century.

Instead of the original portal being moved from the east façade to the south façade or being a 19th-century reconstruction attempt by Nepomuceno, the students proposed that the portal was moved from the south façade of the Low Choir to its new location on the south façade of the church today. For the students, the position of the Tagus River at the bottom of the painting in relation to the body of the church does not mean that it was literally to the right of it; it only served to emphasize the fact that Saint Auta's relics arrived by sea from Cologne. In the lower part of the painting, a small boat is discreetly depicted which, as it is in the foreground, may be assumed to have a more reliable position.

Another crucial point to the students' arguments is an architectural contract signed in 1517 between D. Joana de Ataíde and the masons Rodrigo Afonso and Pêro de Bruges which compares the church of Madre de Deus to the church of Nossa Senhora da Rosa in Mouraria, Lison [31]. In this contract, the proportions of the original Madre de Deus church are described:

> "(. . .) in that house they will build a Church that must be thirty-three spans wide [7.26 m] and fifty-six spans long [12.32 m] because Madre de Deus has so much, and the lady wants it from that greatness. The church will have a chapel twenty spans wide [4.40 m] and twenty-one spans long [4.62 m] that will be the head and will be all the height of Madre de Deus and the altars will have its steps like the altars of Madre de Deus." [31] (p. 76—translated by the authors from its original Portuguese)

When converted to current measurements, the dimensions of the church correspond precisely to the dimensions of the Low Choir. Unfortunately, the church of Nossa Senhora da Rosa was destroyed, rebuilt, and re-modified during the 1755 Lisbon earthquake, so no comparisons could be made today. Despite this, the students were able to leverage the accuracy of the point cloud data and the dimensions referred to in the text to deduce that the only plausible space for the church could have been the Low Choir space.

Even with concluding on this overall arrangement of the church, the students did not have concrete evidence to reconstruct the interior architectural atmosphere of the church. Instead, the only references available were the two interior paintings from the 16th-century mentioned above [28,30]. Although we do not know for sure if these are depictions of the original church, historians leave this possibility open. At the very least, the paintings were used to create a plausible 16th-century atmosphere (Figure 7).

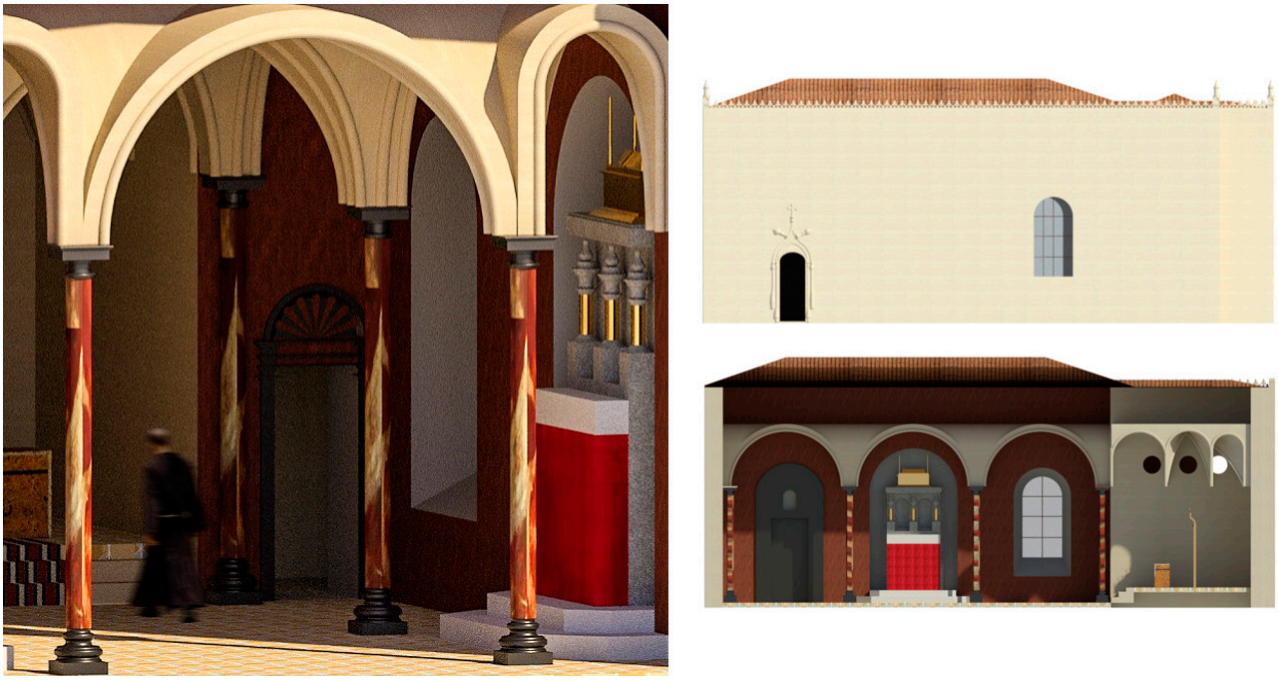

Figure 7. Reconstruction of the original church—Hypothesis 1. (**Left**): Three-dimensional rendering of the church's interior. (**Top right**): South façade. (**Bottom Right**): Longitudinal section. Credits: Beatriz Fabião, Laura Guia, Mariana Alves, and Ricardo Aparício.

3.3. Original Church—Hypothesis 2

This theme visualizes a hypothesis about the early church of Madre de Deus developed by João Simões who draws conceptual links between other architectural precedents of the reformed Colletine order [43]. Madre de Deus is the second oldest of the reformed Clarissa's in Portugal, with the original seven nuns of the monastery having previously founded the Monastery of Jesus in Setúbal. Since we know that the monastery in Setúbal takes precedent from the Convent of Saint Clare in Gandía, and that both buildings took the symmetrical cruciform plan of St. Clare of Assisi as their model, Simões speculates that Madre de Deus would have followed a similar reference.

Simões' hypothesis ignores the architectural contract detailing the dimensions of Madre de Deus from 1517 because it would be physically incapable of containing the numerous paintings and *Della Robbia* medallions as well as retables, relics, and other objects said to have been left by Queen D. Leonor at the monastery [43] (p. 333). In Simões hypothesis, the original church of Madre de Deus would have had a cross plan, the main chapel (12.86 m × 7.60 m), a single nave (17.54 m × 6.25 m), and transept (21.2 m × 6.70 m).

The students' initial analysis of the point cloud data suggested that Simões' hypothesis is plausible if the present low choir and D. Manuel Room were combined, even though there

is no historical or physical evidence to support this. Furthermore, there is no remaining physical evidence of the south transept which appears in Simões' hypothesis.

The students took a critical approach to their reconstruction of this hypothesis by considering that Simões' proposal is highly idealized for a monastery that was constructed from an already existing palace. Using topographic maps compared against *Arrival of the Relics of Saint Auta* [27], the students' reconstruction approach developed from the outside in by introducing numerous cartographic plans they had collected at the beginning of their research. Through this approach, the students were able to speculate upon the flood locations of the south façade which are common in the historic accounts. Furthermore, the south transept which appears in Simões' hypothesis was included in their reconstruction, though they speculate that this volume was likely ignored due to its proximity to rising water from the Tagus River.

Point cloud data of the present building were also used to add credibility to the otherwise highly conceptual hypothesis posited by João Simões. When comparing Simões' proposal with point cloud data, it was determined that the real walls would have had to be much thicker than the sketch proposed by Simões due to the length of the church and lack of interior columns in Simões' proposal. Following comments from invited specialists, the students adjusted their version of Simões' hypothesis by using the dimensions of the existing walls of the D. Manuel room as measured from point cloud data.

Again, without much information about the interior, the primary reference for this second hypothesis was the 1515 painting of *Saint Francis Delivering the Statues* [28]. The painting was used to speculate on various aspects of the interior reconstruction including the columns, flooring, altar, and other details (Figure 8).

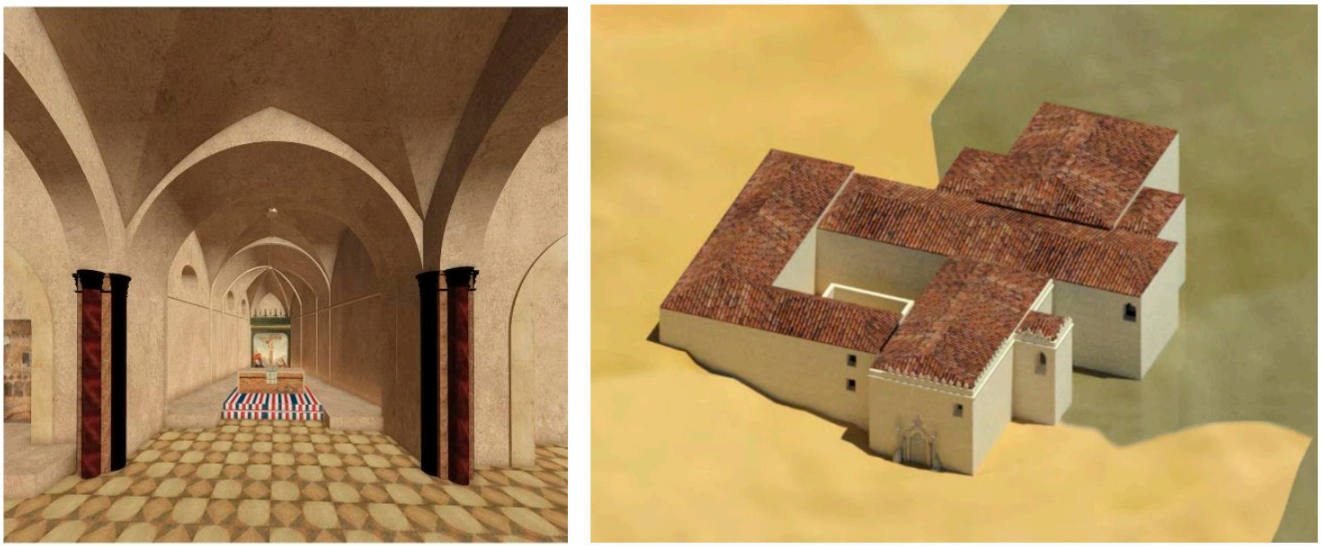

Figure 8. Reconstruction of the original church—Hypothesis 2. (**Left**): Church interior. (**Right**): Overview of the entire church during a period of rising water from the Tagus River. Credits: Inês Almeida, Beatriz Santana, and Bryan Rodrigues.

3.4. Original Church—Hypothesis 3

This theme explores a 3D-printed volumetric model of key spaces of the exterior and interior of Madre de Deus from the 16th-century. Historians leave open the possibility that the three church paintings originally housed by the 16th-century church of Madre de Deus could have been actual depictions of it. In this third hypothesis for the 16th-century church, the virtual reconstruction approach attempted to overlap three paintings: one depicting the exterior: *Arrival of the Relics of Saint Auta* [27] and two depicting the interior: *Saint Francis Delivering the Statutes* [28] and *Tryptic of the Presentation of the Child* [30]. The proposal also obeyed the dimensions found in the 1517 contract [31] and the measurements taken from laser scanning survey data.

Of the three paintings, the most likely to belong to the church is the painting of the façade because it documents an actual historical event of the arrival of relics to the church. The other two paintings are less certain, though aspects of their materiality and architectural features certainly reflect the architectural interiors of the 16th-century.

The interior of the church was generated through a series of perspectival exercises that attempted to reconstruct the spaces of the paintings. At first, each painting was reconstructed separately, and then the volumes depicted on the façade were used to interpret how these 3D reconstructions could have corresponded. This activity was undertaken along with physical models which divided the paintings according to a series of planes. Whether or not the original church looked like this, the process eliminated the doubt about whether the paintings shared correspondence. In the end, few correspondences were present though a peculiar space arose that could perhaps share some similarities to the original (Figure 9).

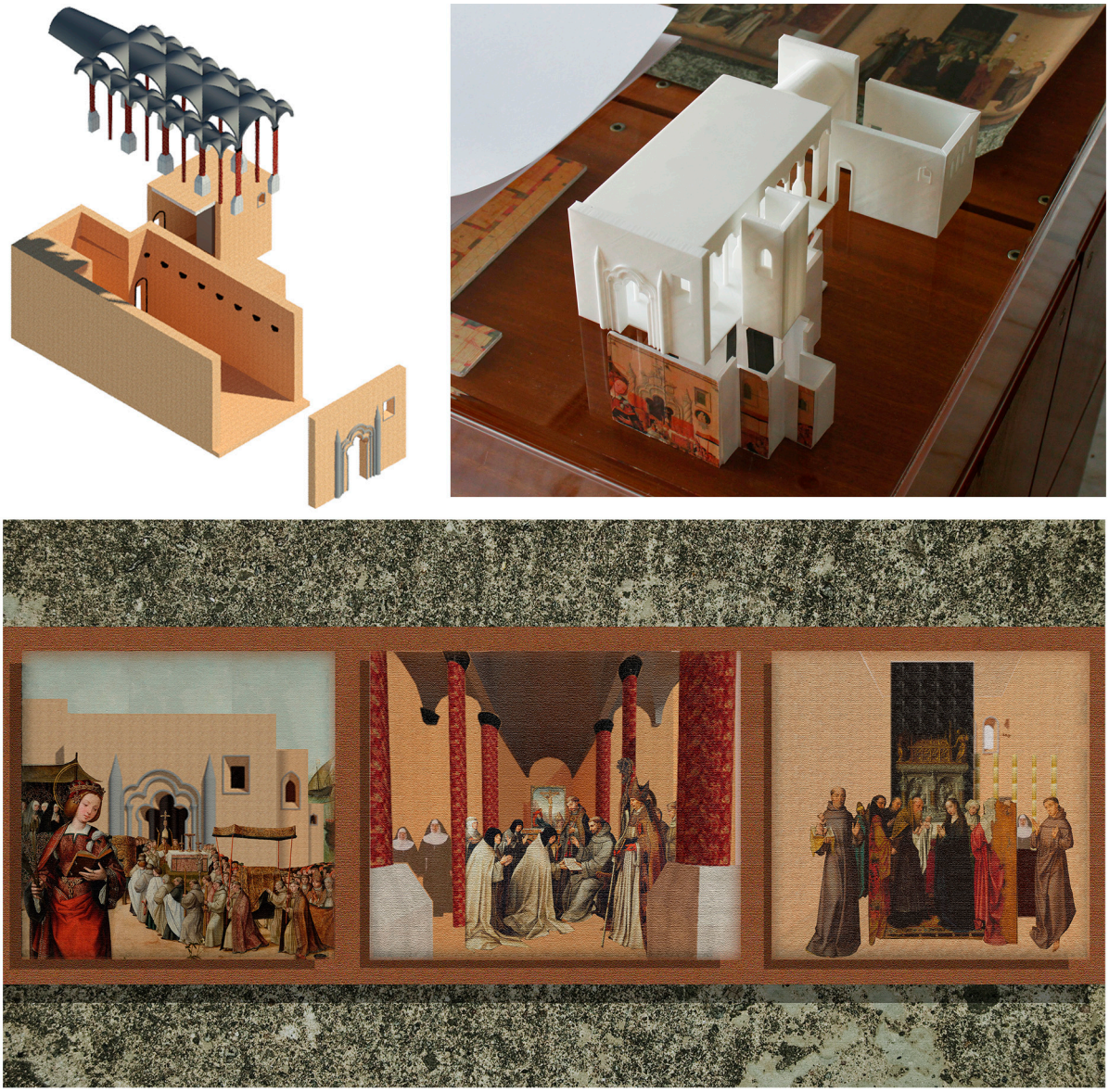

Figure 9. Reconstruction of the original church—Hypothesis 3. (**Top left**): Digital model. (**Top right**): Three-dimensional printed model. (**Bottom**): Reinterpretation of the original paintings used in the virtual reconstruction and modified according to the results of the final model. Credits: Lucas Miranda.

3.5. Arab Room

The Arab Room, today known as the Chapel of Queen D. Leonor, is one of the original pre-monastic spaces of the building dating back to its function as a palace consisting of some houses and a vegetable garden. The name of the Arab Room comes from the wooden Mudéjar ceiling carved in Arabic motifs. This motif, framed with a decorated cord of wood, was a connecting feature of the spaces of the original palace belonging to the widow of Álvaro da Cunha. The goal of this theme was to reconstruct the original atmosphere of the chapel and to better understand how it was modified in the time of Queen D. Leonor. The space, according to historians, is constituted by ceramic tiles, gold leaf detailing, and medieval floor patterns. The ceiling of this room is perhaps one of the most important architectural elements in our reconstruction efforts of the 16th-century because legend tells us that it was the main inspiration for transforming the building into the Monastery of Madre de Deus. The rope detail, originally covered in gold leaf, was a common feature of the Mudéjar style of the 15th and 16th-centuries in Portugal. It was interpreted by Queen D. Leonor as the rope of St. Francis and thus the perfect place for the founding of a monastery for the small group of Poor Clares arriving from the Monastery of Jesus in Setúbal.

This cord element also appears in stone in other parts of the building, such as the façade and in the small cloister, two spaces which would have been modified in the time of Leonor's conversion of the space into a monastery. Such stone detailing also corresponds to what can be seen in the Monastery of Jesus in Setúbal. Historians also suggest that the Arab Room originally housed two flights of stairs on either side of an altar leading up to the small cloister on a higher level (Figure 10). This hypothesis suggests that the space was used as a central circulation space for nuns in the monastery to reach the original church. The remains of Queen D. Leonor are located at the entrance of this space near the entrance to the low choir, as per King D. João III who transferred them there following his expansion of the monastery. The corridor connecting the Arab Room to the low choir and probably to other spaces such as the infirmary and dormitories was likely outside and part of the houses belonging to Álvaro da Cunha. On advice from invited experts, the flooring of the Arab Room would have had a medieval character best expressed in a few examples, one being the painting attributed to Nuno Gonçalves and the other being the chapel of Saint Estêvão in the cloister of the Cathedral of Lisbon.

Figure 10. Reconstruction of the Arab Room. (**Left**): Interior rendering. (**Top right**): Three-dimensional reconstruction prior to the 16th-century. (**Bottom right**): Three-dimensional reconstruction in the 16th-century. Credits: Maria Salvador and Madalena Roque.

3.6. Modeling Nepomuceno's Plans

After the extinction of the religious orders in Portugal in the 19th-century, the architect José Maria Nepomuceno carried out a survey of the Monastery of Madre de Deus to convert it to the Casa Pia asylum. The plan used a scheme of red (to be built), grey (found and kept), and yellow (found and demolished). Volumetric interpretations of these layers of history contributed to a better understanding of work carried out across all themes. They are of particular importance to understanding the chronology of the building because they show the state of the building prior to and including Nepomuceno's modifications.

The task of this group was to model two versions of Nepomuceno's plans, the version of what Nepomuceno supposedly built (red version), and the version of what Nepomuceno supposedly found when he first documented the building (yellow version) (Figure 11). These models would also take into consideration the point cloud data of the present to see what remains today of Nepomuceno's modifications.

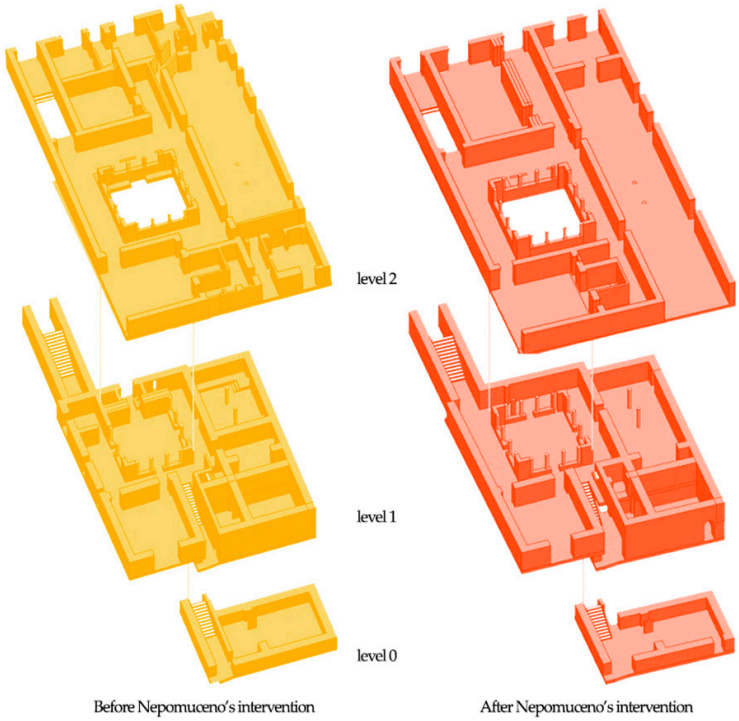

Figure 11. Three-dimensional reconstruction of Nepomuceno's drawings in the spaces around the small cloister depicting the building before interventions (in yellow) and after (in red). Credits: Sofia Cruz.

Modeling from the drawings was very useful for deciphering the complex circulation between the spaces and how they used to function, including access from the small cloister to an upper level believed to be part of the new refectory. In several cases, the model also helped to identify locations of walls previously filled in. When cross comparing point clouds with the 2D historic drawing set, it was possible to find prior connections between adjacent spaces and possible locations of altarpieces believed to have been situated between the small cloister and the original church on a lower level.

The model was particularly important in understanding the small cloister. Prior to its symmetrical plan and present use, the small cloister was originally divided into several rooms according to the pre-existing palace. This space served originally as a lavatory and a place to wash garments when the palace was transformed into the Monastery of Madre de Deus in the 16th-century. The cloister was also an open space at that point in time, serving as a kind of exterior patio space. To the east, where the fountain of Saint Auta is located, was a closed space with three rooms. The central space housed the miraculous water and was connected to a smaller place with a window overlooking the small cloister, whose

use is not entirely known. The third is closed off with a side entrance with unknown use. In the south wall, there is a closed niche that is thought to be the house of the Retable of Saint Auta.

When comparing Nepomuceno's drawing to the point cloud proportions, a great exaggeration of the dimensions of the space of the cloister was observed. The small cloister is curiously much smaller than depicted in the 19th-century, yet it is unlikely that the proportions of this space would have changed because it is believed that the location of the Saint Auta fountain on the west wall remained the same.

3.7. Low Choir

Due to its adjacency to the Tagus River, it is speculated that the space known today as the low choir once served as an entrance to the pre-existing palace prior to the building's conversion into a monastery. While we know that the space served as a choir following the expansion works by King D. João III, it is unknown whether this space was the original church or the choir of the 16th-century. Following a previously developed hypothesis, this model explores the hypothesis that the space served as the original choir, which would have been situated behind the high altar of the former church. For this proposal, laser scanning data were used as the primary reference that other historic references could be fitted to.

The proposal takes reference from a ceiling described within the 1639 testimony, *News of the founding of the Madre de Deus Convent of the Barefoot Religious Women of Lisbon* [25] (Fl 7v-8). The corded ceiling mentioned in this text would have been built in the Mudéjar or Manueline style depending on whether the space was modified upon its transformation into a monastery. Because the only existent Mudéjar ceiling from the 16th-century is the one in the Arab Room, this proposal selected the church of the Monastery of Jesus in Setúbal as its stylistic precedence. The nuns in the testimony mention that the ceiling was ordered by Queen D. Leonor who likely would have had a Manueline stylistic preference. The famous example of Manueline architecture in Setúbal uses an ornate stone rope detail.

The students' proposal combines this detail with vaults (Figure 12) depicted inside the lower choir in Nepomuceno's 19th-cenutry façade drawing [32]. These were interpreted as traces of the original 16th-century ceiling which were later demolished. The location of the columns in the elevation corresponds to the interior plan. According to the plan drawing, Nepomuceno intended to reposition one row of columns. Today, however, the ceiling is flat and without any supporting columns, signifying that this intention was likely never carried out. Despite this, we can still see ornaments that reflect where the former columns would have been. These ornaments are located at the intersections of the existing ceiling panels and may have been kept as a physical memory of the former vaulted ceiling. These locations, as measured by the point cloud, were the basis for the vault reconstruction.

The reconstruction compared Nepomuceno's elevation drawing with the current point cloud data to determine the height of the vault and the roof. For this, the rope detail of the exterior bell tower, also depicted in Nepomuceno's drawing, was used as the roofline of the model. A similar roofline is shown in the façade painting *Arrival of the Relics of Saint Auta* [27]. Furthermore, this detail is similar to the ceiling detail of the monastery in Setúbal and is thought to be from the 16th-century.

Aside from the ceiling, a comparison with the monastery in Setúbal also proved helpful in making the space function as a choir. In Setúbal, an altar membrane detail hides the visibility of the choir so that the nuns could have sung during mass without being seen. This is an important detail to consider since the nuns were not allowed to be seen. In Setúbal, a large folding panel with a painting covers this altar membrane after mass. When the nuns received alms, the panel could also be shut, with a small door only to pass a hand through. The students used this detail as a reference within their reconstruction. Unlike in Setúbal, the choir sits slightly below the level of the church and faces the opposite direction.

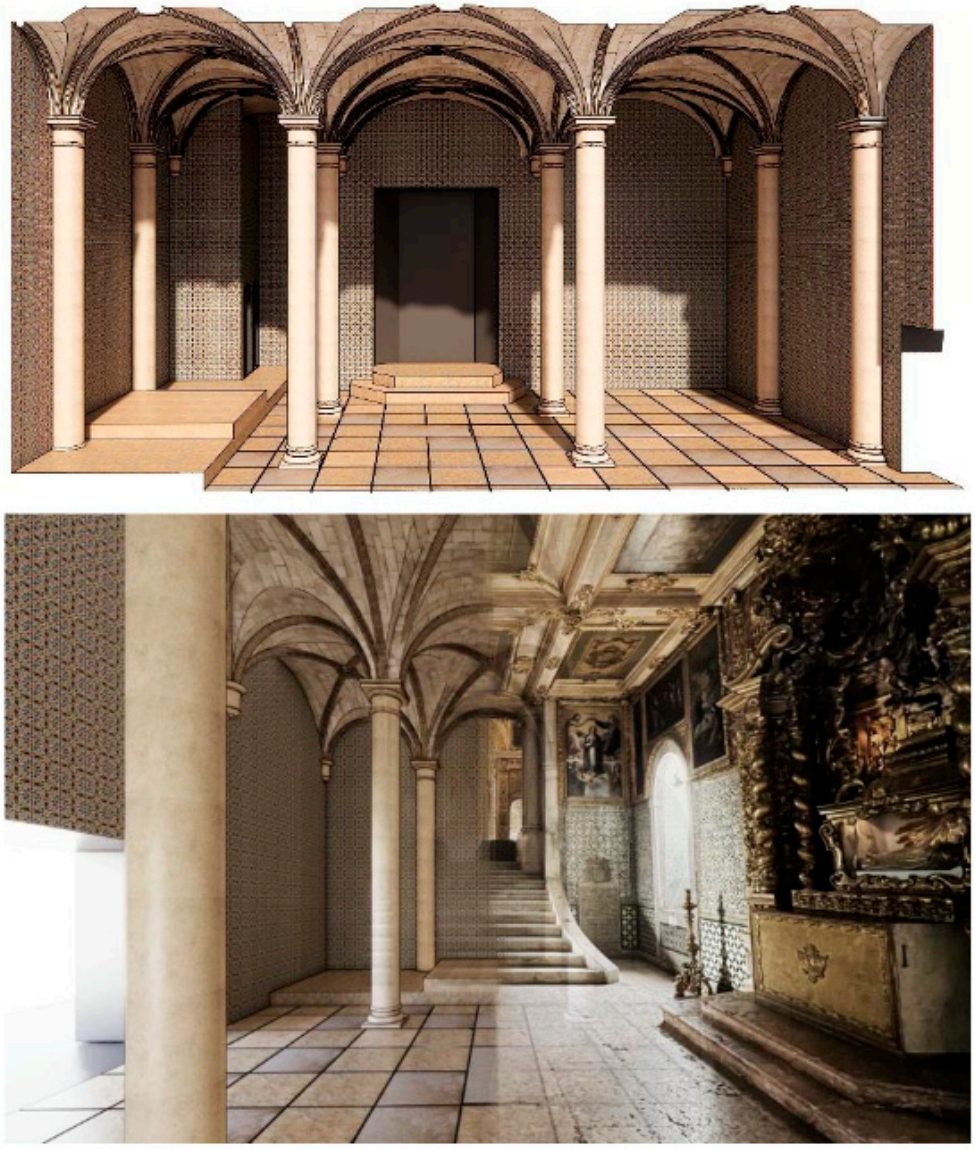

Figure 12. (**Top**): Section of the virtual reconstruction of the Low Choir. (**Bottom**): Comparison of the same space in the 16th and today. Credits: Jolanta Krzywdzińska.

Another important aspect to consider is the need for choir stalls. Today, the space known as the high choir houses stalls which are believed to date back to the 16th-century. These choir stalls would have been reconstructed on the above level when the church was expanded and the new high choir was built. Today, the arrangement of these stalls is in units of four or eight. The students deconstructed these and proposed a new re-arrangement that could seat the thirty-three nuns believed to have lived in the monastery in the 16th-century and fit within the columns.

A further consideration for the arrangement of the stalls was the carpet with trees and animals believed to have once been in the space. The use of carpets before the altar was a common 16th-century practice, signifying that the location of the carpet was in the center of the space between the columns and the front of the altar membrane (Figure 13). The carpet is housed today in the Museum of Ancient Art, Lisbon. It is believed to have been cut down from its original length of 6 m; today, it has a width of 2.95 m and a length of 4.39 m [45]. It is based on the chahar bagh (four gardens) of classical Persian garden design and was chosen by Queen D. Leonor. Though not an architectural element, the location of this carpet within the original space is a necessary consideration to validate the arrangement and original atmosphere of the space.

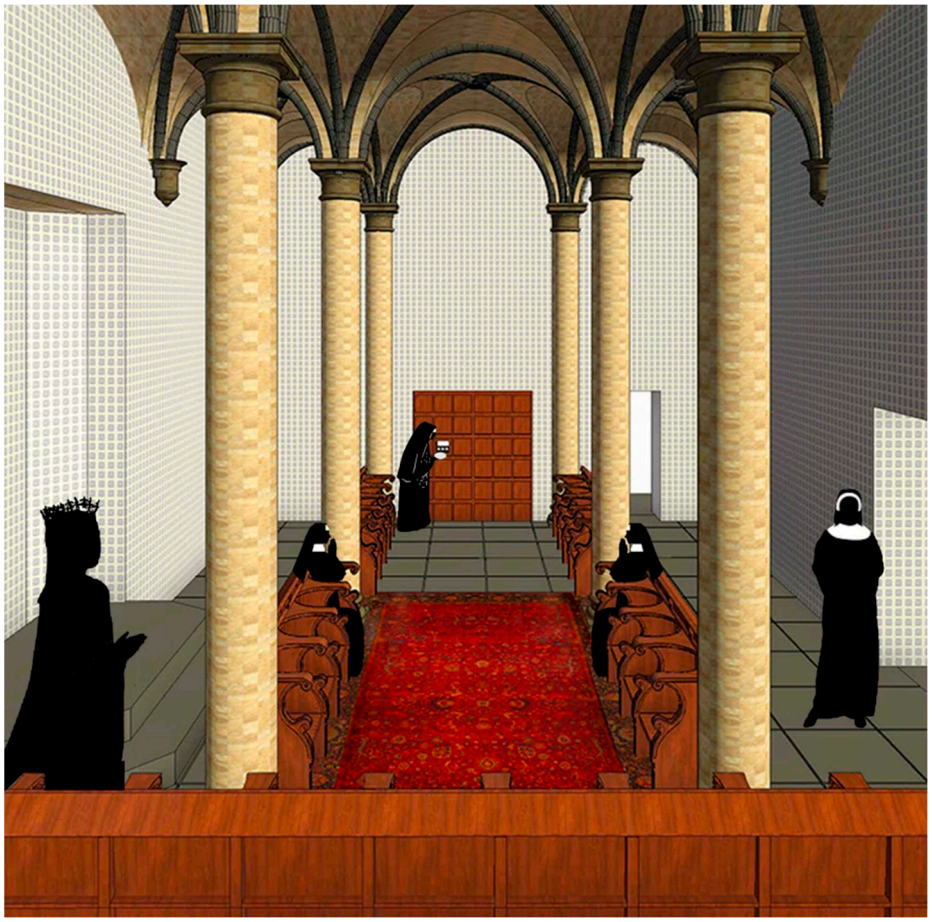

Figure 13. Reconstruction of the Low Choir including the altar membrane, Persian carpet, and choir stalls. Credits: Emeline Gallais.

3.8. Reconstruction and 3D Print of the 17th-Century Church of Madre de Deus

Around 1551, the pre-existing monastery was expanded by King D. João III because of complaints from the nuns and because he believed the monastery deserved a building that could live up to its royal patronage. The main requirement of the nuns was bigger living spaces and a larger church to hold more people and resist the constant flooding of the old church. By the end of 1624, when the works were completed, the Monastery of Madre de Deus included a new church, refectory, infirmary, cloister, and bell tower. A private royal balcony was also installed, to give the royal family exclusive opportunity to view the mass without being seen by the public.

The period between the constructions made during King D. João III's reign and the adaptation of the building into the Maria Pia Asylum is unclear since there is little documentation other than the drawings of Nepomuceno in the 19th-century [32] and the written testimony of the nuns from the 17th-century [25]. Yet, to better understand the 16th-century, it was important to reconstruct the way in which the building could have evolved in the 17th-century to situate the work historically.

Based on previous research, illustrated depictions of the building, and Nepomuceno's 19th-century drawings, this project recreates a schematic overview of the volumes related to Madre de Deus in the 17th-century (Figure 14). Through digital modeling, it was possible to separate the two layers of Nepomuceno's drawing to reveal the state of the façade prior to the Maria Pia Asylum project and to make comparisons with other representations of the building across history. This exercise allowed us to better understand what was modified by the time Nepomuceno encountered the building and to concretize the conflicting depictions of the façade across history, which vary greatly according to the artist.

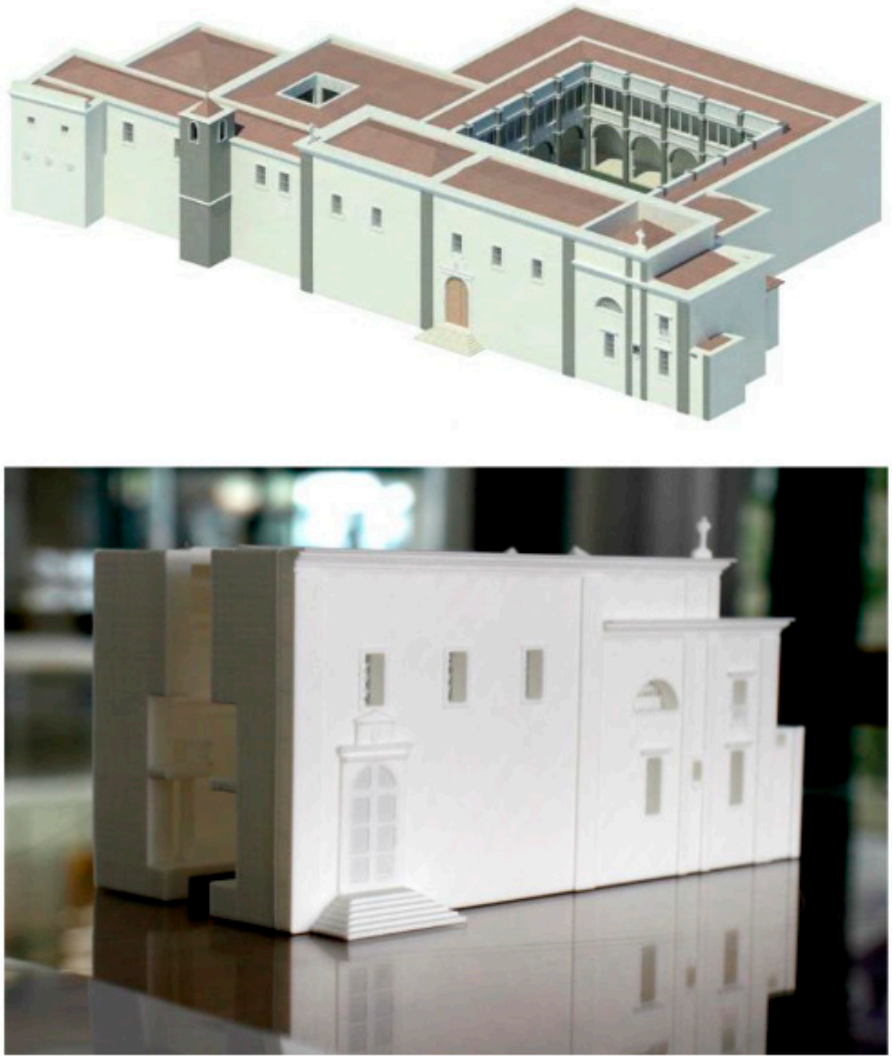

Figure 14. Virtual reconstruction and 3D Printing of the 17th-century Church of Madre de Deus. (**Top**): Three-dimensional model of the entire building's perimeter. (**Bottom**): Three-dimensional printing of the 17th-century church. Credits: Bianca Friebel.

The engraving, "Vista do Convento da Madre de Deus" by Dirk Stoop, c. 1662 [34], provides crucial historical information about the façade of the building following the expansion of the building in the 17th-century. Although there is a clear exaggeration of scale and perspective distortion of this representation, many of the elements of the engraving are seen in a later façade drawing by Nepomuceno which can help to understand the evolution of the building in a more comprehensive way. In Nepomuceno's façade, both the original building and the new intervention appear in the same drawing, which confuses the reading of the 19th-century façade. By comparing the linework against other depictions, it was possible to base the model of the 17th-century entirely on the metric survey drawing made by the architect José Nepomuceno two centuries later.

One interesting discovery is the disappearance of the Manueline front portal of the church depicted in the 16th-century painting of the façade and its re-emergence in the 19th-century by Nepomuceno. There are no records of how the 17th-century entrance door to the new church emerged, but it was certainly part of the 17th-century construction. The door in the church of the Cardaes Convent, Lisbon, founded in 1681, is a similar example of how the portal to Madre de Deus would have looked in the 17th-century. It is speculated that during José Maria Nepomuceno's transformation of the place, the portal of the original church from the 16th-century was found covered in a wall and was carefully removed and

placed where it can be seen today. However, it is not possible to confirm for sure since the entire south façade underwent renovations which added new windows believed to be a Neo-Manueline invention created to reinvoke the 16th-century monastery.

After the digital modeling, the project explored 3D printing as a dissemination artifact. For this, the focus went only to the church itself. To make the interior of the church observable, the model was sectioned into three parts: the façade itself and two sections of the church volume. To make the printing process possible, many of the elements, such as the front portal, staircases, and small details like railings and crosses, had to be divided from the original model and printed separately to be assembled manually afterward. Each piece was carefully exported into the STL format and brought into software known as Cura, a slicing program that allows users to manage, visualize, and simulate the appearance of their 3D models prior to the final printing. The model was printed with an Ultimaker 2 Extended + machine with a thermoplastic filament named PLA (polylactic acid) and it took around 4 h and 34 min to bring all the pieces to reality.

4. Discussion

Collaborations between museums and academia can create mutually beneficial intellectual experiences for the valuation of heritage. In the case of the National Tile Museum, students were able to create a rigorous, scientifically based database of digital assets in HBIM to help understand and promote the historical significance of the building. Future iterations of the project will be facilitated by this HBIM methodology because of its parametric modeling functions and the organization of building elements into easily importable families. All the work produced during this experience is modifiable to new information or interpretations as the project moves to consolidate this information into a holistic proposal of the 16th-century. Part of our future aim is to reflect upon what these conclusions imply about the arrangement of the spaces of the building. To do this will require that we consider the living spaces such as the dormitories, refectory, and kitchen which were not part of this initial study.

In future work, we hope to further investigate the new questions that our students raised. For instance, many new interpretations of the drawings of Nepomuceno in the 19th-century were posited in ways that had not previously been observed. They noted how the numerous modifications could be keys to understanding the 16th and 17th-century versions of the building. Specific locations of filled-in points of access between spaces, dismantled walls, and demolished features like staircases and altars could help our understanding of the nuns' circulation within the spaces of the former monastery. We speculate that the use of ground penetrating radar in the future could allow us a better understanding of the building by uncovering some of these lost traces.

The unique pedagogical approach of this research has contributed in many ways to the virtual reconstruction project. Students often brought new sources of information, such as cartographic maps, or new references to other buildings which were not originally part of the research considerations. Students also frequently challenged the expert opinions with new observations which had not previously been considered. Through the capacity to visualize their hypothesis, it was possible for students to contradict historical interpretations that had previously only been resolved through text. Through the students' visualizations, the research is in a better position to receive expert opinions, including both disagreement and validation.

This pedagogical approach was designed for a relatively limited group of students (ideally 15 to 20 students at most) to allow for the continuous monitoring of projects. This condition was made possible within the scope of the fifth year of the Integrated Master's in Architecture program, given that this HBIM course (as well as all other course offerings) is optional. We believe this to be advantageous since the enrollment of students indicates a pre-disposition and availability to the subject, facilitating the teaching–learning process. It should also be noted that the position of the course in the last year of the program attracts students with greater maturity and preparation to deal with the complexity of

research questions and, consequently, more preparedness to generate their own questions. Finally, a major advantage that should be mentioned is the diverse multi-national profiles of the students who attended this HBIM course. This diversity was made possible under the Erasmus+ Program (integrated by Instituto Superior Técnico) which encourages the exchange of students within the European Union. The range of experiences, educational and cultural, brought by these students has proved to be a catalyst for differentiating perspectives and approaches, enriching their HBIM projects.

The students were at the forefront of an ongoing research project of national significance. They made profound contributions to the work while learning the state-of-the-art digital tools in their field. Because their modeling workflows were required to consider the complex relationship between modeling and historic credibility, they were exposed to a rich understanding of 16th-century Portugal and the iconic Manueline architecture which characterizes it. This historical awareness was apparent in the many cases of reconstruction where an understanding of the strict observance of the nuns of the monastery helped to formulate plausible hypotheses, i.e., spaces belonging to the functions of the nuns had to be strictly private and unobservable by the public and the nuns were also not allowed to peer outward.

Over the past two decades, the digital paradigm has helped to open new pathways for the communication of architectural heritage. Though we have achieved this temporarily in our online exhibition of the research, we also hope to be able to make future iterations of this research accessible in a virtual experience by leveraging new developments in gaming technology for digital storytelling aims. From our experience thus far, however, we have observed that the storytelling of history happens not only through the demonstration of a singular research result but also through the communication of the complex research activity itself. This factor can bring diverse peoples into engagement with the work, not only those interested in history. In the case of Madre de Deus, we have already described above how each generation has produced its own artifacts which emerged through a kind of compulsion to revive the past. From the written testimony of the nuns in the 17th-century to the Neo-Manueline reconstruction by Nepomuceno, each provides a unique cultural layer of interpretation. The process of virtual reconstruction attempts to explain this chronology while tying these previous records into new architectural expressions and narratives. Silberman reflects that, "we should therefore resist overstating the potential of digital heritage for creating a definitive, Objective reconstruction of the past and focus instead on its role as a tool of historical reflection within contemporary society" [46] (p. 83). In this sense, we have felt it necessary to share our methods and results, even though we have not and may not ever reach a single, fully agreed-upon reconstruction of the past. The research activity itself has already played a crucial role in the re-telling of this lost monastery, which we hope will contribute to emphasizing the building's rich past.

Author Contributions: Conceptualization, J.R. and A.T.; methodology, J.R. and A.T.; software, J.R.; validation, J.R. and A.T.; formal analysis, J.R. and A.T.; investigation, J.R. and A.T.; resources, A.T.; data curation, J.R. and A.T.; writing—original draft preparation, J.R. and A.T.; writing—review and editing, J.R and A.T.; visualization, J.R.; supervision, A.T.; project administration, A.T. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A Paintings and Drawings Used in the Virtual Reconstruction

Figure A1. Arrival of the Relics of Saint Auta to the Church of Madre de Deus (Chegada das Relíquias de Santa Auta à Igreja da Madre de Deus), c. 1522. © José Luiz Bernardes Ribeiro/CC BY-SA 3.0. File: St. Auta Altapiece—Arrival of the relics of St. Auta at Madre de Deus Monastery—Lisbon Workshop—ca. 1522—oil on oak.JPG—Wikimedia Commons (Available online: https://commons.wikimedia.org/wiki/File:St._Auta_Altapiece_-_Arrival_of_the_relics_of_St._Auta_at_Madre_de_Deus_Monastery_-_Lisbon_Workshop_-_ca._1522_-_oil_on_oak.JPG) (accessed 27 August 2023).

Figure A2. *Saint Francis Delivering the Statutes of the Order to Saint Claire (S. Francisco Entregando os Estatutos da Ordem a Santa Clara)*, 1515. Jorge Afonso, Public domain, via Wikimedia Commons. Available online: https://commons.wikimedia.org/wiki/File:S._Francisco_entregando_os_Estatutos_da_Ordem_a_Santa_Clara_Jorge_Afonso_MNAA.jpg (accessed 27 August 2023).

Figure A3. *Tryptic of the Presentation of the Child in the Temple (Tríptico da Apresentação do Menino no Templo)*, c. 1501–1525. Goswijn van der Weyden, Public domain, via Wikimedia Commons. Available online: https://commons.wikimedia.org/wiki/File:Goswin_van_der_Weyden_-_Apresenta%C3%A7%C3%A3o_do_Menino_no_Templo,_Santo_Ant%C3%B3nio_e_S%C3%A3o_Francisco.jpg?uselang=pt#Licenciamento (accessed 27 August 2023).

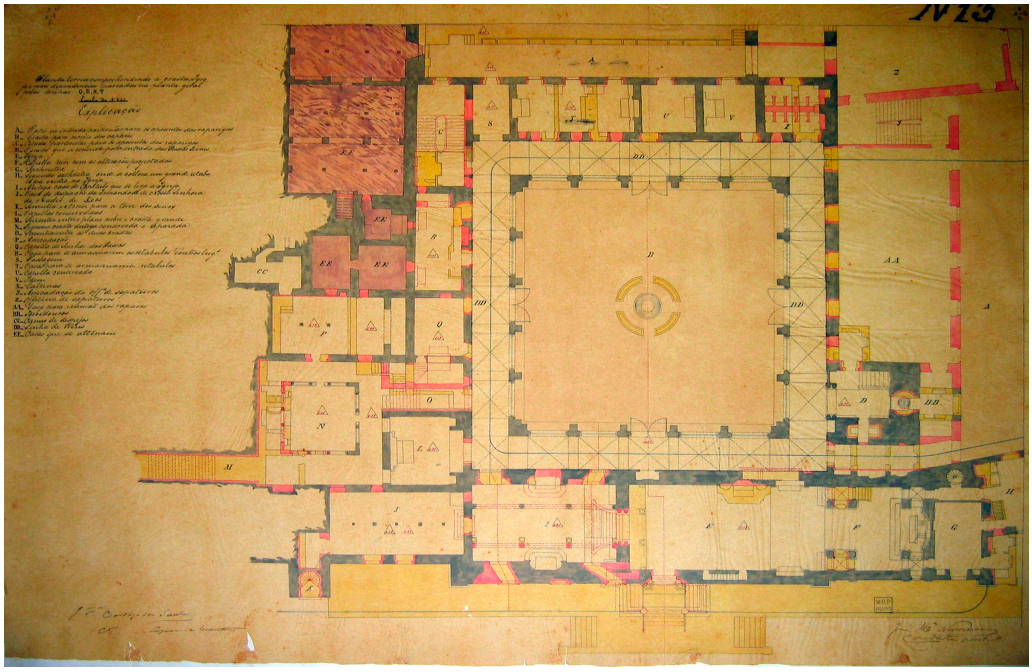

Figure A4. 19th-century floorplan (drawing No° 13) by the architect José Maria Nepomuceno. Library and Historical Archive of the Ministry of Social Equipment.

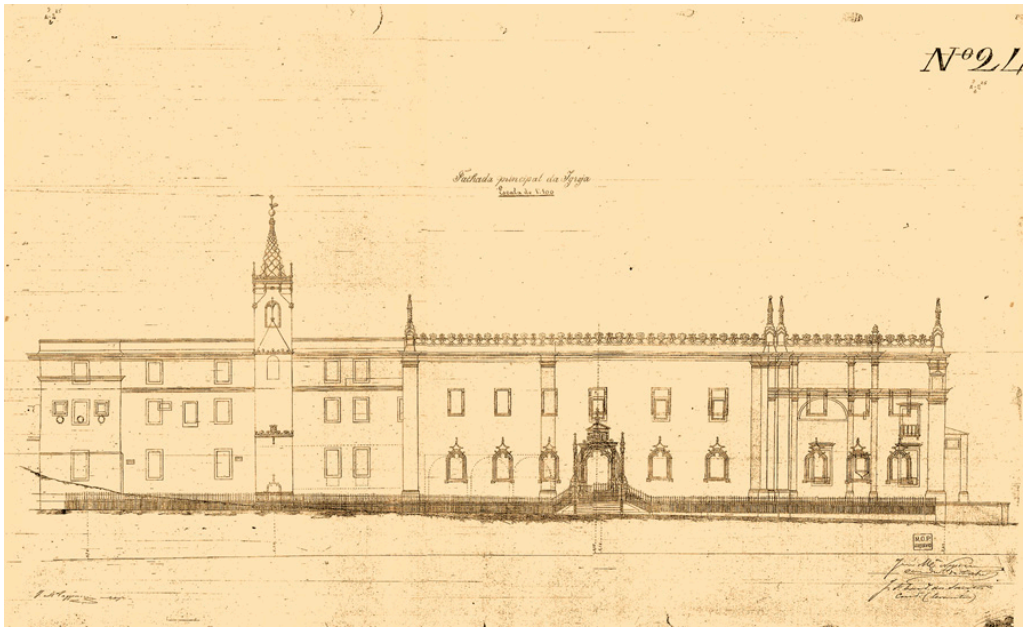

Figure A5. 19th-century elevation (drawing No° 24) by the architect José Maria Nepomuceno. Library and Historical Archive of the Ministry of Social Equipment.

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