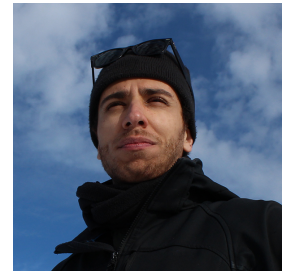# Lorenzo Cardarelli - Curriculum Vitae

1st February 2026

Born: 24th July 1995

Place of birth: Rome

Contact: lorenzo.cardarelli@uniroma1.it

ORCID: 0000-0002-2436-9967

GitHub: https://github.com/lrncrd

Bibliography and research interests

I am an archaeologist specialising in quantitative methods and protohistoric Italian archaeology. I completed both my Bachelor's degree (2017) and Master's degree (2019) at Sapienza University of Rome, where I focused on the analysis of ceramic materials from the protohistoric settlement of Monte Cimino (Viterbo, Italy). In 2020, I began a fully funded PhD at the University of Bari Aldo Moro, developing a pioneering project titled "Variability and Standardisation of Vessel Shapes in the 2nd and First Half of the 1st Millennium BC in Continental Italy: a Data Science and Machine Learning Project for the Quantitative Study of Archaeological Ceramic Profiles."

My research experience includes a visiting researcher position at the Österreichisches Archäologisches Institut in Vienna, Austria (March–June 2022), followed by an associate researcher role at the CNR – Istituto di Scienze del Patrimonio Culturale, Area della Ricerca Roma 1 (April 2022–September 2023), and a postdoctoral research fellowship at Sapienza University of Rome (2023–2024), where I contributed to the PRIN 2020 project "HERDS. Animal Husbandry and its Economic Role in the Development of Central Mediterranean Protohistoric Societies." I currently serve as a postdoctoral research fellow at Sapienza University of Rome within the Proto PArCo Project, focusing on the quantitative analysis of Iron Age pottery from the Palatine Hill and 3D reconstruction.

I combine traditional archaeological methods with cutting-edge technological approaches, including quantitative analysis, computer science tools, and statistical programming. My technical expertise extends to machine learning and deep learning applications for material classification, territorial analysis, database management, topic modelling, and the dissemination of research findings through dynamic web documentation. My research interests centre on material culture and societies from the Bronze Age to the Early Iron Age in Italy. Beyond my in-depth knowledge of protohistoric Italian material culture and social dynamics, I have developed expertise in 3D modelling and rendering software for reconstructing and visualising archaeological contexts.

Research interest

- Quantitative and computational archaeology.

- Machine Learning application in archaeology.

- Bronze and Iron Age of Italy.

- Topic Modelling for Digital Humanities

- 3D reconstruction of pre- and protohistoric environments

- GIS application in archaeology.

Skills

- Programming languages (R, Python) with a specific focus on statistical aspects and data analysis (NumPy, Pandas, Scikit-learn, tidyr), plotting and data visualisation (Matplotlib, Seaborn, Plotly, ggplot2), network analysis (NetworkX).

- Familiarity with frameworks for neural network development (Pytorch).

- Proficiency in languages for creating and publishing scientific documentation (LaTeX, Markdown, Quarto) and generic web development (HTML, CSS).

- Knowledge of software for 3D modeling and rendering of archaeological materials (Blender, Unreal Engine 5).

- Understanding of the GIS environment (Qgis, SAGA), including geoprocessing, raster analysis and integration with programming languages (Rasterio, Folium, Geopandas).

- Database processing using SQL

- In-depth knowledge of Bronze Age and Early Iron Age societies and culture in Italy.

- Proficiency in version control software (Git)

Education

11/2020 – 11/2023	**PhD**	📍 *Bari, Italy*

Aldo Moro University
PhD course in *Patrimoni archeologici, storici, architettonici e paesaggistici mediterranei*
Project title: *Variability and standardisation of vessel shapes in the 2nd and first half of the 1st millennium BC in continental Italy: a Data Science and Machine Learning project for the quantitative study of archaeological ceramic profiles*

In the context of my PhD, the topics I extensively explored and the tools I utilised included:

- Statistical analysis.

- SQL database management.

- Python programming.

- Version control using Git.

- Development of Deep Learning architectures.

- Territorial analysis through GIS.

- Creation of dynamic and accessible documentation via web frameworks.

- Documentation and digitization of extensive archaeological materials.

- Analysis of social components through material culture.

Tutor: Dr Marco Bettelli
Grade: Excellent with honours

2019	**Master's degree in Archaeology (LM-02)**	📍 *Rome, Italy*

Sapienza, University of Rome
Thesis title: *Produzione vascolare dalla vetta del Monte Cimino (VT)*
During the thesis work, I undertook the following tasks:

- Technical drawing of approximately 750 ceramic fragments.

- Material management using a relational SQL dataset.

- Statistical and quantitative analysis of the ceramic material.

- Typological analysis of the material and comparisons with contemporaneous sites.

- Social analysis of the context based on the archaeological record.

Supervisors: Prof Andrea Cardarelli, Dr Barbara Barbaro
Grade: 110 with honours/110

2017	**Bachelor's Degree in Archaeological Sciences (L-01)**	📍 *Rome, Italy*

Sapienza, University of Rome
Thesis title: *Produzione vascolare dal contesto cultuale del Monte Cimino (VT)*

During the thesis work, I undertook the following tasks:

- Technical drawing of 350 ceramic fragments.

- Material management using a relational SQL dataset.

- Typological analysis of the material and comparisons with contemporaneous sites.

- Social analysis of the context based on the archaeological record.

Supervisor: Prof Andrea Cardarelli
Grade: 110 with honours/110

Work experience

05/2025 – *current*	**Research fellowship**	📍 *Rome, Italy*

Dipartimento di Scienze dell'Antichità - Sapienza University of Rome, Piazzale Aldo Moro 5
Research grant within the **Proto PArCo: enhancement of the protohistoric evidence under the responsibility of the Colosseum Archaeological Park**, specifically focusing on quantitative analysis of archaeological 3D reconstruction of Iron Age Rome, database management and GIS analysis.

09/2024 – 11/2024	**Archaeological excavation**	📍 *Fratta Polesine (RO), Italy*

Dipartimento di Scienze dell'Antichità - Sapienza University of Rome, Piazzale Aldo Moro 5
Archaeological excavation of the protohistoric settlement of Frattesina (Fratta Polesine, RO) Directors: Prof. Andrea Cardarelli, Sapienza University of Rome; Prof. Paolo Bellintani, Soprintendenza per i Beni Archeologici della Provincia Autonoma di Trento.
Archaeological operator; Compilation of US sheets; Reliefs and photoplans; Laboratory and cataloguing activities.
Società Archeologica SAP. Via Fienili 39/a, 46020 Quingentole, Mantova (MN)

12/2023 – 11/2024	**Research fellowship**	📍 *Rome, Italy*

Dipartimento di Scienze dell'Antichità - Sapienza University of Rome, Piazzale Aldo Moro 5
Research grant within the **PRIN 2020** project **HERDS. Animal Husbandry and its Economic Role in the Development of Central Mediterranean Protohistoric Societies**.
GIS and statistical analysis, communication and presentation of results through web frameworks, query and management of database, plotting, bioinformatic analysis.

09/2023 – 10/2023   **Archaeological excavation**   📍*Fratta Polesine (RO), Italy*
Dipartimento di Scienze dell'Antichità - Sapienza University of Rome, Piazzale Aldo Moro 5
Archaeological excavation of the protohistoric settlement of Frattesina (Fratta Polesine, RO) Directors: Prof. Andrea Cardarelli, Sapienza University of Rome; Prof. Paolo Bellintani, Soprintendenza per i Beni Archeologici della Provincia Autonoma di Trento.
Archaeological operator; Compilation of US sheets; Reliefs and photoplans; Laboratory and cataloguing activities.
Società Archeologica SAP. Via Fienili 39/a, 46020 Quingentole, Mantova (MN)

09/2022 – 10/2022   **Archaeological excavation**   📍*Arcevia (AN), Italy*
Dipartimento di Scienze dell'Antichità - Sapienza University of Rome
Archaeological excavation of the protohistoric settlement of Monte Croce-Guardia (AN) Director: Prof. Andrea Cardarelli, Sapienza University of Rome.
Archaeological operator; Compilation of US sheets; Reliefs and photoplans; Laboratory and cataloguing activities.
Archeosistemi Cooperative Society. Via Nove Martiri, 11/A 42124 Reggio Emilia (RE)

09/2021 – 12/2021   **3D reconstructions of buildings and artefacts**   📍*Rome, Italy*
Dipartimento di Scienze dell'Antichità - Sapienza, University of Rome, Piazzale Aldo Moro 5
Realisation of 3D reconstructions of dwellings and artefacts from the protohistoric settlement of Monte Croce-Guardia (AN) for the video "*Il villaggio protostorico di Monte Croce Guardia 1200-950 a.C.*", presented in "*Se tremila anni sembran tanti... Il villaggio protostorico di Monte Croce Guardia - Arcevia 1200-950 a.C.*" (Arcevia - AN, 09/07/2022).
Using a completely open-source framework, a series of dwellings discovered during archaeological investigations were reconstructed in a philological manner. This reconstruction included material selection, modeling texturing, and was achieved through the analysis of archaeological documentation from the site, as well as from contemporaneous or comparable contexts. Additionally, a wide range of materials, such as ceramics, weaponry, tools, and furniture, were meticulously reconstructed.

09/2021 – 11/2021   **Archaeological excavation**   📍*Arcevia (AN), Italy*
Dipartimento di Scienze dell'Antichità - Sapienza, University of Rome, Piazzale Aldo Moro 5
Archaeological excavation of the protohistoric settlement of Monte Croce-Guardia (AN) Director: Prof. Andrea Cardarelli, Sapienza University of Rome.
Archaeological operator; Compilation of US sheets; Reliefs and photoplans; Laboratory and cataloguing activities.
Archeosistemi Cooperative Society. Via Nove Martiri, 11/A 42124 Reggio Emilia (RE)

09/2020 – 11/2020   **Archaeological excavation**   📍*Arcevia (AN), Italy*
Dipartimento di Scienze dell'Antichità - Sapienza, University of Rome, Piazzale Aldo Moro 5
Archaeological excavation of the protohistoric settlement of Monte Croce-Guardia (AN) Director: Prof. Andrea Cardarelli, Sapienza University of Rome.
Archaeological operator; Compilation of US sheets; Reliefs and photoplans; Laboratory and cataloguing activities.
Akhet S.R.L., Closellinaz, 44/A, 11010 Roisan (AO)

Publications

Journal article
2026

Counting rather than weighing: metrological analysis and machine learning reveal the monetary potential of pre-contact Ecuadorian axe-monies Montalvo Puente C. E., Lago G., Cardarelli L., Costantine-Castro J., Pérez Molina J. *Journal of Archaeological Science: Reports*, 69

Book section
2025

The legacy: the Data Science movement Cardarelli L., *Analyse des données and archaeology fifty years later: from data analysis to data science*, All'Insegna del Giglio

Journal article
2025

Quantifying morphological standardization through binary matrices with an application to the ceramic assemblage of an early complex society Cardarelli L., Fragnoli P., D'Anna M. B., *Paléorient.*, 51

Journal article 2025	**PyPotteryLens: An Open-Source Deep Learning Framework for Automated Digitisation of Archaeological Pottery Documentation** Cardarelli L., *Digital Applications in Archaeology and Cultural Heritage*, 38
Journal article 2024	**PyPotteryInk: One-step diffusion model for sketch to publication-ready archaeological drawings** Cardarelli L., *Journal of Cultural Heritage*, 74
Journal article 2025	**From pencil to pixel: assessing ceramic 2.0 against manual and laser-aided techniques in archaeological pottery documentation** Alessandri L., Cardarelli L., Cesaretti A., Dan R., Fiorillo A., Sotgia A., Cusimano L., Della sala G. A., Rossi C., *Digital Applications in Archaeology and Cultural Heritage*, 37
Preprint 2025	**PyPotteryInk: One-Step Diffusion Model for Sketch to Publication-ready Archaeological Drawings** Cardarelli L., *arXiv:2502.06897*
Journal article 2025	**Chert sources and territorial behaviour after the Neolithization process: An exploratory analysis from Grotta Battifratta (Rieti, Central Italy)** Carletti E., Conati Barbaro C., Allegretta I., Cardarelli L., Forti L., Monno A., Terzano R., Eramo G. *Quaternary International*, 717
Preprint 2024	**PyPotteryLens: An Open-Source Deep Learning Framework for Automated Digitisation of Archaeological Pottery Documentation** Cardarelli L., *arXiv:2412.11574*
Book section 2024	**Vessel typological classification: comparing archaeologist perspectives to a digital approach** Cardarelli L., Erbetti F., Paniccia C., Paolini E. *Studi in onore di Andrea Cardarelli*, Naus Editoria
Book 2024	**Morphological variability and standardisation of vessel shapes in the 2nd and first half of the first millennium BC in continental Italy. A data science and machine learning project for the quantitative study of archaeological ceramic profiles** Cardarelli L., *Edipuglia*, ISBN 979-12-5995-084-0
Journal article 2024	**From fragments to digital wholeness: an AI generative approach to reconstructing archaeological vessels** Cardarelli L., *Journal of Cultural Heritage*, 70
Journal article 2024	**CQARCHAEO: a python package for cosine quantogram analysis and Monte Carlo simulations.** Lago G., Cardarelli L., Ialongo N., *Archeologia e Calcolatori*, 35.1
Journal article 2023	**The Late Bronze age hilltop site of Monte Croce Guardia in the context of Bronze Age and Early Iron Age settlement organization in Peninsular Italy.** Cardarelli A., Di Renzoni A., Bettelli M., de Neef W., Scacchetti F., Cardarelli L., Paniccia C., Paolini E., *Origini*, XLVII
Journal article 2023	**Traditional and digital typologies compared: the example of Italian protohistory.** Cardarelli L., *Origini*, XLVII
Journal article 2023	**Defining Southern Etruria Final Bronze Age settlement models using an integrated GIS and machine learning approach.** Cardarelli L., *Archeologia e Calcolatori*, 34, 2
Journal article 2023	**Tracing the human movements of three thousand years ago by volcanic grinding tools in the Final Bronze Age settlement of Monte Croce Guardia (Arcevia-Marche Region, central Italy)** Santi P., Cardarelli A., Bettelli M. Di Renzoni A., Cardarelli L., Paniccia C., Renzulli A., *Scientific Reports* 13, 7022
Journal article 2023	**Money or ingots? Metrological research on pre-contact Ecuadorian "axe-monies"** Montalvo Puente C. E., Lago G., Cardarelli L., Pérez Molina J. C., *Journal of Archaeological Science: Reports*, 49
Journal article 2022	**A deep variational convolutional Autoencoder for unsupervised features extraction of ceramic profiles. A case study from central Italy.** Cardarelli L., *Journal of Archaeological Science*, 144
Journal article 2022	**Dimensionality reduction for data visualization and exploratory analysis of ceramic assemblages** Cardarelli L., Lapadula A., *Archeologia e Calcolatori*, 33, 2

Journal article
2020

Capienza delle forme vascolari, da un metodo open source all'uso di modelli regressivi: il caso dell'insediamento protostorico del Monte Cimino Cardarelli L., *Archeologia e Calcolatori*, 31, 1

Experience gained during university education

09/2019 – 11/2019;
09/2018 – 11/2018;
09/2017 – 11/2017;
09/2016 – 11/2016;
09/2015 – 11/2015

Archaeological excavation   📍 *Arcevia (AN), Italy*
Sapienza University of Rome, Piazzale Aldo Moro 5
Archaeological excavation of the protohistoric settlement of Monte Croce-Guardia (AN)
Director: Prof. Andrea Cardarelli, Sapienza University of Rome.
Archaeological operator; Compilation of US sheets; Reliefs and photoplans; Laboratory and cataloguing activities.

06/2016 – 07/2016;
06/2015 – 07/2015

Archaeological excavation   📍 *Soriano nel Cimino (VT), Italy*
Sapienza University of Rome, Piazzale Aldo Moro 5
Archaeological excavation of the settlement and place of worship at Monte Cimino (VT).
Director: Prof. Andrea Cardarelli, Sapienza University of Rome.
Archaeological operator; Compilation of US sheets; Reliefs and photoplans; Laboratory and cataloguing activities.

11/2019

Systematic archaeological survey   📍 *Fratta Polesine (RO), Italy*
Sapienza University of Rome, Piazzale Aldo Moro 5
Systematic archaeological survey of the protohistoric settlement of Frattesina di Fratta Polesine (RO). Director: Prof. Andrea Cardarelli, Sapienza University of Rome.
Archaeological operator; Laboratory and cataloguing activities.

01/2017 – 11/2017;
01/2019 – 12/2019

Laboratory work on archaeological material   📍 *Rome, Italy*
Sapienza University of Rome, Piazzale Aldo Moro 5
Laboratory activities on archaeological material from the protohistoric settlement of Monte Cimino (VT).
Drawing ceramic materials; Cataloging via SQL database.

Conference talks

2024

30th EAA annual meeting New perspective in quantitative archaeology: data driven approaches in pottery analysis, Cardarelli L., Rome, 28th - 31st August 2024

2024

30th EAA annual meeting New directions in chert provenance: towards new basis for detecting mobility ad territorial behaviour in central Italy during prehistory, Carletti E., Eramo G., Cardarelli L., Forti L., Allegretta I., Monno A., Conati Barbaro C., Rome, 28th - 31st August 2024

2024

30th EAA annual meeting Presentation of the project "Southern Ecuador and Northern Peru as an Andrean interface (AD 500-1532)", Lara C., Cardarelli L., Lago G., Montalvo C., Tacconi S., Costantine A., Rome, 28th - 31st August 2024

2023

Conversation - Museo Numismatico, Banco Central del Ecuador Avances sobre los estudios de las hachas-monedas, Montalvo Puente C. E., Lago G., Cardarelli L., Pérez Molina J. C., Quito (ECU), 23rd July 2023

2023

13° International Congress on the Archaeology of the Ancient Near East (ICAANE) Workshop Serialising, standardising, specialising: Investigating a techno-social nexus underlying social complexity. Cardarelli L., Computerised approaches for investigating the morphological standardization ofArslantepe VI A pottery, Copenhagen, 24th May 2023.

2020

IAS – Incontri di Archeologia 2020. Digital Humanities Session I-II Cardarelli L., Capienza delle forme vascolari, un metodo basato su strumenti e formati open source che include l'uso di modelli regressivi: il caso dell'insediamento protostorico del Monte Cimino. Rome, 19th November 2020.

Associations

07/2025 – *current*	**Associate researcher**	📍 *Rome, Italy*

CNR - Istituto di Studi sul Mediterraneo
Associate researcher in the project **Mediterranean Digital Humanities Lab**
Topic modelling, LLMs for humanities

04/2022 – 09/2023	**Associate researcher**	📍 *Rome, Italy*

CNR - Istituto di Scienze del Patrimonio Culturale, Area della Ricerca Roma 1
Staff Prehistory and Protohistory Research Group; Staff MAD-Lab | Modelling Archaeological Data
Position held within the **PRIN 2020** project "**Mobility, Social Integration, and Culture Change in the Mediterranean Bronze Age**" with a specific focus on GIS analysis related to territorial movement using statistical programming, including statistical and network analysis.

02/2024 – *present*	**Member**	📍

Istituto Italiano di Preistoria e Protostoria

Packages

Ceramatic2.0	A computer vision pipeline for archaeological drawings. `https://github.com/lrncrd/Ceramatic2.0`
CQArchaeo	A Python package for calculating and plotting Kendall CQA results (Cosine quantogram analysis). `https://github.com/lrncrd/CQArchaeo`
PyPotteryLens	A Python package with a graphical interface for the automatic filing of archaeological ceramics from PDFs `https://github.com/lrncrd/PyPottery`
PyPotteryInk	A deep learning Python package for automating the digital inking process of archaeological pottery drawings `https://github.com/lrncrd/PyPotteryInk`
PyPotteryLayout	A Python package for the intelligent creation of artefact tables `https://github.com/lrncrd/PyPotteryLayout`

Other Projects

Ceraloop!	A web-based framework for analysing the concepts of "perception" and "comparison" in archaeology. With Prof. Julian Bogdani `https://ceraloop.lad-sapienza.it/;https://github.com/lad-sapienza/ceraloop`

Didactic activity

03/2025 - 05/2025	**Application of Computer Vision for the management of archaeological legacy data** Computer vision lab for Archaeology students, Sapienza University of Rome. With Prof. Julian Bogdani

02/2025 - 05/2025	**Archaeology and Artificial Intelligence (AI): potential, opportunities and risks of a new digital era** Introductory seminar on Machine Learning and Archaeology, for Archaeology students, Sapienza University of Rome. With Dr. Luca Alessandri
03/2024	**Machine learning e computer science in archeologia: tematiche, applicazioni e prospettive** Introductory seminar on Machine Learning and computer science in Archaeology, for PhD students of the XXXVII Cycle in Archaeology, Sapienza University of Rome
02/2022	**Python vs R - An archaeological challenge** Applied programming languages course to archaeology. XXXVI and XXXVII cycle of the Doctorate in *Patrimoni archeologici, storici, architettonici e paesaggistici mediterranei*. University of Bari 'Aldo Moro'.
03/2021	**QGIS basic course** Basic QGIS application to archaeology. XXXVI cycle of the Doctorate in *Patrimoni archeologici, storici, architettonici e paesaggistici mediterranei*. University of Bari 'Aldo Moro'.

Editorial work

Peer-review	Journal of Archaeological Science; PLOS ONE; Computer Applications and Quantitative Methods in Archaeology (CAA) - Conference; Journal of Cultural Heritage; STAR: Science & Technology of Archaeological Research; npj Heritage Science; Archaeological Prospection; Nature Scientific Reports

International experience

03/2022 – 07/2022	**Visiting Researcher** *Österreichisches Archäologisches Institut*	📍 *Vienna, Austria*

Funding and grants

2025	Postdoc scholarship, gross 22,000€/year (duration: 24 months)
2023	Postdoc scholarship, gross 22,000€/year (duration: 12 months)
2020 – 2023	PhD scholarship, gross 16,000€/year (duration: 42 months)

IT skills

OS	Windows GNU-Linux
Office & Editing	Microsoft Office Adobe Photoshop Adobe Illustrator Adobe InDesign GIMP

Editing video & content creation	Adobe Premiere Pro Adobe AfterEffects
GIS Softwares	Qgis Arcgis SAGAgis
Version control	Git
Database	Microsoft Access
Programming & markup	R Python HTML CSS Markdown Bash SQL LaTeX
Statistical software	Past SPSS
Computer graphics	Blender Unreal Engine 5 Unreal Engine 4 Quixel Mixer Substance Painter Armor Paint

Language Skills

Italian	Native
English	Intermediate

Additional information

Driving Licence	B