

Digital data and tools in transformative education to preserve architecture and cultural heritage: case studies from Italy and Poland

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ABSTRACT: In this article, the authors present the findings and results of a recent study focused on various collaborative activities mostly between Italy and Poland, and digital teaching platforms aimed at educating future architects. These architects are envisioned as curators of digital data and experts in using digital tools in the field of architecture and architectural heritage. The investigation had two main objectives. Firstly, it aimed to develop an educational programme that serves the aforementioned purpose, and secondly, to facilitate educational experiments by integrating education and research in the realm of digital architecture, specifically in support of architectural and urban heritage. All teaching experiments conducted in this study were closely related to the ongoing European Union (EU) research and didactic projects: H2020 PROMETHEUS and EMDMVREA. The authors propose that a European approach to digital transformation for cultural heritage sustainability should emphasise the consolidation of knowledge for young students, enabling them to interact and collaborate with the creative industries and virtual products. This can be achieved by familiarising students with the languages and practices of digitisation and content enrichment.

Keywords: Architectural education, professional training, educational needs, educational strategies, technological progress, digital architecture, cultural heritage

INTRODUCTION

The need for a high level of digital literacy, which refers mostly to today's younger generations, has led to the expansion of technology in education, both in primary and secondary schools, as well as in higher education and the academic field [1]. Information and communication technologies (ICTs) are evolving to meet new challenges related to the skills of future professionals and the demands of a new generation of students, who are increasingly aware of, and curious about, digital challenges [2]. Also the integration and interpenetration of the uses of emerging technologies in the educational sector and everyday life has enabled the development of effective digital media and e-learning environments [3].

In the cultural heritage (CH) education field, starting from 1998 [4], more active teaching methods have been experimented, with in-field studies and laboratorial activities prevailing over the more traditional classroom lessons [5]. Furthermore, there is an added value in adopting ICT in cultural heritage education. ICTs help to facilitate the access of cultural heritage to a wide range of people, thus allowing knowledge sharing, as well as recognising the importance of one's own tangible or intangible heritage [6]. For example, contemporary museums are increasingly looking for people who are able to promote collections and cultural events both inside and outside the physical spaces of the building [7].

The figure of the *digital curator*, which is gradually emerging in all the world [8], is based on the use of ICT applied to cultural heritage. These are not only used for the documentation of heritage for its preservation over time, but also to its promotion and enhancement to an increasingly broader, more aware and demanding audience. The nowadays challenge is to train specialists who know how to manage the production of digital output in the field of architecture and architectural heritage management.

JOINT EDUCATIONAL ACTIVITIES FOR CH DIGITAL CURATOR TRAINING

Advances in technology, tools and opportunities to generate new, more inclusive and appealing outputs have affected the areas of documentation and creation of digital databases of cultural heritage. The emergence of digitisation, big data databases, the Internet of things (IoT) interfaces and simulation environments - such as augmented reality, immersive reality and mixed reality - has opened up new ways for innovative multidisciplinary research and education in architecture and engineering [9]. Traditional systems of education and training are combined with new ways of heritage education, through tools that allow an in-depth analysis of the architectural context and the examination of several data that can optimise the process of design, planning and management at both architectural and urban levels.

Methods and tools for the representation and visualisation of architectural objects, both existing and non-existing, are increasingly being experimented within the Bachelor's degree courses in building engineering, architecture, and in the 1st and 2nd level Master's courses. From the first academic years, within the drawing and architectural surveying courses of international faculties of architecture and building engineering, students are put in a position to work with digital tools - related to digitisation of cultural heritage - that they will find in tomorrow's workplace. Thanks to this, students will begin to dialogue with graphic languages within heterogeneous teams, creating their own alphabet of signs and drawings that will allow them to interact with the client and the audience.

Dynamic animations, novel viewpoints and information databases that amplify the communicative capabilities of a given architectural asset are now among the objectives of training future professionals who will work in the field of digitisation of cultural heritage, and must possess the necessary skills and knowledge in digital technologies to adequately address the contemporary challenges.

The objective of this learning-by-doing training process is to enable the student to increase his/her own areas of interest and his/her own specific abilities, both of software and of specific operations to manage the entire digitisation process. Recently, a group of academic experts with the support of specific digital laboratories placed in the University of Pavia (UNIPV), the University of Florence (UNIFI), both in Italy, and Gdańsk University of Technology (Gdańsk Tech) in Poland, worked together on developing an educational offer focused on the new digital curator figure, through creating educational experiments directed at digital architecture supporting architectural and urban heritage.

LEARNING-BY-DOING EDUCATIONAL METHODS - CO-OPERATION BETWEEN ITALY AND POLAND

International educational experiences, aimed at educating young students on the subject of heritage knowledge and documentation, have been organised between Pavia, Florence and Gdańsk since 2022, and are still ongoing. They were articulated in a series of events (study days, seminars, training sessions) and were attended not only by teaching staff experienced in the field of documentation and fruition of cultural heritage, but also by students from various geographical origins, from different degree courses and with different academic backgrounds. All of the proposed activities involved heterogeneous groups of students (three to five per group) who were able to interact with each other by discussing their specific skills and organising themselves to achieve specific objectives given by each of the proposed activities. Figure 1 is a schematic presentation of the learning-by-doing methodology.

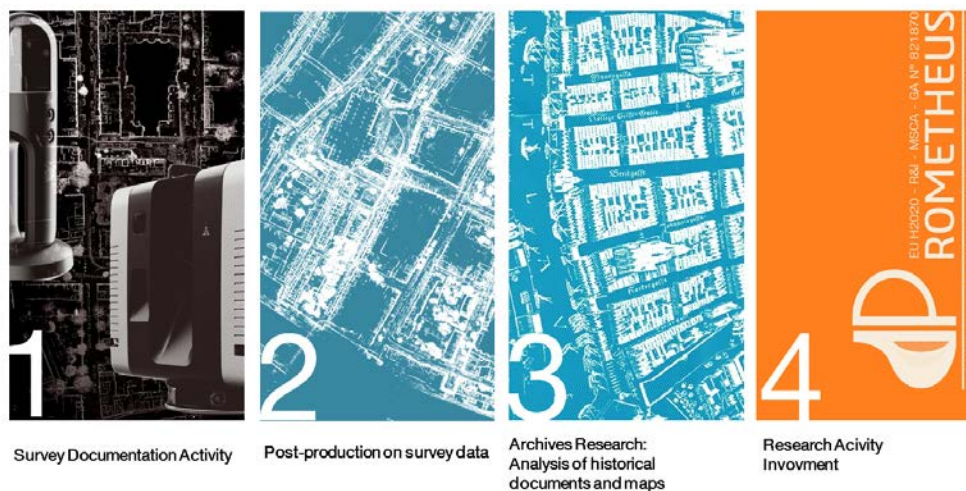


Figure 1: Methodology scheme of the educational experiences.

Some of these events included field activities, in which students tried their hand at using digital acquisition tools and direct observation of the architectural context examined. On other occasions, the activities were carried out entirely in the classroom, using previously acquired digital data (either by the students or by other practitioners). The common objective of all work activities was to stimulate and compare students at a similar level of learning in terms of cultural interests or technical skills [10], using an *active* rather than *passive* approach to learning, i.e. observing and performing practical actions, both individual and in groups [9][11].

International Seminars of the Pavia Digiweek

In September 2022, the University of Pavia organised a week dedicated to the topic of *digitality* in cultural heritage. The event, entitled Pavia Digiweek, saw the participation of international lecturers and students from different faculties (ADN of Singapore, from Lublin, Gdańsk, Kraków, Poland, from Argentina, as well as some from Italian faculties, Pavia, Florence, Matera). Specifically, three training seminars lasting a total of five days were organised, in which a number of topics related to the tools and methods to recognise and value cultural heritage were addressed: 1) virtual architecture design studio; 2) heritage building information modelling (HBIM) for cultural management; and 3) reliable geographic information systems (GIS) for urban planning modelling. The event was an opportunity to experience the effectiveness of

teaching from different points of view: workshops were organised, which allowed teachers to collaborate, verifying each other's skills and noting the need to standardise the language. At the same time, the different learning methods of the students with respect to the curricula of origin were verified.

The goal of this proposed innovative and interdisciplinary educational offer was to address the growing skills shortage among young professionals around the world, who pursue a career in not only architecture and cultural heritage domains, but also in other creative industries related to the production of multimedia, gaming and digital environments. Many tools used in the current practice of architectural design and cultural heritage management, such as the commonly applied computer-aided design or parametric modelling, and some more advanced, rapidly developing tools and systems, such as parametric and generative design, 3D and procedural modelling, visualisation techniques, multimedia creation, virtual reality (DR) [12], building information modelling (BIM) [13], or GIS [14], are very useful in numerous other creative industries [15]. Thus, the proposed programme responds to societal and labour market needs by creating new possibilities in educating future professionals in this field.

Elective Courses of Gdańsk Tech

The 2022 Gdańsk Tech Elective Design I course (along with CAD, integrated architectural design and methodology of scientific work courses) and Summer School Gdańsk 2023 (combining Elective Design II and architectural drawing courses), both entitled: *The Gdańsk Fortification Route. Survey and Analysis for Evaluation Enhancement and Management of European Cultural Heritage Routes* were dedicated to Bachelor, Master and PhD students exploring challenges, conflicts and concepts of cultural heritage preservation and protection at the urban level, their connection to architectural and urban design in the time of digitalisation, and their importance for the future of the cities.

The aim of those courses, based on the case study city of Gdańsk, was to understand the problem of cultural heritage and develop innovative solutions of architectural and urban design responding to significant variations of the rapidly changing digital era considering digital tools and conditions regarding cultural heritage (see Figure 2). Both elective designs were planned to be conducted with the involvement of visiting professors from UNIFI and UNIPV. The courses were carried out in the form of block activity and as a part of the international research workshops linked to other obligatory courses and combining classes for first-year students in architectural drawing, as well as for students of higher years, including PhD students.

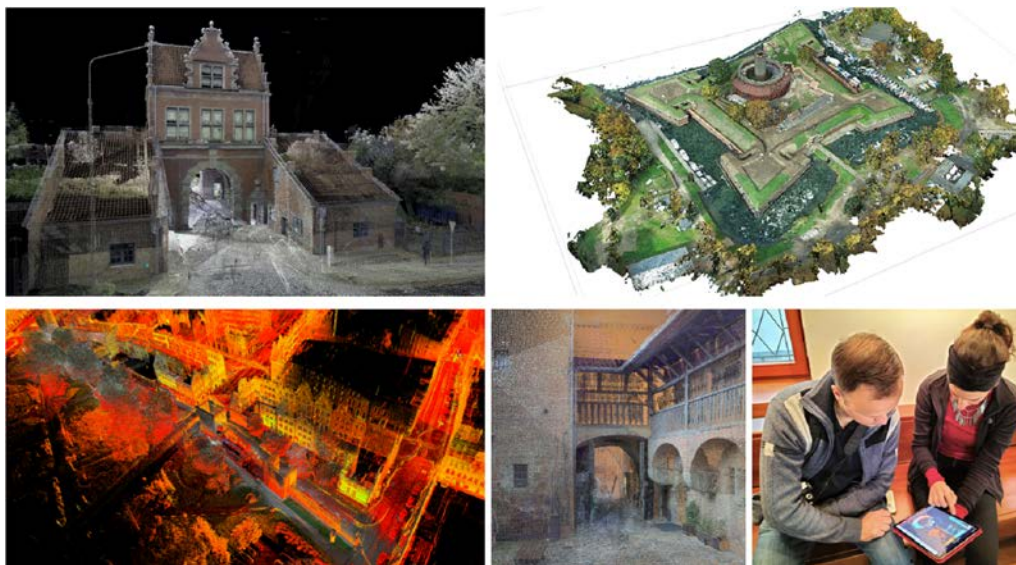


Figure 2: Gdańsk Tech elective courses work and results, Gdańsk, October - July 2023. Images and photographs by the authors.

The multidisciplinary courses include the following teaching elements:

- 1) field trips including open-air lectures and laboratories (practical activities) on methods of surveys and analysis, to promote a direct contact with sites in order to increase the acknowledgement of their value;
- 2) laboratory activities to increase teamwork and problem-solving skills on post production and design of tools and methods of work;
- 3) workshops to show methodologies and results of research activities. Workshops had also the aim to develop common approaches, in particular regarding cultural heritage sensitisation;
- 4) seminars/lectures to illustrate the state of research or a particular topic;
- 5) remote collaborative exchange platform: through the implementation of a collaborative platform for knowledge exchange between researchers and students, during the project and after its conclusion; students are also required to learn relative methods and practices for their sequent use.

The goal of those elective courses was to understand the most important issues and challenges in architecture and city planning in the context of cultural heritage at the urban level in the digital era. This includes: 1) understanding the main problems related to cultural heritage such as: to promote a conscious approach and develop effective strategies for the conservation and preservation of cultural heritage, by offering a didactic opportunity of knowledge and sharing of research content supported by the immersive experience of a visit into virtual reality (VR) visualisations of international cultural heritage sites; and 2) understanding of how technology can preserve and promote cultural heritage, and to experience a virtual tour, discovering information and opportunities for architectural sites within digital environments and multimedia contents. A multidisciplinary approach, team work, critical thinking and understanding of the approaches to the issue of cultural heritage routes are the achievements of the didactic activity.

Both courses were strictly linked with the series of international research workshops within the research project H2020 MSCA - PROMETHEUS [16]. This project aims to explore surveys and analysis for the evaluation, enhancement and management of European cultural heritage routes, and involve academic and non-academic institutions from such cities as: Pavia, Italy, Valencia, Spain, Gdańsk, Poland. As a part of this project, international workshops with the members of all the above-mentioned institutions were carried out in Gdańsk with the participation of Gdańsk Tech Bachelor, Master and PhD students.

The elective courses organised within the international activities of the European Union (EU) project and experimentation activities were supported by digital laboratories of all the higher education institutions (HEIs) - DAda-LAB - UNIPV, DaB-LAB - Gdańsk Tech and DIDA-LAB - UNIFI. The courses, promoted by Gdańsk Tech, UNIPV, UNIFI, and other academic and professional partners, are an initial step towards rethinking the educational programme shaped by technology. This experimental didactic activity is aimed to establish an international dialogue on the practices of digital documentation of historical territorial heritage for the development of technological recovery, restoration and administrative management programmes, through the optimisation of 3D databases and information models.

Jane's Walk Event for Participatory Activity

In collaboration with the information technology company CTA.ai and the Faculty of Architecture at Gdańsk Tech first-year students organised a walk along the trail of Gdańsk fortifications in the lower town. The walk, entitled *Jane's Walk - Gdańsk Fortification System* was part of the international initiative Jane's Walk and was primarily led by students. It served as an additional educational activity focusing on the digital environment and the acquisition of digital knowledge within the Drawing of Architecture course for Gdańsk Tech Bachelor students. On the *Night of Museums* on 15 May 2023, two walks were conducted. Both walks were planned and conducted by students in collaboration with invited guests and experts. The walks were accompanied by the In the City AR application, which was co-created with students. Through this application, local guides affiliated with the *Association of Historytellers (Zwiazek Opowiadaczy Historii)* shared captivating stories about different locations in the district.

The event encompassed a broad cultural experience, allowing participants to visit usually inaccessible places and explore them through VR and on-line applications. Besides fostering closer ties with EU research and teaching projects [17][18], this activity provided students with opportunities to collaborate with professional companies and partners beyond the academic community. It enabled the dissemination, sharing and promotion of collective accomplishments in the field of digitisation.

Erasmus-blended Intensive Programme for an International Educational Project

Blended intensive programmes (BIP) are teaching programmes involving short periods of face-to-face learning activities combined with virtual learning and co-operation, in which groups of students, teaching and administrative staff from different countries can participate to collaborate on specific tasks collectively and simultaneously.

Digital platforms for cultural heritage enhancement (DIGIPLA) is a BIP project, whose aims is to offer an advanced educational experience on the opportunities of applying and improve digital skills in the field of architecture and engineering, triggering interdisciplinary experiences on the implementation of digital contents and virtual products for CH management. The didactic programme organised by the experimental didactic and research laboratory DAda-LAB of UNIPV will be focused on frontal lectures and practical workshop activities. It will involve students from different countries (Italy, Poland, Germany, Spain) to collaborate in the production of digital works.

CONCLUSIONS

In today's rapidly evolving digital landscape, architectural education must confront the challenges posed by the ever-changing digital world. The objective is to educate the architects of the future who will serve as custodians of digital data and experts in utilising digital tools within the realms of architecture and architectural heritage.

As it was mentioned above, various joint activities and teaching digital platforms, such as Digiweek workshops and seminars, elective design courses, engagement in additional participatory cultural events supported by collaboration with non-academic partners (VR and IT companies) and the planned BIP DIGIPLA international programme were proposed by

international group of scientists. This was possible with the support of appropriate digital laboratories located in Pavia, Florence and Gdańsk that worked on developing an educational offer serving the aforementioned purpose and creating educational experiments towards digital architecture supporting architectural and urban heritage. During a series of experiments, it was possible to introduce at different levels of student's joint workout didactic methodologies based on different backgrounds, and approaches bringing together different audiences on the international level from education to practice and through participatory activity serving society. In addition, presented education experiments by linking education and research introduce students to different research areas.

All experiments based on particular case studies are closely related to the ongoing European research H2020 PROMETHEUS project. Development of the new methodologies based on the case studies from research, besides enriching the project itself, gave an opportunity to experimenting with digital technologies embodied in the educational offer and an opportunity to engage students in a current research project. Apart from this, the involved HEIs gained experience in building new curricula for studies and made a solid base for a future application for a joint project on a new innovative didactic programme in the field of architecture and urban heritage.

A new Master's degree course called Virtual Reality Engineering and Game Design for Architecture and Cultural Heritage (VREA) is being developed to cultivate a new type of professional who will oversee the technological advancements, while also possessing a critical appreciation for architectural heritage, its preservation and its enhancement. The VREA project aims to establish the foundation for an international joint Master's programme that will produce a new generation of architects and engineers equipped with the cultural and technical knowledge required to manage digital twins in the field of cultural heritage. Additionally, it will outline the future direction of study for architects and engineers. The outcome of this endeavour will be an innovative, comprehensive and internationally oriented curriculum that enhances the competencies of all project participants. Its primary focus is to educate future architects and engineers who are well-prepared to tackle the challenges of the 21st Century [18].

The proposed innovative methodology within the presented teaching activities aims to offer an advanced educational experience on the opportunities of applying and improving digital skills in the field of architecture and engineering, triggering interdisciplinary experiences on the implementation of digital content and virtual products for CH management. The European digital transformation approach for the sustainability of CH requests to consolidate a background of knowledge for young students to interact and collaborate with the world of creative industries and virtual products, applying languages and practices of digitisation and content enrichment.

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REFERENCES

1. Hashim, H., Application of technology in the digital era education. *Inter. J. of Research in Counseling and Educ.*, 1, 2, 1 (2018).
2. Díaz, P., Ioannou, A., Bhagat, K.K. and Spector, J.M., *Learning in a Digital World: Perspective on Interactive Technologies for Formal and Informal Education*. Singapore: Springer (2019).
3. Levano-Francia, L., Sanchez Diaz, S., Guillén-Aparicio, P., Tello-Cabello, S., Herrera-Paico, N. and Collantes-Inga, Z., Digital competences and education. *J. of Educ. Psychology-Propositos y Representaciones*, 7, 2, 579-588 (2019).
4. Council of Europe, Committee of Ministers, Recommendation No. R (98) 5 of The Committee of Ministers to Member States Concerning Heritage Education, (1998), 4 June 2023. www.kultura.ejgv.euskadi.net/r46-4874/es/contenidos/informacion/manifiestos_patrimonio/es_8658/adjuntos/DOC56.pdf
5. Szczepański, J., Valuation of architectural heritage by multicultural student groups. *Global J. of Engng. Educ.*, 21, 3, 196-201 (2019).
6. Ott, M. and Pozzi, F., Towards a new era for cultural heritage education: discussing the role of ICT. *Computers in Human Behavior*, 27, 4, 1365-1371 (2011).
7. Sylaiou, S. and Papaioannou, G., *ICT in the Promotion of Arts and Cultural Heritage Education in Museums*. In: Kavoura, A. and Kefallonitis, E. and Giovanis, A. (Eds), *Strategic Innovative Marketing and Tourism. Springer Proc. in Business and Economics*, Cham: Springer, 363-370 (2019).

8. Karatas, T. and Lombardo, V., A multiple perspective account of digital curation for cultural heritage: tasks, disciplines and institutions. *Adjunct Publication of the 28th ACM Conf. on User Modeling, Adaptation and Personalization*, Genoa, Italy, 325-332 (2020).
9. Beck, D., Augmented and virtual reality in education: Immersive learning research. *J. of Educational Computing Research*, 57, 7, 1619-1625 (2019).
10. Garrison, D.R., *E-learning in the 21st Century: a Framework for Research and Practice*. London: Routledge (2011).
11. Bandura, A., The explanatory and predictive scope of self-efficacy theory. *J. of Social and Clinical Psychology*. 4, 3, 359-373 (1986).
12. Kowalski, S., Samól, P., Szczepański, J. and Dłubakowski, W., Teaching architectural history through virtual reality. *World Trans on Engng. and Technol. Educ.*, 18, 2, 197-202 (2020).
13. Dell'Amico, A., HBIM and digital documentation for development reliable parametric models on complex systems. *AIP Conf. Proc.: Inter. Conf. on Construction Digitalisation for Sustainable Develop.: Transfor. through Innov.*, Hanoi: Vietnam, 2020, 2428, 1, 020006 (2021).
14. Doria, E., La Placa, S. and Picchio, F., From reality-based model to gis platform. multi-scalar modeling for irrigated landscape management in the Pavia plain. *Inter. Arch. Photogramm. Remote Sens. Spatial Infor. Science*, 48, 2, 73-80 (2022).
15. Parrinello, S. and Dell'Amico, A., Experience of documentation for the accessibility of widespread cultural heritage. *Heritage*, 2, 1, 1032-1044 (2019).
16. EU Horizon 2020 Research and Innovation Programme under the Marie Skłodowska-Curie Project. *Prometheus: PROtocols for Information Models librariES Tested on HERitage of Upper Kama Sites*. Grant Agreement No. 821870 (2019), 10 June 2023, www.prometheush2020.eu/, www.cordis.europa.eu/project/id/821870/en
17. Borucka, J., City walk: a didactic innovative experiment in architectural education. *World Trans. on Engng. and Technol. Educ.*, 17, 2, 158-163 (2019).
18. Borucka, J., and Parrinello, S., VREA Project - a digital curator for architecture and digital perspectives for heritage management and enhancement. *Inter. Arch. Photogramm. Remote Sens. Spatial Infor. Science*, 48, 2, 289-296 (2023).

BIOGRAPHIES



Justyna Borucka as an assistant professor in the Faculty of Architecture at Gdańsk University of Technology (FA-GUT), Poland, and the Vice-Dean for Development and Internationalisation of the FA-GUT. Since 2015, she has served as a board member and vice president of the Polish Architects Association (SARP o.Wybrzeże). She was a DAAD Scholar of International Women's University Kassel, Germany (2000) and a DAAD postgraduate scholar at HAWK, Hildesheim, Germany (1999-2000). She has been a visiting researcher at many European universities among others: HafenCity University, Germany, L'Aquila University, Italy, Royal Academy Copenhagen, and DTU, Denmark, Aalto University, Finland, Gazi University, Turkey, TU/e Eindhoven University of Technology, Netherlands, Pavia University, Florence University, Italy and a visiting professor at Sapienza University of Rome, Italy (2016) and KADK, Denmark (2018), and recently at Luzofona University, Lisbon, Portugal (2023). She has been conducting

research and actions promoting various forms of participation and urban regeneration interventions into the public spaces and preservation of cultural heritage.



Sandro Parrinello is a full professor in the academic discipline of representation of architecture at the University of Florence, Italy. He was the scientific director of the DAda-Lab research laboratory at the University of Pavia from 2016 to 2023. He holds a PhD in representation and survey sciences with the title of European Research Doctor. From 2012 to 2019, he was a visiting professor at Perm National Research Polytechnic University, Russia, and in 2015 received an honorary degree from the State Academy of Civil Engineering and Architecture in Odessa, Ukraine. In 2016, he was a visiting professor at Cracow University of Technology, and in 2022 a visiting professor at Gdańsk University of Technology, both in Poland. He is responsible for numerous national and international research projects, is a member of editorial committees of international scientific series and journals, and has organised numerous international conferences on heritage documentation topics.



Francesca Picchio is an associate professor in the academic discipline of representation of architecture in the Department of Civil Engineering and Architecture of the University of Pavia. Her PhD is in the field of architecture, and since 2023 she has been scientifically responsible for research projects promoted by the DAda Lab of the University of Pavia. She has participated in national and international research projects, including two European projects, coordinating documentation activities in the historical centre of Samara, Russia, in Central America, in Panama, and in Middle East territories - Iran, Israel, and Palestine. She is involved in architectural and urban documentation projects aimed at enhancing architectural and landscape heritage by developing virtual fruition and digital database management systems.

