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The Origins of the Postgraduate Programs on Cultural Heritage Knowledge, Management, Conservation, and Communication in Italy: A Vision of the Past as Engine for the Next Future

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Abstract: A discriminating, multi-disciplinary knowledge is a necessary expertise that all the actors who operate in the management, conservation, and communication of Cultural Heritage (CH) must have. They are, therefore, expected to be seriously prepared in many fields. However, a proper training program for them, which effectively combines humanistic studies with scientific ones, is difficult to be arranged when there is lack of comprehensive perspective in the education system. This paper introduces the experiences of the postgraduate programs that were established for many years at the Scuola Normale Superiore in Pisa, Italy. Through a calibrated mixture of theoretical background and practical applications taught by high-profile scholars, those programs proved to be effective in the preparation of figures later dealing with the CH at different levels. The clear organization of those specialized lectures, the innovation introduced with hands-on practical case studies and the adoption of state-of-the-art techniques, led to an educational paradigm that is still efficient, whose outcomes also demonstrated how it can be inspiring for future high-level learning programs, which must be oriented towards fostering an aware preparation for leading operators involved in the conservation and dissemination of CH.

Keywords: heritage education; digital heritage education; archaeology; heritage management education; heritage communication education

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1. Introduction

The Italian education system in the field of Cultural Heritage (CH) knowledge, management, conservation, and communication is strongly rooted in the work of Paola Barocchi (1927–2016), Full Professor of Art History and Vice-director for many years at the Scuola Normale Superiore (SNS) in Pisa, Italy (Figure 1) and in her joint experience with one of the authors of this paper beginning from the middle of the 1990s.

These trials suggested the didactic organization of large part of today's curricular courses (e.g., the course in Innovation and Organization of Culture and the Arts at the University of Bologna (https://corsi.unibo.it/2cycle/gioca, accessed on 24 August 2021) and post-graduate courses such as the Scuola del Patrimonio founded by the Italian Ministry of Culture (MiC), and of didactic guidelines such as the Curricula Guidelines for Museum Professional of ICOM released in 2000 [1].

Reviewing, nowadays, these first trials and today's postgraduate programs, we can observe that the original features were much more sophisticated and powerful when compared to today's outcomes. Most qualities of the first attempts to develop a postgraduate program for the graduate in art history, architecture conservation, and archaeology were lost due to an inaccurate translation into new programs.

We remark that, at the time, teaching related to the exploitation of Information Technology (IT) techniques in the field of CH was limited to listing software commands or to

computer programming techniques, without any link to the problems that those systems could allow to solve. Moreover, the usual teaching system was based on frontal lessons supported by images of the fine art, architecture, and described archeology artefacts. To achieve direct experiences, sometime visits to the sites were organized.

Figure 1. Paola Barocchi in her library.

In this paper, we aim to describe the didactic structure, the didactic methods developed, and the outcomes of the first post-graduate courses organized by the SNS from 1997 to 1999 and beyond, until 2011.

Three perspectives are here integrated: those expressed by the director of the course, those of a teacher, and those of a former student and then teacher (today senior curator at the Centro Internazionale di Studi di Architettura Andrea Palladio in Vicenza (Italy) (CISA AP)) to fully describe the original methodological approach. They will, thus, allow a complete understanding of the didactic system, methods, and topics together with the understanding of knowledge skills acquired by attending students, both in the theoretical and practical approaches ("to know and to do").

The paper includes eight sections: following this introduction, the background is described in Section 2. In Sections 3 and 4, the new methodologies and didactic organizations previously introduced are explained in detail. In Section 4, an in-depth description of the organization and methods adopted in a module of the courses better explains how new IT-related content was disseminated. Section 5 is devoted to the description of the follow-up of the courses through a major case. Section 6 depicts the following experiences and their features. In Section 7, the main outcomes achieved are summarized. Finally, in Section 8, are the conclusions.

An accurate description of the innovations of the first post-graduate courses organized by the SNS is not an easy goal using a paper structure that follows the typical research

presentation technique in the field of scientific knowledge, since it is far from the habitual way to report events and methodologies in the fields of fine arts, architectural history, and archaeology. To improve the clarity of the paper and to better understand novelties, links, improvements, changes of paradigms, behaviors, knowledge organization models adopted, and didactical model developed, their description is done using a technique usual for the humanities: a multiscale narration, switching from general themes to detailed aspects of a specific course. This kind of organization reveals the knowledge dissemination technique developed in the courses. This way the reader can more easily understand what is described and the reasons that led to write this paper.

2. Background

2.1. Paola Barocchi's Cultural Ecosystem

During the 1970s, following the attention to computerization that had characterized the library cataloguing sector, several projects relating to the art heritage started. These works initially focused mainly on systematic inventories and cataloguing. At the same time, 'experts' on inventorying methods related to the CH started to meet and share knowledge, methods, and standards.

Following these first experiences, in the years 1976–77, Paola Barocchi launched the firsts IT projects related to historical and artistic documentation at the SNS [2], exploiting two extraordinarily favorable local factors:

- the presence in Pisa of a university always at the forefront in the IT field (the University of Pisa) together with the CNuCE, the National University Center for Electronic Computing, founded in 1965;
- the SNS environment in which, despite some initial hesitation, the contamination of knowledge was easy due to the contiguity of 'humanists' and 'scientists' [3].

Starting from this cultural 'milieu', Paola Barocchi conceived various applications of IT to the study of art history, going well beyond the limits of the time, which were the lack of interaction possibilities and the small power of memorization, computation, and visualization. In fact, there were no personal computers, tablets, smartphones, or even the Internet; electronic computers were very large machines, in which 'punch cards' were used as a recording medium.

The motivation distinguishing Paola Barocchi's approach to the use of automatic processing did not arise from cataloguing needs, as usually proposed by the applications of the time, but it originated from specific research needs [4]. In particular, she understood how the IT tools could be pivotal to allow scholars to access the sources quickly and easily and, more generally, she was able to foresee future developments and the essence that the new tools were bringing to knowledge.

This research was fueled by a solid background derived from the continuous exchange with worldwide scholars. Moreover, Paola Barocchi underlined in 1988 that two distinct levels of activity could be identified: "on the one hand the need to experiment with new procedures, and on the other the need for continuous information and accurate contact with the outside world" [5].

The fundamental condition required to justify the attempts to solve the complex problems generated by art-historical research based on electronic data was a strong awareness of the need to recontextualize the work of art according to the various aspects of its specific history (patronage, owners, market prices, restorations, etc.). From a technical point of view, an acute analysis of the situation was illustrated by [6], who suggested that "the computerization of art history needs integration in many senses, i.e., it needs integration, media integration, and integration between disciplines" (p. 314). To this aim, it is necessary to make a great effort towards data formalization and normalization and above all "to stop thinking in terms of the target software and start with a more abstract way of representing the reality: the conceptual schema" [7] (p. 317).

To shape this background, in 1978, she organized in Pisa, in collaboration with the Villa I Tatti, the University of Siena, the Ministry of Cultural and Environmental Heritage and

the CNuCE (which in the meantime became an institute of the CNR), the first international conference "Automatic Processing of Art Historical Data and Documents" [8] involving speakers from eleven countries. Thanks to this initiative, fundamental relationships were established, which would be affecting the projects of the following years: with the Paul Getty Foundation, with the Harvard University Center for Italian Renaissance Studies in Florence, with the Warburg Institut.

Paola Barocchi's intent was to "solicit information on the initiatives underway and on the various systems adopted, also offering [...] the opportunity for concrete demonstrations", a method that later became central in the design of the educational system object of this paper.

Other important parts of Paola Barocchi's project were the establishment in 1979 of the Center for Automatic Processing of Historical Artistic Data and Documents (which will be renamed Computer Research Center for Cultural Heritage—CRiBeCu in 1990) and the publication, since 1980, of the "Bollettino d'informazioni" (Information Bulletin) of the Center, which intended not only to offer scholars the results of their experiences in the field of the collecting history but also to elaborate through them methodological and instrumental solutions to promote new research programs: a key point of the teaching for the future post-graduate courses.

Strictly linked with her research activities, she started a program addressed to the field of education with a new didactic able to generate new skills due to the synergy between the humanities and computer science. Therefore, specific courses and seminars were created as early as 1978. The aim was always to propose real cases, also addressing new fields of study and offering opportunities to connect different skills and educational backgrounds: scholars, managers, curators of collections and archives, restorers, IT specialists [9]. A method that will be later taken up in the following post-graduate courses.

In the mid-1990s, the research system in the field of the IT application to the CH, as conceived by Paola Barocchi in the previous fifteen years, was well delineated and accurately developed. However, the educational project was limited to the simple IT alphabetization to art history of archaeology scholars and students.

To expand the possible learning outcomes and recipients, a new program was developed starting from the following years, together with one of the authors of this paper, with the aim of shaping a new integrated knowledge to the future operators in the CH field.

2.2. The Academic Setting

In the mid-1990s, the educational world in Italy was undergoing a deep revision of its entire apparatus, including the schools as well as the university and post-university education, long life, and distance learning.

This revision was a consequence of the progressive awareness of the importance of the university system in the cultural and economic growth of the country, of the strengthening of public and mass university as an engine for the civil system, of the modernization need for a system that was still based on the professional work as a matrix of didactics despite the Italian Ministry of University promoted research as an academic activity (it took the name of Ministry of University and Scientific Research). This knowledge generation had to be followed by its dissemination through didactics that, through the rise of digital technologies and the introduction of low-cost multimedia systems, began to be progressively transmit remotely via the Internet. Italy was the fourth European country to connect to the network, after Norway, the United Kingdom, and Germany in 1986. The connection took place from the National University Computing Center at the University of Pisa, where the research group was among the most advanced in Europe and it opened the doors to the dissemination of knowledge that was different from simple frontal communication or guided exercises in the classroom.

The Law no. 341 of 19 November 1990 "Reorganization of the university teaching systems" ("Riforma degli ordinamenti didattici universitari") allowed universities to activate education courses and external cultural and training activities, including those targeted to

the cultural updating for adults, as well as those for permanent learning, and specialization and professional continuing education courses.

This law encouraged many experimental initiatives towards the construction of training systems, answering to the world of work needs and to the new instances proposed by the first spreading phase of the IT-based (Information Technology) techniques. This was also the regulation that activated the higher education courses promoted by the SNS since 1997 in the Management and Communication of Cultural Heritage training field.

The success of these initiatives led to a formalization of the teaching model in the Decree of 3 November 1999, no. 509 of the Ministry of University and Scientific Research entitled "Regulation holding rules concerning the didactic autonomy of universities" ("Regolamento recante norme concernenti l'autonomia didattica degli atenei"), which codified the university course of higher education as "a professionalizing post-graduate course with 10 to 25 credits aiming at a specialization or a specialized deepening established based on of art. 6 of Law 341/1990".

A strong boost to this post-curricular activity, both with economic incentives and with steering documents, was also given by the support of the European Union (EU), which, during the 1990s, progressively introduced the definition of contemporary society as a knowledge society.

This definition was universally accepted starting from 2000 when the Lisbon Summit highlighted the need for Europe to speed up its transition to the knowledge society, to invest in the growth of mass computerization and, above all, to 'recalibrate' the so-called 'education welfare' system [10].

The topic, in fact, was already typical of the reflection consolidated in the EU since the first half of the 1990s. At the time, several EU documents—the 1993 White Paper "Growth, Competitiveness, Employment. The challenges and ways forward into the 21st century", by Jacques Delors, President of the European Commission from 1985 to 1994, the 1995 White Paper "Teaching and learning—Towards the learning society" by Edith Cresson, Commissioner responsible for research, education and training; the OECD (Organisation for Economic Cooperation and Development) book "Learning at all ages" of 1996—introduced reflections on the learning process centrality.

Delors' White Paper focuses on a particular type of unemployment that characterizes the European system: the 'technological unemployment'. According to the White Paper, technological unemployment is strongly linked to a level of education and professional training that is inadequate to the nowadays fast technological development and to the globalization of the economy.

Education and training, thus, became instruments of active policy useful to adapt the professional preparation level, especially in young people, to the new and ever-changing needs of the labor market. The principle that must guide training interventions is to favor the enhancement of human resources throughout life.

Based on this, it is envisaged that education and training systems will be reformed so that they can be more closely linked to the world of work, as well as will become a continuous training system that can allow greater development of employment.

To reorganize the education and training system, it is important to allocate funding for training programs and to involve companies in these processes, e.g., it is useful to promote training courses by expanding forms of internship and apprenticeship in companies or to reduce social charges for those companies that activate training courses for their employees.

The restructuring of the Structural Funds, and in particular the reorganization of the European Social Found (ESF), which applies to the 1994–1999 period, placed the raising of skills at the top of its priorities. The new goal, aimed at "facilitating the adaptation of workers to industrial change and changes in production systems", stressed the importance of maintaining skill levels and extended the benefit of the ESF, for the first time, to all Member States, to employed workers.

Other EU programs, such as FORCE (1991–1994) and Leonardo da Vinci (1995–1999), were also main instruments aimed at accessibility promotion. They were oriented to

promote innovation in professional training and, thus, contributing to the development of new training approaches and tools to foster access to training and skills.

This is the (cultural and economic) framework in which the Higher Education courses of the SNS took shape.

A 2000 document by the Commission of the European Communities summarizes the didactic methodological framework underlying the educational project, indicating the development of effective teaching, and learning contexts and methods as a fundamental objective: "As we move into the Knowledge Age, our understandings of what learning is, where and how it takes place, and for which kind of purposes, are changing. We increasingly expect teaching and learning methods and contexts to recognize and adapt to a highly diverse range of interests, needs, and demands, not only for individuals but also for specific interest groups in multicultural European societies. This implies a major shift towards user-oriented learning systems with permeable boundaries across sectors and levels. Enabling individuals to become active learners implies both improving existing practices and developing new and varied approaches to take advantage of the opportunities offered by ICT and by the full range of learning contexts. Quality of learning experience and outcome is the touchstone, including in the eyes of learners themselves. But little effective change and innovation can take place without the active involvement of professionals in the field, who are closest to the citizen as learner and are most familiar with the diversity of learning needs and processes." [11] (p. 13).

2.3. The IT for CH Environment in the Mid-1990s

At the beginning of the 1990s, the initial aims of the CH community, i.e., the automation of catalogues and inventories, were achieved. The conference proceedings of the "Automatic Processing of Art History Data and Documents" organized by the SNS, in collaboration with other Italian and foreign institutions, well document these experiences.

The project of "Automatic Processing of the Catalogue of Cultural Heritage" [12], a collaboration between SNS, Istituto Centrale per il Catalogo e la Documentazione (ICCD), fostered by its Director Maria Luisa Polichetti, and the CNuCE Institute of the CNR was well established, exploiting the potential of the relational Information System (IS) architecture.

Other experiences experimented successfully with the recording of digital images on optical disks connected to alpha-numeric databases, and with the use of digital cartography. A wide range of issues related to the use of computers in art history (from thesauri to lexicons, from cataloguing issues to the processing of documents, to the problem of integrating databases), had been subjected to efficient and concrete trials, a sign of growing success in the use of technologies.

The advent of IT in the world of museums gradually spread in Italy in the late 1980s, generally linked to temporary exhibitions, having the ability to convey appropriate economic resources and significance. During this transition from the initial phase of experimentation to the subsequent phase of development of computer applications and evaluation of methodological implications connected to their potential, CH has been generally considered as a single entity in concept and context [12]. Nevertheless, for the first time, new modalities for the exploitation of information were introduced.

Two initiatives emerged. These are generally considered as the first examples of the widespread use of computer technology implemented for archaeological exhibitions: "The Phoenicians" in Palazzo Grassi in Venezia in 1988 [13] and "Rediscovering Pompeii" in the IBM Gallery of Science and Art in New York in 1990 [14].

Only in the 1990s did IT permanently enter the museum field, due to the introduction of computer graphics first on workstations and then on PCs, filling the gap between temporary exhibitions and stable institutions: the museum becomes a center for cultural debate on computers and education.

This application of computer graphics was propaedeutic to the first attempts to make use of virtual reality (VR) technology in the field of culture, and (at almost the same time)

it also proved to be instructive when the potential advantages of applying the Internet in a cultural context were first considered, starting with "networks of virtual museums" early in the 1990s [15].

The recurrent idea of a "museum without walls", or "virtual museum", spread in Italy in the second half of the 1990s, acquired a prominent position in communication strategies. The origin was probably the workshop "Museum without walls—New Media for New Museums," in 1994 organized by the University of Ferrara, together with the University of California, Berkeley. This two-day initiative presented to all participants a unique experience as testified by Paul Quintrand, one of the founders of the "Groupe de Recherche pour l'Application des Méthodes Scientifiques à l'Architecture et à l'Urbanisme" in Marseille and by Michael Naimark, one of the founders of the Media Lab at MIT in Boston [16,17], followed by the panel at SIGGRAPH 1995 "Museums without walls: new media for new museums" [18].

More in general, computer graphics allowed from the beginning of the 1990s to transfer in digital, colorimetrically corrected images reproductions of paintings, books, manuscripts, drawings, photos, etc. using the 'bitmap' technique [19].

Although the creation of synthetic images—what we now commonly call 'rendering'—allowed photo-realistically simulated virtual reconstructions of architectural environments and scenes with features and natural phenomena such as lighting, water, and atmosphere at the end of the 1980s, however, it was only at the beginning of the 1990s that commercial systems based on raster graphics began to deal extensively with the processing and digital reproduction of artworks images and more generally of CH images, also thanks to the development of new graphic applications such as Adobe Photoshop, Adobe Illustrator, or Macromedia Freehand. These were able to manage the color and to select it considering the spatial and semantic information [20].

It will only be at the end of the 1990s that Humanities begin to think about systematic digitization operations of documentary deposits (i.e., not only paintings, drawings, or sculptures, but all related documents) to extend to visual art and to the original document the construction of the textual databases typical of the previous decade.

From a technical point of view, these works were the evolution of the sporadic and limited experimental projects of the previous decade, among which we cite the digitization of the manuscripts at the Vatican library, which exploited the pioneering but ruinous IBM Pro/3000 scanner [21], and the high-resolution imaging system for paintings VASARI (Visual Arts: System for Archiving and Retrieval of Images) scanner [22].

Furtherly, computer graphics—as written—introduced the VR [23], allowing to visit 'live' or with synthesis movies ancient buildings, to get closer and closer to frescos discovering different layers and techniques, to navigate 'inside' layers and ages into archaeological sites. More in general—as quoted by Paola Moscati [12]—to meet the requirements of a system that should provide artworks and monuments with a network of references to their historical, artistic, and geographic contexts, advanced technologies of 3D imaging and animation as well as simulation tools are necessary to plan and implement virtual exhibitions and visits based on data contained in various archives, logically integrated along virtual itineraries.

The development of digital 3D imaging and modelling, basically our way to attempt a description of the physical 'real' or imagined world around us using numbers—during the 1990s—was the key to enabling these experiences.

In the early 1990s, 3D models were already well adopted in the field of architectural digital representations. Historical analysis and research had already produced several examples of models for existing architecture leading to some excellent results, e.g., the famous example of the Cluny Abbey built by IBM in 1992 thanks to three students from the École Nationale Supérieure d'Arts et Métiers that used drawings by American archaeologist Kenneth John Conant. IBM produced a 16-min movie *Mémoires de pierre* that was released in 1992 [24].

In the same years, in various research centers, different researchers felt that digital reality reconstruction exclusively from drawings was excellent for usage in the filmmaking field and very effective for communication to a wide audience, but very limiting for architects and historians.

The true added value that digital modeling techniques could bring, was a real mold "digital surrogate", also working as an IS as the basis for conservation and re-design purposes. This implies two requirements in the CH field: the semantic construction of digital models, in which the association of semantics and architectural shape requires looking at a building as a cognitive system; and the construction of the 3D models of existing artefacts from reality-based 3D data [25] (pp. 47–69, Strategie di rappresentazione digitale: Modelli per la conservazione e il restauro). Many attempts were done to build 3D semantic models exploiting the theories proposed by George Stiny and William J. Mitchell at Massachusetts Institute of Technology (MIT) [26] and by Paul Quintrand [27]. The second requirement needed, at the time, to follow two different and converging paths, both based on the use of experimental laser scanners. The first was the use of experimental time-of-flight technology developed for large architectures. A breakthrough came thanks to the setting up of a collaboration between the University of Ferrara and the new company Cyra Technologies, which had just finished the first nucleus of the system now known as Leica ScanStation P40/P30 and, in January 1997, decided to scan the Hearst Memorial Mining Building facade within the campus of the University of California, Berkeley [28] (Figure 2). In the same year, Katsushi Ikeuchi, one of the fathers of Computer Vision, and Marc Levoy, at the time professor at Stanford University and now Vice President and Fellow at Adobe, started their experiments with the same equipment for their projects on Great Buddha [29] and Digital Michelangelo [30]. The second one was the use (started in the 1980s [31]) in 1995 for the "Mothers of Time" exhibition at the Canadian Museum of Civilization of polychromatic triangulation-based laser scanners developed by a group at the National Research Council of Canada (NRCC) [32]. NRCC also prepared an interactive 3D virtual display to let the visitors examine high-resolution stereo 3D models of the Figurines in either a monoscopic or stereoscopic viewing mode, using active shutter glasses. Visitors could examine the figurines by manipulating a track ball and changing the display modes. The display reverted to a predetermined animated sequence when unused for a given time.

This event allows us to reconnect to the emerging using of ICT in the museums, at the time basically consisting in the use of hypermedia [33] and VR.

During these years, the radical transformation of the traditional systems of safeguarding, management, and exploitation of cultural resources is definitively ascribed to new and increasingly sophisticated technologies able to provide didactic aids, mainly with an interactive nature. Moreover, it emerged the idea that ICT solutions were extremely important to ensure the connection between a central hub, which covers the whole area or theme under consideration, and the different peripheral subsystem hubs, opening the doors to the Internet-based applications as the most important vehicle for the diffusion of cultural information [34].

From a methodological point of view, the concept that museums should not limit themselves to operate through mere duplication or simplification of the visit and its traditional support tools emerged [35]. The experiments needed to be oriented towards the enhancement of all the multimedia potential to complete knowledge (enriching the audiovisual experience), integrate documentation, encourage cross-reference reading and highlight the intercorrelation among information. This required an interpretative and reconstructive effort necessary for a full comprehension of ancient reality.

CH and museums by now constitute a reality in the Information Society, as it is demonstrated also by the European Commission programs in which the cultural sector has gradually assumed a leading position for the development of new products and services to be delivered over digital networks.

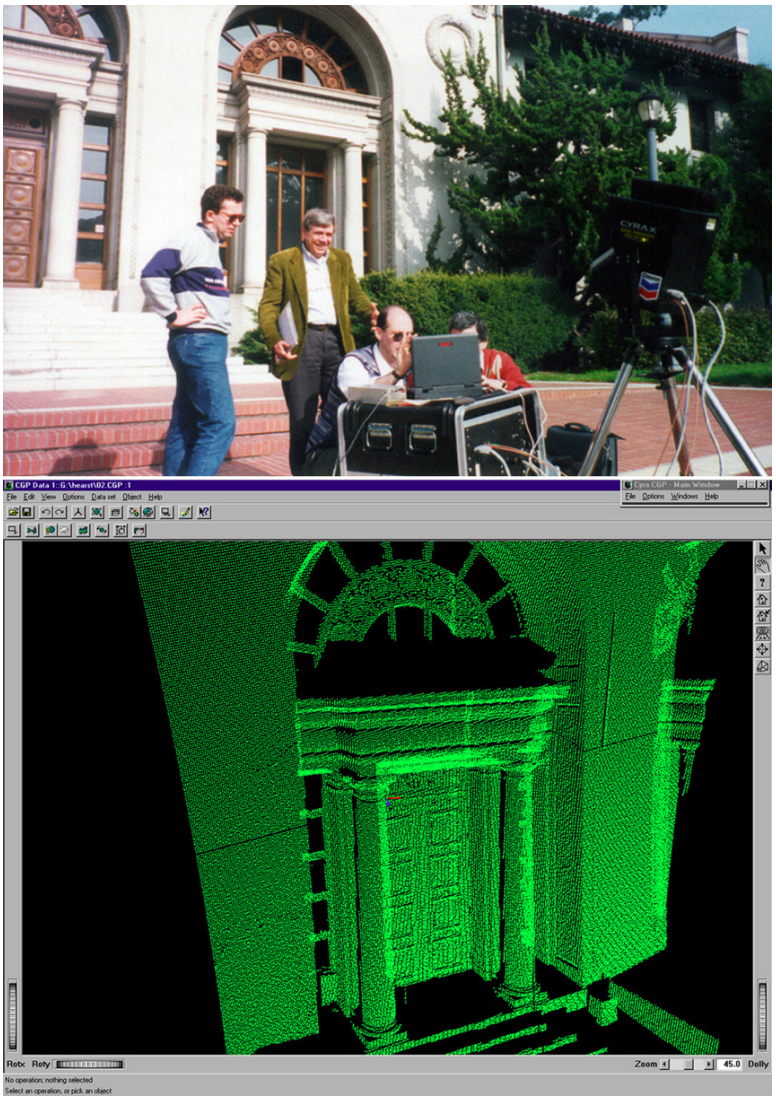

Figure 2. Hearst Memorial Mining Building main façade survey: surveyors at work and a single shot point cloud of the laser scanner Time-of-Flight prototype Cyrax, 1997.

In February 1995, the High-Level Group of the European Commission organized the First Meeting on the Information Society, in Brussels under the Chairmanship of Commissioner Martin Bangemann.

During the meeting, a list of eleven pilot projects was approved: Global Inventory (of projects); Global Interoperability; Cross-Cultural Education and Training; Bibliotheca Universalis; Multimedia Access to World Cultural Heritage; Environment; Global Emergency; Government Online; Global Healthcare; Global Marketplace for SMEs; Maritime Information Systems.

These projects aimed to trace the guidelines of the Information Society.

In June 1995, the worldwide *G7 Summit* approved and adopted the above-mentioned list of projects.

Practical demonstrations focusing on the four principal sections identified by the Multimedia Access to World Cultural Heritage project were presented at the ISAD Conference (Information Society and Developing Countries) held in Midrand, South Africa, in May 1996. During this conference, four demo projects were selected principally referring to the specific contents of museums and art galleries: a 3D acquisition system for museum artefacts, a laser scanner presented by the National Research Council of Canada in Ottawa; filing of the Museo di Storia della Scienza in Florence; the visualization of the Nefertari

Tomb, developed by Infobyte, Rome; the "SUMS" Navigation, developed by SUMS Corporation in Toronto [36]. In 1997, these cases were the most accurate representations of the nodal trends and emergent patterns in the subject matter: communication, learning, knowledge processing, and knowledge management.

3. Developed Methodologies: The First Higher Education Courses Promoted by the SNS

3.1. Previous Experiences and the Birth of the Courses

As mentioned in Section 2, during the years 1980–1985, Paola Barocchi, at SNS, promoted courses on the use of the computer for the staff of Superintendences. Within this framework in the same years, she conceived and organized, very successfully, an innovative and pioneering program of didactic-practical courses aimed at giving a basic introduction to the use of digital resources to the staff of the artistic-archeological directorates/Superintendences. Art historians and archaeologists working in these institutions were unaware not only in the use of advanced tools but also on trivial skills. These courses, held in Pisa, had a strong hostility from many colleagues within the SNS, who believed that this pioneering initiative was not appropriate for the traditions of the SNS, because too professional and too strongly linked with a strange and not mature technology.

Shortly after the mid-1990s, Barocchi decided to undertake more ambitious educational projects, overcoming the teaching of the simple basic use of the new computerized instruments. In 1996, she proposed to one of the authors of this essay—an archaeologist and, therefore, a professional figure different from her own, an art historian—to design and to carry out a new type of course, based on the integration of knowledge from different fields and with both theoretical and professional experiences.

The aim was no longer the communication of the latest knowledge in the field of art history or archeology, or the literacy to computerized techniques for the staff of the superintendencies, or to teach how to create databases to support historical and artistic research, such as those that Barocchi promoted in the previous decade in close collaboration with the Accademia della Crusca (an institution that fosters philological researches on the historical evolution of Italian language) chaired by Giovanni Nencioni. The novel goal was to communicate a multidisciplinary knowledge in which IT was included as an operation tool in its context.

A ten-day-long experimental course, in which the skills of the archaeologist and art historian were merged to create a new cultural container, was designed and implemented.

The course began in the month of September of that year in Cortona—a small town in the Arezzo province, in Tuscany, where the SNS owned a monumental Villa called "Il Palazzone", built between 1521 and 1527 on a project by the architect and writer Giovan Battista Caporali—a disciple of Perugino and a friend of artists of his time such as Pinturicchio, Bramante, and Signorelli (Figure 3). This location, far from the Pisan polemics, was ideal to allow innovative experiments, without provoking contrary reactions.

The course was divided into two sections, a subdivision then resumed in the later courses. The historical and artistic part was handled by Paola Barocchi together with the Accademia della Crusca, while the archaeological part was handled by Benedetto Benedetti with the collaboration of Mario Torelli, a pupil of Ranuccio Bianchi Bandinelli, full professor of archaeology in Perugia, and several aids by Alessandra Melucco Vaccaro, an archaeologist known for having made significant innovations in the area of the Early Middle Ages and classic archaeology, and in the field of restoration, and by Piero Guzzo, the director of the Archaeological Superintendence of Pompeii [37].

This organizational structure shaped two central points for future courses: concurrency and integration of different and complementary disciplinary skills; and planning of the didactic structure by disciplinary experts of the highest possible level of competency. This last feature was fundamental at the time, since the knowledge was embodied by the experts—there was not the Wikipedia (created in 2001), the Internet was still very poor in contents (even if the NCSA Mosaic browser was introduced five years earlier), and the

number of on-line scientific documents were very limited (even if the Adobe PDF (Portable Document Format) dated from 1993).

Figure 3. The "Palazzone" in Cortona.

The presentation of real case studies in which all the theoretical and practical aspects from different disciplinary perspectives were reconstructed in an integrated form was another methodological innovation. Following this approach, complete experimentation examples for the entire 'lifecycle' of monumental complexes were illustrated. The usual presentations of the analysis, conservation, and restoration problems were complemented by those concerning the daily management. This integrated discussion involved the co-presence of several actors who worked on the case study: thus, the teaching was held by multidisciplinary groups. Furthermore, practical aspects were also addressed, such as those related to the daily life of a monumental complex, which not only included the conservation of monuments or the excavation activities, but also the management of tourists, the cleaning, the catering and the guardianship services, the infrastructural network, and the relations with local authorities.

This was a major innovation compared to the Italian academic tradition, which essentially provided for the acquisition of pure theoretical knowledge and ex-cathedra lessons to which the professional side was completely extraneous.

The short and innovative course, thanks also to the extraordinary success of participation and of involvement, not only for attendees but also for teachers, laid the cultural foundations for projects of greater size and importance.

The high cultural level and success of the attempt induced the Tuscany Region, together with the Province of Arezzo, to propose a few months later to Benedetto Benedetti and Paola Barocchi a three-year-long EU-funded project for annual master courses with a consistent budget. The project, entitled "Research and development: management and communication of cultural heritage" was funded and, in October 1997, the first postgraduate program course in "Communication and management of Cultural Heritage" was launched. The two 1998–1999 and 1999–2000 editions followed.

The title already revealed a key feature of the project: the educational path was linked to a program of conferences, meetings, and, above all, research, planning, and orientation activities to place scientific achievements at the basis of the organization of our society.

The project focused on an educational program of high professional training and aimed to integrate the scientific investigation on historical-artistic heritage with the application of methodologies and research techniques for the construction of advanced conservation management, enhancement, and communication systems for CH. For the same purpose, the didactic initiatives were linked to a program of conferences, meetings, and, above all, research, planning, and orientation activities.

The location was the same as the 1996 experimental course: the town of Cortona.

The Convent of S. Agostino, managed by a subsidiary company of the Municipality of Cortona, which was also entrusted with the administrative management of the project, was added to the Palazzone, where, held in the great hall of with the Papacello's frescoes, remained hosted seminars of scientific and cultural relevance. The Palazzone rooms hosted the teachers and the staff of coordinators.

Benedetto Benedetti was appointed scientific and didactic director, while Paola Barocchi was the responsible director.

The postgraduate course received great publicity from an article published on the weekly magazine *L'Espresso* (which at the time had a weekly circulation of almost half a million copies) by the journalist-archaeologist Marisa Ranieri Panetta. Probably thanks to this, for the first edition of the course, the SNS received 1200 applications compared to the 45 places available.

3.2. The Courses Structure and the Didactic Framework

The structure of the 1997 postgraduate programs was extremely complex and included two types of courses: master degrees (three masters lasting 21 weeks for a total of 700 h distributed over six to seven months from October to spring), and professional specialization courses (three courses lasting six weeks for a total of 200 h).

The number of students admitted to each of the three masters was 30, while five were admitted to the professional specialization courses.

The selection, open to graduates under the age of 33, was based on the curriculum evaluation: exams with the grades of the degree course, the title of the thesis, the name of the supervisor, academic scientific qualifications (specializations, doctorates, scholarships), professional qualifications, work experiences relevant to CH. The selection then included, for each address, an interview, with the presentation of the degree theses on a pre-selection of 30 short-listed candidates. During the evaluation phase, technical-scientific curricula demonstrating knowledge in the fields of CH (e.g., conservation and restoration, scientific representation—photographic and digital) were also considered.

Attendance was compulsory, registration and meals were free.

The achievement of the master included a final exam by a commission always appointed and chaired by the scientific director of the course.

At the end of the master's degree, internships were provided for the eligible ones at public and private structures operating in the sectors of management, conservation, and communication of CH.

Finally, a diploma was issued both for the master and for professional specialization courses in two forms: an administrative certification from the Tuscan Region, and a scientific certification from the SNS.

The three masters corresponded to three paths:

- Artistic historian path. Paola Barocchi was responsible, with the collaboration of Sandra Pinto, Director of the National Gallery of Modern Art in Rome, and Simonetta Lux, full professor of History of Contemporary Art at the "Sapienza" University of Rome;
- Archaeological path. Benedetto Benedetti was responsible, with the collaboration of Mario Torelli, Alessandra Melucco Vaccaro, and Piero Guzzo;
- Conservation and preservation path. Michele Cordaro, director of the Central Institute of Restoration in Rome (today's Istituto Superiore per la Conservazione ed il Restauro) was responsible with the collaboration of Giovanni Carbonara, full professor of Architectural restoration at the "Sapienza" University of Rome, where he directed the "School of Specialization in Architectural Heritage and Landscape".

The master was divided into three modules:

a. Basic module: consisting of the basics of IT, management, conservation;

b. Path module: different for the three masters. For the historical-artistic master's degree it concerned the management and enhancement of CH in the territorial context; for the archaeological master's degree it concerned the methods of conservation, management, and enhancement of the Archaeological Heritage; for the conservation and preservation, it concerned the methods of conservation and preservation of the urban architecture;

c. Professional specialization module: which was common to the professional specialization courses. In this course, case studies were presented and discussed: management of monumental complexes, analysis of scientific components, construction of digital databases. These were in turn divided into three groups, among which the student could select:

- Analysis, survey, and representation of the landscape,
- Digital publishing, multimedia, web design, and distance learning,
- Management, enhancement, and promotion systems. The lectures were held mainly by economists and lawyers—led by the economist Marco Causi, Pietro A. Valentino and Luca Zan—who were specialized in the various aspects of management and governance of museums and archaeological parks.

We will focus on education only in the field of IT that was a new driver to convey the knowledge and management process.

First, it should be noted that although there were three distinct masters, they presented a common initial training consisting precisely and not coincidentally in the IT formation. This section concerned basic information (introduction to the personal computer and its hardware and software components; overview of operating systems and of the application programs; the printing; the Windows 95 operating system; the Microsoft Office 97 package; basics of digital imaging; photo retouching lab) and some advanced topics of which were provided only theoretical features: hypertexts and multimedia, multimedia applications on CD-ROM; the Internet. It corresponded to the need for learning from scratch of archaeologists and art historians who not only did not usually have any notion but who often rejected it as well, and that of architecture graduates who often had at least basic notions and who, in any case, showed great interest in the instrument, thanks to its potential for specific and daily use.

In the master continuation, students encountered other notions and had further workshop moments related to computerized techniques, but these were more focused on the specific uses related to the address selected by the students of the course (historical-artistic, archaeological or conservation and preservation).

It should be remembered that, at the time, the application to CH of IT-related technologies was still a growing discipline. Due to this reason, great attention was given to two aspects: the choice of high-level scholars as teachers for generic lectures that would

have weighed down an already onerous path; the general coordination by two scholars of different backgrounds: a humanist interested in IT technologies—Benedetto Benedetti—and a computer scientist intrigued by the applications of CH—Paolo Paolini, professor at the Politecnico di Milano, scholar of multimedia and hypermedia systems and expert in Human–Computer Interaction.

The collaboration between Benedetti and Paolini led to strengthening the didactic concept of integrated presentation on the uses of IT in the field of CH so that their illustration was done by groups of representatives for all disciplines who had contributed to the experience.

A typical case was the pioneering regional GIS for the Superintendence for Cultural and Environmental Heritage of the Valle d'Aosta Region, which eased detailed and documented control for the entire territory of the autonomous province. It was an extremely innovative system featuring all the characteristics needed for accurate management of the cultural assets existing all over the region. Its development was possible due to the limited territorial extension of the region. For this reason, despite its great success, the system was emulated on a large scale only much later.

This case also shows another feature of the education proposed: to provide only innovative case studies, i.e., the product of research and experimentations.

The student was, thus, trained in interdisciplinary knowledge and processes typical of his future work and in knowing how to innovate processes using IT techniques.

This could be easily observed from the analysis of the educational paths, e.g., the student of the conservation and preservation path at the end of the master had acquired methodologies for the scientific research in the field of historical and artistic heritage integrated with computer processing applications combined with field survey techniques; economic, administrative, and legal management systems; conservation and preservation methodologies and technologies, also according to quality standards (Restoration Chart and Risk Chart); systems for the enhancement and promotion and dissemination of CH; optimization of services, systems, and techniques for exhibition and design installations; methods of data collection, processing, and communication; image processing; multimedia hypertext editing; virtuality, electronic cartography.

3.3. Didactics and Research: The Case Study of the Pompeii Archaeological Area

Among the case studies presented, the one concerning the archaeological area of Pompeii (an archaeological site visited every year by over three million tourists (pre-COVID) and destination for more than thirty archaeological missions, but which in any case for 4/5 is still buried today [38]) certainly was the most paradigmatic for the prominence and for the many innovative activities carried out. This case study was illustrated many times over the years, generating an unmatched path between research and didactic in the field of CH.

In the 1997 master, the complexity of the case study of the archaeological area of Pompeii was exposed in two weeks of lessons, including all the topics about the site: archeological, historical, artistic, conservation, management, economic, communicative.

Besides the Superintendent Piero Guzzo, teachers were the administrative managers to illustrate the financial statement of the site and the real aspects of the daily life of an archaeological site. Always regarding the administrative problems, there was a communication by Giuseppe Gherpelli, at the time an economic consultant of the site and who later became the manager of the Superintendence of Pompeii to support the scientific director Piero Guzzo. Luca Zan, professor at the University of Bologna in business administration sciences, also a consultant from Pompeii, gave a lesson on the same topic. The teaching of economics, marketing, and finance (corresponding to the innovation of the site management) opened a path unusual at the time, since economic-administrative management had always been considered a marginal aspect compared to the cultural one, and then not worthy of attention. The management of the CH was considered an aspect of economic

policy, according to the school of Paolo Leon, and the costs of cultural assets, in terms of a collective good, had to be supported by the state government.

In addition to this economic focus, the subjects of conservation and restoration were addressed with specific reference to those of the frescoes—a type of artefact recurring in Pompeii. The topic was illustrated by restorers and scientist of the Istituto Centrale del Restauro (the today Istituto Superiore per la Conservazione ed il Restauro (ISCR)) in Rome who worked in Pompeii together with the high-level local restorers.

The multimedia communication theme was entrusted to Francesco Antinucci, at the time research director at the Institute of Cognitive Sciences and Technologies (Istituto di Scienze e Tecnologie Cognitive) of the Italian CNR, an expert in communication of CH through digital technologies. Starting from this presentation, a project concerning the frescoes of Pompeii was developed, aimed at impaired blind people, which produced a system to transform tactile impressions into sound sensations. The system was donated to Pompeii, but it was later abandoned and remained unused.

Other lectures derived from the forward-looking site management of Piero Guzzo who always left free access to Pompeii to high-level scholars, allowing foreign universities to open excavation fields creating a culturally progressive, international environment.

Among them, we remember the American anthropologist and archeologist Ezra B.W. Zubrow who brought, with great success, a cognitive vision [39].

The case study of the Pompeii archaeological site suggested to Paola Barocchi the idea of the research project "La fortuna visiva di Pompei" [40], launched four years later in collaboration with the National Library in Florence, the Archaeological Superintendence of Pompeii, and the Deutsches Archeologisches Institut in Rome (Figure 4). The project concerned mainly the cultural and artistic perspective, rather than the pure archaeology. Its purpose aimed at gathering, analyzing, and reconstructing the visive archives and the development of the historical perception of the monumental complex of Pompeii through the graphic sources and the texts produced from its discovery, which took place in 1748, until the end of the 1800s.

This stratification of perceptions, diversified according to the taste of the time and the different languages, cultural points of view, and interpretations of the authors/visitors, offers a main and perspectival tool that can be very helpful to scholars to recompose and define the cultural identity of Pompeii today as a world cultural monument. "La fortuna visiva di Pompei" is certainly the best example of a flourishing of research projects resulting from the didactic experiences of the courses that continued beyond their duration.

Later, there was a research project on the Pompeii site born from discussions held during the lessons to provide material for the last SNS courses, sealing a virtuous circular path capable of constantly creating and disseminating new culture: the project "The critical model of the Unified Information System of the Special Superintendence for Archaeological Heritage of Naples and Pompeii ", the result of a collaboration between SNS and the Special Superintendence for Archaeological Heritage of Naples and Pompeii (SANP) with the collaboration of the University of Bologna, Liberologico Srl, CINECA, Bruno Kessler Foundation of Trento (FBK), and Polytechnic of Milan [41].

The critical proposal for an IS, stimulating new ideas and new models, led to the development of an extremely wide cultural path, including themes such as:

- the reconstruction (physical and virtual) of the archaeological layers;
- the relationship between remaining ruins and lost cities during various urban phases;
- the coexistence of multiform approaches on the same object (i.e., the preserved and restored Pompeii and the historically reconstructed and interpreted Pompeii between Samnite and Roman, Bourbon, Italian up to now);
- the relationship and integration between the conservative approach and the historical one;
- the way of placing the sequential timeline in communicating archaeological knowledge;
- the choice of the communication approach, between conservative and emotional, that favors the original phase of the site trying to reproduce it for the visitor by entering

it culturally-emotionally or trying to keep the complex and historical value of the site intact suggesting various concurrent and possibly non-alternative access and reading possibilities.

This path generated a new didactic, original and stimulating for the future.

Figure 4. "La fortuna visiva di Pompei" project overview.

3.4. Stages as on-Field CH Work Exploiting IT-Based Techniques

The internships were a key element for the educational project both for the possibility of acquisition of a high-level professionalization experience and for the type of proposal envisaged, which included practical activities strictly linked to the need for automation in the CH sector. To understand it, we will follow the 1998 path of one of the authors of this paper, Ilaria Abbondandolo. Her stage at CISA AP concerned the construction of a database on documentation relating to cognitive investigations and the restoration of Palladian buildings. At the end of the internship, Abbondandolo was hired by the CISA AP.

Since 1958, the CISAAP has established itself as one of the most important research institutes for the history of architecture, especially the Renaissance one. The research activity of the CISA AP, which is coordinated by a panel of some of the finest specialists in the field in Europe and North America, includes exhibitions, courses, seminars, and workshops that are dedicated to Palladio, modern and contemporary architecture as well as the conservation and restoration of historic structures.

Tutors of the stages were Guido Beltramini and Mario Piana, now professor of restoration at University IUAV in Venice.

The study concerned Palazzo Chiericati in Vicenza, which at the time was the subject of a campaign of cognitive investigations performed during the restoration of the façade.

The aim of the research was to identify the types and classes of materials available to verify the methods of archiving and retrieving data.

From an operational point of view, the work involved a methodological side leading to the subdivision of the analysis documents into two subgroups: history of the building (from the construction plan to the first 'conscious' building intervention: archival documents, Palladian drawings, views, and ancient surveys, etc.) and history of the transformations of the building (starting from the first documented transformation, divided into campaigns). The study was limited to the second of these. This selection was followed by a problem-making phase, identifying some fundamental points:

- the need to have unitary information cores, adequately grouping—in theory and in practice—materials of different types (administrative documents, graphics, photographic documentation, etc.);
- the need to build a database providing cross queries: e.g., the results of a query on the 1930s restorations must be able to cross-reference data relating to plasters, roofing, etc. This involved indexing individual documents based on scientific assessments;
- the evaluation of archiving methods, i.e., how to archive documentary data (critical filing and o document image) and graphic data (critical filing and graphic).

This methodological work was in the following years at the basis of the development of the Palladian IS by the CISA AP, today still in use.

The high specialization of the students and, therefore, the type of internship required, however, caused problems for the unpreparedness of the Superintendences and of the cultural institutions to welcome them.

At the end of the first edition of the courses, it was possible to find a suitable stage, that could then translate into adequate effective employment for all graduates, but then it became much more difficult.

Although over time they found adequate accommodation—most of them today are officers of the Ministry, of the Superintendences, managers of the cultural sectors of local authorities or managers of cultural foundations—this difficulty led to a progressive shift in the search for internships/employment prospects outside Italy (e.g., a dozen graduates found employment at UNESCO, others at the famous Christie's auction house in London, etc.) and to rethink the structure of the courses.

4. Developed Methodologies: The Case of the Computer-Aided Technologies for the History of Architecture Module Managed by the CISA AP

4.1. Module Organization

To better understand how a module was made up, we describe the "computer-aided technologies for the history of architecture" module, managed by the CISA AP in 1998–1999, which addresses the three themes in which the daily commitment of the architectural historian is summarized: collecting information on buildings, representing them, detecting them.

At first, the new research opportunities offered by electronic databases were illustrated, also through real examples. Compared to paper documentation, databases show practical advantages immediately evident: space saving and speed of querying. Furthermore, databases allow to reach a much higher number of users and they can convey materials of different nature such as texts, drawings, photographs, etc. For these purposes, a functional and efficient database needs to have some obvious requirements: clarity and accessibility, exhaustiveness, possibility of continuous updating. Three examples were demonstrated. The first made by Werner Oechslin concerning the "Census of architectural treatises" at ETH-Zürich showing results and prospects of future research, and by Mario Piana and Ilaria Abbondandolo about the work started with the Abbondandolo stage at CISA AP: "Planning a database on the documentary materials of the restorations of Palladian buildings". Guido Beltramini presented the Corpus Palladianum on CD-ROM. Marco Biffi gave an in-depth lecture on the problem of the historical lexicon for architecture. Finally, Howard Burns, President of the Scientific Board of the CISA AP, and Daniel Tsai from Harvard University

presented the "Palladio Virtual Museum", a project to shape a heterogeneous database of history and architecture headed by Howard Burns and William J. Mitchell (at that time dean of the School of Architecture at MIT), having as principal investigator Tsai [42].

Secondly, four different applications, to which virtual representations can lead, were described: (a) simulation of a restoration (allowing scholars to analyze and plan the possible interventions on the artifact); (b) virtual reconstruction of unrealized projects to be compared with the building of today; (c) identification of the different construction phases of the artefact; (d) return of surveys.

This section was organized following two different points of view. At first, Guido Beltramini and Marco Gaiani introduced working hypothesis and main open issues dealing with reconstructions, virtual models, and animations. This communication one year later will be systematized in a monographic number of the "Quaderni del Centro di Ricerche Informatiche per i Beni Culturali" della Scuola Normale di Pisa [25]. Then many examples were presented: Manfred Koob of the Technische Hochschule in Darmstadt, the virtual model of the Palazzi Vaticani at the time of Leo X [43]; Pier Nicola Pagliara of the Terza Università di Roma, the reconstructions of Renaissance architectural plans; Marco Gaiani the 3D models of the Palladian architecture of Villa Pisani in Bagnolo and the Basilica in Vicenza [44], made with the collaboration of Howard Burns, and some 3D models of buildings of 20th-century architecture in Italy: the sledge-lift at Lago Nero by Carlo Mollino and the Borsa Merci in Pistoia by Giovanni Michelucci [45]. The critical overview of the 3D model construction working hypothesis by two different professional figures (an architecture historian and an expert of 3D digital representation) was, probably, a major feature of the communication allowing students to put together knowledges usually transmitted as detached: the philological problem and the operational techniques to build the models.

Finally, the advantages of using laser scanners in the survey and for the 3D model construction of the built architecture, fine art and archaeological artefacts were demonstrated by Marco Gaiani. This was another key moment of the presentation because a full explanation was needed, to illustrate how the 2D working hypothesis of the "measure and draw" method was fully abandoned in favor of a new vision and a new method to make surveys as "reality capture" operation [46] (rather than a new piece of technology, it was more a new framework for the architectural survey).

4.2. The CISA AP Activity Using IT as a Driver to a New Way of Studying and Communicating the Architectural History

Overall, the presented activity is not a simple puzzle achieved taking accidental pieces, but the result of ten years of research and of a global strategy. Since 1991, various research projects have been underway at the Centro regarding the application of IT for AH and CH. These benefited from the collaboration of such organizations as the Italian CNR, SNS, Harvard University, and Massachusetts Institute of Technology. The decision to use IT to advance the study of architectural history reflects a strategic decision by the CISA AP, pushed by Howard Burns. It is not a simple adaptation to market novelties; rather, the Centro intends to make use of the new technologies (alongside the continued use of traditional formats such as monographs, exhibition catalogues, facsimile reproductions, etc.) to take advantage of the opportunities offered by these new means (e.g., the direct and immediate access and visualization of archival documents on one's own computer screen).

Following this cultural line, in 1995, CISA AP abandoned the publication of the *Corpus Palladianum* (the series of systematic studies on Andrea Palladio buildings, which the institute had worked on since the 1960s) to start the project of a Palladian database. This was initially settled through two different projects: a database system developed in collaboration with the Graduate School of Design of Harvard University and the School of Architecture at MIT, and three visual-multimedia databases CD-ROM on Palladio themes [47], digital evolution of the *Corpus Palladianum*, still in collaboration with MIT and the University of Ferrara. All these applications, as mentioned, were presented at the SNS master.

The main objective of their design, which is not targeted to a specific final user (it could range from researchers to city users), was to give a response to the issue of joint re-contextualization of cultural expressions with spatial and architectural information. The information was organized according to the double dimension of architectural descriptions identified by James Ackerman: documentation and interpretation [48]. This organizational scheme was translated in the first CD-ROM *Andrea Palladio. Le Ville* in a double access: the first part is titled *Exhibit*, which is descriptive and non-interactive, while the second part, titled *Catalog*, is analytic and intended to support further research (Figure 5).

The information access and interaction techniques and types were developed in a joint project with William Mitchell, which will remain the basis of future Palladian IS that include:

- Spatial navigation and geo-localization: a geographic map allows viewing the existing buildings in the surrounding landscape and also calculates kilometric distances;
- Temporal navigation: a time-chart provides an overview of the various projects, putting them in relation to each other and with salient historic and biographical events;
- Navigation inside the data: guided for city-users; free for scholars and professional operators via SQL query from fields identified by the CISA AP Scientific Board.

The most interesting tool of these applications, from the point of view of Architectural Heritage (AH) historians, was the comparative analysis between different images or texts and cross-analysis between both images and texts. This was obtained roughly allowing to select, copy, and paste text and images in a new window and allowing the user to have all the new windows simultaneously opened on the desktop.

Overall, the applications have generated new AH research to verify and integrate new material with existing evidence, which led to the creation of a register of all known archival documentation as well as an unprecedented critical and philological analysis of every project. Members of the CISA AP Scientific Board have made use of the CD-ROM for almost a decade, for their research, and students of the SNS course benefitted from the scheme to develop future multimedia and IS.

Figure 5. Screens of the multimedia CD-Rom "Andrea Palladio. Le Ville".

4.3. Teaching 3D Modeling for the Architectural History

We think that William Mitchell well summarized problems, aims, goals, and solutions of 3D modeling for AH in one of his latest essays: "The use of three-dimensional digital modelling software, combined with rapid prototyping to create physical models, enables a more disciplined and scholarly approach to reconstruction than has been common in the past. The outcome of the reconstruction process must be a logically consistent three-dimensional object; there is no room to fudge. And a carefully structured digital model provides a framework for documenting the evidence and arguments supporting a reconstruction choice, and for showing possible variants—much as with scholarly footnotes in the editing and reconstruction of ancient texts." [49].

We focus on 3D modeling because Palladio's architecture and Palladian drawings and texts [50] are, in this context, an extraordinary field of experimentation with their clear design thinking and their measurable and observable solutions. They provide a detailed language of architectural form, a specification through formal grammars, an easy interpretation, and a specific role in structuring design thinking. It is possible not only to observe specific Palladio's architecture but to reexamine central issues of design theory giving a comprehensive and systematic treatment of the logical foundations of design thinking. Specifically, Andrea Palladio's work is a paradigmatic case introducing all problems related to the use of 3D modeling for historical survey, analysis, reconstruction, interpretation of AH, and an excellent starting point to develop a teaching method for new techniques and new knowledge.

In our opinion, the subject plays a key role in the whole history of the digital 3D reconstruction applied to the AH field and architecture theories, for reasons related to the methods and the techniques developed to face the issues that lie in representing and interpreting his work.

Motivations regarding the subject are well explained by Wolgang Lotz: "Since the eighteenth century, the name of Andrea Palladio (1508–1580) has stood for architectural perfection. [. . .] The reasons for the present interest in Palladio lie in the qualities of his work. [. . .] many of his buildings have remained practically unaltered, so that it requires no historical imagination to see them in their original form. Finally, Palladio founded his own enduring fame by a book of illustrations and comments on his own work." [51].

Motivations regarding the digitalization of Palladio's work are well explained by the title of Howard Burns' essay *La creazione di un'architettura sistematica e comunicabile* that well clarifies the great interest of the Andrea Palladio architecture since the first stages of IT [52]. The direction given to the Palladian studies by the analysis of Rudolf Wittkower's book *Architectural Principles in the Age of Humanism* (1949) [53] and Colin Rowe's essay *The Mathematics of the Ideal Villa* (1947) [54] connoted Palladian architecture as an outstanding subject to give a seductive look to an instrument that imposed constraints, rather than offering an introspective ability.

Palladio is an excellent subject to demonstrate typical features of digital 3D modeling applications. His drawings are just flattened patterns of three-dimensional solutions. Visualizing them in 3D allows us to notice quickly and clearly the advantages of built projects; the defects of abandoned projects; the complexities that have endangered some of his realizations. Finally, Palladian 3D model construction techniques and the final outcomes marginally followed the well-recognized path of photorealistic interpretation of a lost past, a re-interpretation of the photorealistic appearance of the 'envois' of French architects *pensionnaires* in Rome during the 19th century.

In the case of Palladio, the use of digital technology as an interpretation tool involved a philological analysis of unbuilt projects, unfinished works and disappeared architectures—as the rich and systematic contributions by William Mitchell show—developing techniques and methods to construct the 3D models as cognitive and interpretive systems. The existence of a grammar described by the architect (in his treatise *I Quattro Libri dell'Architettura* published in 1570 [55]), allowed many attempts to reconstruct the complete project from

partial representations, with the aim of discovering design intents, the logic of architecture and possible interpretations of the original drawings.

Furthermore, at the ground of the works presented by the master architect is the concept of 'instauratio' detailed by Howard Burns [56], as a method allowing to find a convincing solution to the problem of missing parts.

'Instauratio' recalls one of the fundamental points of Renaissance culture: the aim to restitute the articulated, rich ancient world from today's ruins. The method to approach this restitution lies in the use of rules from the same system, e.g., the grammar, the syntax, and a Latin vocabulary are the tools to infer the meaning from the context and to understand and complete the missing. Applying this method to the study of Palladio's architecture, the rules for integrating missing or unclear parts can be found in his treatise. *I Quattro Libri* provides grammar, vocabulary, and syntax to be used to proceed in finding a missing part. The text includes shapes, general proportions and rooms and bedrooms, Palladio's types for buildings, villas, and stairs.

Above all, digital technology was used to provide important contributions to highlight the significance of the objects, partially lost in translating the 2D representation on the paper sheet into a 3D space.

Our lessons at the SNS master did not provide for a list of software commands (as usual at the time, but also today) nor a geometric and virtual lighting theory for programmers, but a critical analysis of the 3D modeling and rendering techniques instead, based on these working hypotheses and on an accurate reinterpretation of Palladio's architecture features to understand the better way to translate these elements into a digital form.

Moreover, the SNS master lessons reflected an accurate 3D model of AH construction method developed along five years of research and trials [57] at the School of Architecture of the University of Ferrara exploiting previous works on shape grammar by William Mitchell and George Stiny [58], a consistent 3D reconstruction technique based on the general notion of 'design knowledge' following the—at that time—emerging CAD paradigm of knowledge-based design [59] and a close collaboration with Howard Burns and Guido Beltramini (Figure 6).

We remark, to better understand, that all these features were not easy to achieve at that time, needing a high-costly workstation, expensive software, and specifically trained operators. The 50 Mbyte 3D model of the Villa Pisani in Bagnolo prevented any interactive visualization. The file opening time on the powerful Silicon Graphics Indigo2 used was 7 h. However, the model authoring solution developed allowed to switch quickly among the three different versions of the Villa Pisani, reusing most of geometry and materials implemented as simple variants of the 3D model scene graph. Moreover, the output of the 3D modelling for the Villa Pisani—a 20-min Betacam format photorealistic computer animation (15,000 frames)—was computed on a Silicon Graphics Origin 2000 server with 32 CPUs in a week, at the Silicon Graphics European Center in Cortaillaud (Swiss).

Finally, our presentation at the master was supported by specifically developed hypertext-based tools embedding 3D animations, movies, images, hyperlinks to better show the connections between problems, solutions, and topics. This solution aimed to have a better comprehension but also show to the audience features of the new communication techniques on the field. By doing so, the typical limit of the most popular presentation system at the time (but also today), Microsoft PowerPoint, was overcome: the inability to break with the sequential logic of traditional communication.

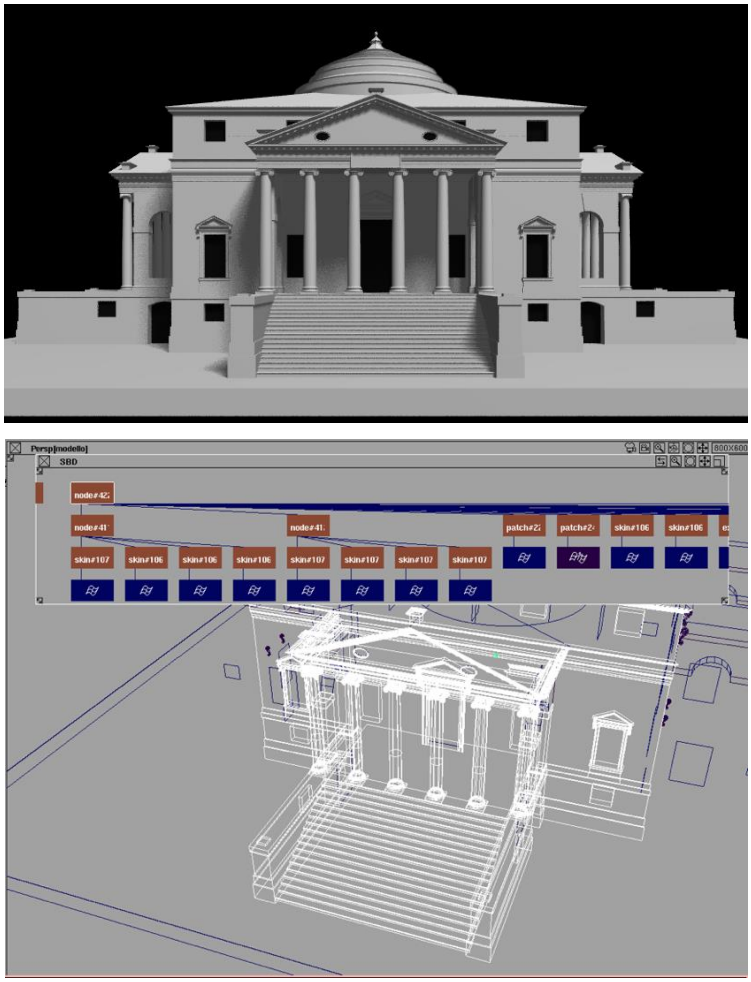

Figure 6. A semantic 3D model of Andrea Palladio's Villa Rotonda built in 1996: a rendered view, and the semantic structure (3D model by Giampaolo Guerzoni).

5. Impacts on CH Policies of Reflections Generated by the SNS Course: The *Culture Counts* Event

The purpose of the SNS courses with their innovations, the educational model developed, and the results achieved, together with the problems encountered during the job placement of graduates were the subject of a workshop in a relevant event that took place in Florence on 4–7 October 1999: *Culture Counts—Financing, Resources and the Economics of Culture in Sustainable Development* by the Government of Italy and the World Bank in cooperation with the UNESCO. As expressed in the title, the focus of the conference was on economics, but related concepts such as sustainability, access, and the digital divide were also considered and discussed in depth. The role of culture in sustainable development was examined, as there was a need for new partnerships among multilateral development agencies, the private sector, foundations, nongovernmental organizations, and universities to support this work. As stated in the proceedings, "the premise of the conference was that culture is crucial to advancing sustainable development." [60] (p. VIII). The conference aimed at:

- promoting the expansion of the economic analysis of, and the resources available to, culture in sustainable development programs;
- expanding the range of institutions and actors involved in culture from a developmental perspective;
- increasing the number of instruments that can be used in these programs.

Culture Counts provided an important forum for experts and key decision-makers to discuss the full range of economic and financial issues associated with the cultural dimensions of poverty alleviation in developing countries.

A set of workshops were held, which included Valuing Heritage—Beyond Economics organized by ICCROM; Museums: Conservation and Management of Cultural Heritage organized by CIVITA association; and Sustainable Development in Communication and Education: Pilot Projects and Case Studies organized by Scuola Normale Superiore di Pisa, Soprintendenza Archeologica di Pompei, MEDICI Framework, European Commission, Istituto Centrale per il Restauro.

Four panels were scheduled:

- Fruition of CH and cultural identity: a project for education;
- Education as stimulus to social and economic development: its impact on the labor market;
- Education and the new technologies for multimedia access to CH;
- Technological innovation and fruition of CH: the role of industry and commerce.

The discussion in the scheduled panels of the four sessions aimed at drawing up a draft of a summary proposal for a prototypical education project in the conservation-management-communication of CH.

The focus was on the main financial, socio-economic, and cultural problems, which must be dealt with by countries with developing or transitional economies, to enhance their CH as a factor both of their global development and of the definition of their cultural identities. A specifically designed and realized education project constituted a fundamental factor in the attainment of this complex goal.

Further meetings of the group were expected as a goal, leading in a short time to the drawing up of a specific global education and training project to be submitted to the participants at the Conference: Master courses in basic CH Management, more Advanced Courses, Courses for Technicians, Refresher Courses at various levels for Continuous Professional Training.

To summarize, all the features of the on-going masters in Cortona were touched and analyzed. Problems were dissected and an attempt to share the cultural approach with the aim to modernize an outdated training/problem-solving system was done.

6. A Joint Progress of Research and Didactics: The Following Experience of Ten Years of Courses

In the mid-2000s, when the three-year cycle of the SNS master courses ended, the advantages of the proposed training actions were already clear (a new trained professional figure, new training, innovative teaching methods, the introduction of IT techniques both as cognitive information management as well as didactic techniques, an excellent response from the students) but also the unresolved problems, i.e., basically a strong resistance of the work structures to the introduction of the new figures in the everyday processes. This led the course director and, therefore, the working group at the SNS to design shorter courses, capable of responding also to the growing demand for specialized content IT-based after a first phase where the demand was basic computerization.

The new formats lasted ten days (with lessons for 60 h) and provided participants with a highly innovative preparation on traditional and emerging topics of CH.

These courses, which no longer had external funding, were very successful and continued until 2006 in Cortona, and then moved to Volterra, to take advantage of the administrative support and location offered by the Province of Pisa and the Municipality of Volterra, until 2011. They exploited most of the experience accumulated in the first three years: the issues to be addressed, the constant relationship with research, the reference teachers selected considering their innovation ability and scientific quality, the teaching method based on case studies offering approaches, methodologies, and achievements relevant to different fields.

A major innovation was the introduction of collaborators and consultants to the course management, according to the theme addressed by the course itself to design it with appropriate knowledge of the matter.

To better understand the aims, themes, and results of these courses, some key experiences are shortly described here.

The first of these courses, titled "CH Management and Enhancement Systems", was held in 2001 in Cortona on 2–19 May. It focused on the public/private relationship, and the analysis of case studies, including the Schoenbrunn Castle, the Louvre Museum, and the Victoria and Albert Museum presented by their responsible managers.

The first course in Volterra was held in the second half of 2006 with the collaboration of Massimo Negri, then director of the European Museum Forum, one of the leading organizations in Europe, founded in 1997, for developing the public quality of European museums (https://www.europeanforum.museum/en/, accessed on 24 August 2021).

The format consisted of a series of three postgraduate courses under the umbrella of the "Research and development in museum communication" title. The courses were focused on museum and exhibitions design; communication and the use of IT in the museum; on portals, websites, and applications addressed to CH.

In 2009 and 2011, the last two courses entitled "Representation and 3D Modeling" were held in Volterra. They were an educational development of research coordinated by the laboratory of the SNS LARTTE (Laboratory for Analysis, Research, Protection, Technologies and Economics for Cultural Heritage), together with the Special Superintendence of Naples and Pompeii in the sectors of the organization of technical-scientific archives, development of territorial representation systems with integrated GIS, representation and 3D modeling of artifacts and archaeological excavations.

These last sections of research, aimed at defining critical standards, for use and under the supervision of the Superintendence, were the core of the courses in Volterra.

In the scientific program and in the implementation of the course—as well as in research—the SNS profited from the collaboration of the University of Bologna, the FBK in Trento, and the National Council of Research of Canada.

The course focused on the analysis and critical evaluation of 3D-based applications of archaeological and museological research aimed at information and communication (Figure 7).

In particular, the aim was to provide the methodological characteristics to make an IS an effective 3D system capable of providing a uniform framework for scientific visualization, effective integration, web-based presentation of sets of heterogeneous space-time data to facilitate the interpretation, exploration, and analysis of large volumes of data with significant geospatial, temporal, and semantic characteristics.

The course included theoretical topics and applications. The lessons focused on the design and processing of 3D-based applications starting from the 3D acquisition and modeling of artefacts and monumental complexes, with special reference to archaeological sites. Significant case studies were presented and analyzed for the state-of-the-art discussion on the illustrated methodologies.

The subtitle of the last of the two courses ("Between knowledge and information: the three-dimensional digital representation of archaeological artifacts and complexes and the definition of scientific standards") well illustrates the features of these ten-day-long specialized courses.

An innovative character of these last courses was the fixing of knowledge accumulated in the previous research and transmitted in the course, belonging to a rapidly evolving field, through a traditional device: a book [61] in which differently skilled scholars—archaeologists, engineers, database designers—focused on methods and techniques developed in the design of 3D-based systems, applying them to the case of Pompeii (Figure 8).

The book is highly technical in its subject matter and language, and it is targeted at practitioners in the field. Despite its technical nature, the volume will also be of interest

to those scholars of AH and urban history who want to use digital reconstruction, or to understand how it is produced and what it can (and cannot) reveal.

The volume is set out as a "manual" or handbook of practice, acknowledging the difficulty of choosing this form for such a constantly evolving subject matter, but making a case for a single book that compares different techniques and offers a practical guide on how to implement them.

A rich bibliography and a glossary make the book a useful tool even for those who are starting to approach these disciplines.

Perhaps this need to establish an approach developed in fifteen years of studies and experiments indicates, better than any other reason, why the courses ended at that point.

Figure 7. The typical teaching method in three images from the 2009 edition of the SNS course "Representation and 3D Modeling": (**a**) frontal lesson; (**b**) teacher working group with students; (**c**) practical lab.

Figure 8. The cover of the book Modelli digitali 3D in archeologia: il caso di Pompei.

7. Results

Analyzing the results achieved over 15 years of experiences, some key points emerge:

A. The development of specific skills—supplemented by transversal ones—is the main learning goal. These multiple transversal skills, capable of nourishing the specialized ones, made it possible to build differentiated and broad-spectrum professional figures. This result was achieved both by combining knowledge from the field of humanities and the field of applied sciences and technologies, but also by creating custom courses that the student could implement, choosing certain professional specialization courses. These transversal skills were, therefore, the result of a curricular structure including flexible solutions capable of specializing different profiles through the introduction of certain disciplinary skills. The possibility to build up multiple transversal skills was an efficient response to a problem that is still largely unsolved today: the training of different professionals (the museum director, the superintendent officer, the person in charge of cultural heritage in local bodies, etc.) able to operate in complex contexts and, therefore, requiring expert knowledge and know-how articulated on multiple areas of expertise.

B. The integration of knowledge concerning a specific problem. This does not consist only and simply in a multidisciplinary approach that provides knowledge from various fields and sources, but instead, it delegates to the students their connection and the possibility to use them, following a long-term process. The integration of knowledge about an area of exercise and to an area of activity and experience allows overcoming the typical problem of the 'master' format, which—by its nature—depletes in a short time and, therefore, hardly achieves this goal.

C. The relationship between theory and expert practice in an era in which knowledge was administered almost exclusively as a theory. The proposed integration was not only between theory and practice but also between knowledge and know-how. To this end, in the experience presented here, not only expert knowledge was shared,

but also expert practices, so that the workshop becomes the exercise testbed for the skills illustrated through case studies. This way workshops are part of a very specific didactic strategy in which the case studies provide real simulation contexts, capable of communicating and making people acquire efficiently, and in a short time, knowledge and know-how strictly addressed to the professional profile to be trained. This method anticipated something that today is fully acquired by the pedagogical disciplines that imply the observation that "practice" is not the simple application of a theory so that such theory cannot be often applied to cases for which it was created [62]. Furthermore, the theory converges directly into the knowledge behind the act in practice, but not into the expert practice to which it is belonging, e.g., to the engineer, who operates not because he directly applies a theory, but in relation to what he expects to be the result, i.e., to his knowledge of the practice. Therefore, what it is possible to learn from the presentation of a real case study is not only practice, but expert practice, i.e., the practice of the expert (the expertise), which is certainly an apparatus nourished by theory, but is not just an application of theory nor a simple knowledge, but a more complex way of knowing how to see and how to act. This is extremely more sophisticated than imagining a workshop simply as an activity where something manual, operational, practical is done, based on the idea that thought should be linked to objects, gestures, etc.

D. A continuous connection and a progressive synergistic enrichment of research, teaching, dissemination, and transfer of the consequences in the world of work due to the proper choice of teaching contents and teaching contexts. As we have seen, the first SNS masters generated new types of research, whose development allowed the construction and implementation of the short courses over the following ten years. This system (as well as the difficulties encountered) pointed out the need for connections with the organization of the CH administration system to raise awareness and guide changes through the creation of documents, experimental proposals (such as the Information System for the archaeological area of Pompeii [63]), events for discussion with the relevant bodies and with the political world (such as the *Culture Counts* event). This certainly arises from the integrated interdisciplinary vision of curricular structures, capable of generating new problems according to a system well clarified by Karl Popper [64] and capable of nourishing research again.

These didactic features anticipated typical characteristics of today's methods relying on paradigms such as STEAM. This acronym refers, in the field of science education, to a group of disciplines identified as fundamental to face the challenges of the future (Science, Technology, Engineering, Arts and Mathematics), taught according to an integrated and interdisciplinary approach favoring the students' recognition, in everyday contexts, of the formal knowledge codified in school disciplines [65]. However, the goal is much broader because it is not limited to a single type of knowledge, i.e., humanistic or scientific, but associates both to shape new figures.

Other characteristics, such as the recursiveness of research, didactics, and the introduction of their results into the social system are still distant objectives.

8. Conclusions

This paper describes the origins of the postgraduate programs on CH Knowledge, Management, Conservation, and Communication in Italy by SNS and its partners.

They originated as an answer to two major issues emerging at the time: the alphabetization in the computerized processes and the need in the Italian superintendencies for figures experts not only in the history of art, archaeology, or architecture or in the conservation of CH, but also in the process and communication management of the knowledge.

It was probably the community's refusal to recognize the need for these skills that determined their end together with a contemporary phenomenon in Italy: the progressive inclusion of foreigners in the top roles of public bodies of CH. Once the training systems in Italy fell, the necessary skills had to be taken abroad, where they existed, due to the

growing presence of specialized schools. However, from that experience, the clarity of the objectives and an innovative and efficient teaching approach remains, still up to show a path for the future.

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