

Original Study

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Pottery Goes Public. Performing Archaeological Research Amid the Audience

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Abstract: The project *Pottery Goes Public* explores the potential of 3D analytical tools to assess to what extent they can provide us with new interpretations and insights into the technological aspects of ancient pottery manufacturing. However, developing innovative 3D imaging techniques for ceramic analysis is not the only aim of the project. Since its inception, *Pottery Goes Public* has been designed to involve a wider audience not only into the study of ancient potting techniques, but also into the very process of carrying out the research. As advocated by the proponents of a reflexive approach to archaeology, in order to make the past relevant to contemporary society it is imperative for the archaeologist to include all interested parties into every stage of the analysis, from the formulation of the research questions to the dissemination of outputs. In this sense, the deployment of modern 3D technologies proved to be an indisputably powerful medium of communication and interaction with the public at large. Performing live archaeological research with cutting edge tools is a key step towards opening up academic research to multiple actors and actively engaging them with the archaeological interpretative process.

Keywords: 3D scanning, 3D reproduction and printing, archaeology and public, multivocality, pottery technology

1 Research Backgrounds and Aims

1.1 From *Pottery Goes Digital* to *Pottery Goes Public*: Two Projects, One Common Thread¹

Archaeologists have, over the past two decades, increasingly adopted reflexive and multivocal stances to create a more inclusive, participatory archaeology. While digital technologies were not at the forefront of

¹ We would like to express our gratitude to Dr. Barry Molloy for granting us the opportunity to present *Pottery Goes Public* at the workshop *Breaking the Mould. Seeing through time. Exploring the use of 3D models of objects in archaeological research*, held at the University College of Dublin, October 15th and 16th 2016. This presentation paved the way for the publication of the project in the current Topical Issue. Special thanks are also due to the anonymous reviewers for their careful reading and the many insightful comments that contributed to shape a stronger manuscript. All remaining errors are our own.

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the methods described by Hodder in his seminal work on reflexive methods published in *Antiquity* (1997), it has become clear that many of the original aims can be fundamentally reinforced by the application of new generations of computer assisted technologies for visualization, recording and planning. Indeed, the growing digital toolset at our disposal and the rise of social media have played a central role in involving non-specialists in the archaeological discourse. However, these efforts often remain confined in the realm of heritage management, excavations (where all parties involved should have a voice at the *trowel's edge*, thus enabling them to provide additional interpretations of 'their' local past; Hodder, 2000, 2003, 2005), museum collections, and only rarely so in off-site, post-excavation research such as material analysis. One should probably ask whether disclosing the interpretative process through open access platforms and blogs, as well as making the data accessible through virtual museum collections to both specialists and non-specialists, did actually lead to a truly reflexive and multivocal practice within archaeology. Unless archaeologists are in the field holding their trowels, they tend not to be in contact with non-specialists, who often become part of the research process only during its last stages, when the final results are displayed. Today archaeologists have a wide array of possibilities to process and visualize information in novel ways and to demonstrate archaeological research, but do they truly involve other voices into this process (Llobera, 2011)? As recently pointed out by Berggren et al. (2015), longstanding research projects using cutting edge IT technologies – such as is the case at Çatalhöyük – call for a reassessment of the widespread use of digital tools. A reevaluation is necessary in order to evaluate their contribution not only “to increase the accuracy and detail of recording methods, but also to further reflexive aims, defined in general terms as the situating of recording within its social and interpretive contexts” (Berggren et al., 2015, p. 434). The project presented here, *Pottery Goes Public*, is ideally positioned to explore new ways of communicating science-based knowledge to diverse audiences while performing both on and off site ceramic analysis using 3D scanning, 3D visualisation methods and 3D printing.

*Pottery Goes Public*² stems from the experience of *Pottery Goes Digital*³ (hereafter PGD), a multidisciplinary project launched in late 2014 by a team of digital archaeologists and ceramic analysts based at the University of Amsterdam. The main goal of PGD was to explore the full potential of 3D imaging techniques and 3D analytical tools in order to determine to what extent they may lead to novel forms of interpretations and provide new insights into pottery studies with particular reference to the analysis of ancient potting technologies. A large and growing body of literature has investigated the meaning of the production and technological knowledge embedded in ceramics, showing how much it can add to our understanding of the complexity of social relationships made manifest through the manufacture and use of these objects.⁴ In fact, the detailed reconstruction of operational sequences (or *chaîne opératoires*) engages with aspects of embodied practice as learned behaviour, conscious and unconscious. The reconstruction provides “the ability to move between different scales of analysis – from individual creator to larger communal and regional technological systems that enable, as well as constrain, production choices”, and helps to address questions of social agency and materialization (Kohring, 2006, p. 100).

Drawing on a *chaîne opératoire* approach, we placed particular emphasis on issues concerned with the very process of pottery making in the attempt to illustrate how significantly the integration of 3D technology within ceramic analysis may implement the quality and quantity of information at our disposal for detecting ancient potting methods beyond the current practice of digital archiving and documentation. Traditionally, the assessment of potting techniques starts with the macroscopic analysis of vessels' surface features, that is “the detailed visual examination of macroscopic surface traces that relate to the forming processes used by the potter” (Knappett, 1999). This means that archaeologists rely almost exclusively on their experience in the visual and tactile examination of ceramic material in order to investigate the morphology and co-occurrence of features such as striations, fractures, imprints and grooves. The experiment carried out within the framework of PGD helped us demonstrate that the integration of 3D scanning technology within

² Presented at EAA 2015 conference in Glasgow and at the *Breaking the Mould Workshop* held at the UCD at Dublin in 2016.

³ Presented at CAA 2015 conference in Siena and the CAA-NL/FL Chapter meeting 2015 in Amsterdam (see Revello Lami et al., 2016).

⁴ See most recently an overview of recent trends in technological approaches to pottery studies in Dobres, 2010.

standard procedures of macrotrace analysis not only enables us to record vessels' surface topographies more systematically and in greater detail than with the naked eye, but also may lead ultimately to the development of algorithms that automate the process of identifying different forming techniques.

To this end, modern experimental wheel-coiled and wheel-thrown pots have been recorded with a 3D scanner. (Several 3D scanners were assessed, both laser and structured light. See Revello Lami et al., 2016). The resulting 3D archive of experimental ceramics and related surface macrotraces, for which all stages of the manufacturing process were known, has been implemented and compared with archaeological material, namely coarse ware ceramics from Central Italy dated from the Iron Age to the Late Archaic period. The selected sample was particularly well suited to address the question about automated detection of potting techniques: on the one hand, the wide time span includes objects realized in several methods (handmade, wheel-coiled and wheel-thrown); on the other hand, coarse wares hardly ever feature a slip as surface treatment, therefore providing a perfect testing ground for the digital analysis of surface macrotraces. Both experimental and archaeological potsherds formed the testing material to develop the algorithms for automatic detection of potting methods. The analysis of 3D data has been based on geometry as opposed to image recognition: we have mainly used a combination of contours, curvature analysis, surface normals, various smoothing and decimation algorithms to detect and make more visible different surface features. For each type of macrotrace we set up a pipeline to find it, using a combination of the above-mentioned algorithms and special parameters relevant to the properties of the feature for we were looking. The few simple methods experimented within the framework of PGD proved to be valuable undertakings that allow us to continue towards this direction. Incorporating 3D techniques into macrotrace analysis not only eases the process of acquiring data, largely implementing the available archive of ceramic surface features, but also makes those data interactive and always accessible for further verification. The further elaboration and definition of the above algorithms to suit the specific needs of our research may result ultimately in a robust expert system, providing a powerful diagnostic tool to detect even complex manufacturing processes.

The promising results of PGD led us to another challenge: how to draw public attention to such a very specialized line of research? Or in other words, how to make the analysis of ancient potting technologies relevant to contemporary society and how to involve different audiences throughout the process? *Pottery Goes Public* has been designed to answer these questions. At its core lies the intention to develop innovative ways to engage the public with the study of pottery and with the techno-cultural context in which ceramic objects were made and used by applying digital technologies. In line with interpretative and reflexive approaches to archaeology, the ultimate aim of the project is to make the practice of carrying out scientific research “a multi-voiced, multi-stranded, contingent process” (Morgan & Eve, 2012, p. 523).

1.2 A Bottom-Up Approach to Capture the Audience's Imagination

In order to reach and capture the imagination of multiple audiences, *Pottery Goes Public* (hereafter PGP) adopted a bottom-up, reflexive approach: the objectives set and the outcomes expected have been largely shaped by the participation of the public. As we will see, PGP may be considered as a contributory project designed by specialists where the public mostly contributes to the collection of experimental data (Shirk et al., 2012, p. 29), as well as a co-creation, because the involvement of non-specialists has raised new issues relevant to the scientific purposes of the research. Since its inception, PGP has been planned not just as a virtual exhibition, for we deal with live post-excavation, ongoing research by means of 3D scanner and 3D printer applied technologies. The project, therefore, holds a middle-ground position between a guided tour through an excavation, a hands-on experience and a virtual museum.

As mentioned earlier, PGP is rooted in a wider framework, the main scope of which is to use 3D imaging techniques to enhance the quality and quantity of archaeological information embedded in ceramic vessels. For the project, we applied the same pipeline developed within PGD to automate and quantify macroscopic observations for detecting potters' technical gestures and related strategic choices of artefact manufacture. In this case, however, we decided to extend the analysis to wheel-fashioned ceramics and black gloss ware (with special attention to stamped specimens) instead of focusing on coarse wares. 3D scanning provides a much more accurate representation of the complete topography of objects than

traditional drawings and descriptions: notwithstanding the presence of a layer of slip, additional features can be recorded in greater detail such as the stamp's depth and orientation, which are important indicators to break into single actions within the whole operational sequence that the potter followed to produce a black gloss bowl. 3D data on fine ware ceramics from mid- to late-Republican contexts in central Tyrrhenian Italy have been implemented with existing data about the shape of the vessel, fabric and provenance. Furthermore, we decided to experiment with the automatic measuring and comparing of the stamps, which are a distinguishing feature for a black gloss specific group, in order to speed up and automate the process of analysis as well as to make the workflow scalable.

The ultimate goal of the project is to make all collected material and acquired data accessible through a comprehensive, online platform with graphical user interface for especially flexible user experiences (Maschner, Schou, & Holmes, 2013, p. 266). The platform enables specialists to easily compare different assemblages with those stored in the 3D database, and non-specialists to browse and possibly implement the existing collection, with the goal that they will feel connected to a shared 'mobile' heritage and more involved in the reconstruction of the stories embedded in those objects.⁵ As Maschner, Schou and Holmes (2013, p. 265) rightly pointed out, we consider a "Virtual Archaeological Repository" essential to the democratization of material analysis and the sharing of data to both scholars and other stakeholders (in our case local Italian communities and museum visitors). As stated at the beginning of this paper, by reflexively engaging with technologies it is possible to bridge the division between the technical and the social within archaeological practice and public outreach (Morgan, 2015, p. 135).

1.3 The Sublime Triangle: Archaeologists, Ceramics and the Public

To explore the full potential of 3D imaging techniques applied to pottery studies, we selected a different dataset than the household wares investigated for *Pottery Goes Digital*. For PGP, we also chose to incorporate into our reference collection fine ware assemblages, which feature different physical characteristics, especially more complex finishing techniques as opposed to the rough surfaces of coarse ware vessels. The incorporation of different wares raises different technological questions as well as methodological issues in terms of digital analysis. We decided to focus our attention on a single ceramic class, Italian black gloss pottery, that proved to be an exemplary topic, not only because of its ubiquity across all Italy and beyond, but in particular for its morphological and stylistic heterogeneity. Too often specialists have observed these characteristics only through the lens of a typological approach, largely overlooking the wealth of information possibly retrievable from the study of its specific technology. Because it allows for movement between different scales of analysis, a *chaîne opératoire* approach is ideally situated to grasp the regional complexities of Italian black gloss ware, and 3D technology provides the best tools to perform, share and implement multiscale analyses.⁶

For the purpose of the project, we had the opportunity to investigate two different case studies: the closed context of a set of complete black gloss bowls recovered from the the Secca di Capistello shipwreck, which were on temporary display in the Netherlands at the Allard Pierson Museum (Amsterdam), and the many fragments of black gloss bowls bearing stamped decoration found at the site of *Satricum*, Italy. The two different locations, a museum and an ongoing excavation, form an excellent basis to test our approach to public outreach.

⁵ Part of the data acquired during the project have been incorporated into the currently forming 3D archive set up within the framework of *Tracing the potter's wheel: investigating technological trajectories and cultural encounters in the Bronze Age Aegean*, a project directed by Dr. Jill Hilditch, based at the Department of Archaeology (ACASA) of the University of Amsterdam. One of the main aims of the project is to enhance pottery analysis with 3D techniques in order to reconstruct operational sequences of pottery production and track technological innovations such as the potter's wheel. We are thankful to Dr. Hilditch for allowing us to resume the work by taking part in her project.

⁶ Provenance and production technology of black gloss ware from *Satricum* is the research subject of our colleague M. Louwaard's PhD thesis. We are greatly indebted with her for having shared with us her knowledge, findings and actual pots-herds.

1.3.1 A *Chaîne Opératoire* Approach to Black Gloss Ware

Black gloss ware denotes a heterogeneous group of tableware characterized by its shiny black slipped surface that was produced in Italy from the late fifth to the first century BC. As one of the most commonly found fine wares in all excavations across Italy, black gloss ware is also the chief chronological indicator for the period of its production and circulation (Di Giuseppe, 2012, p. xv). It was used as table ware and for ritual and funerary practices, characterized by a highly depurated clay and a coating of black slip that makes the vessels impermeable. The coating is achieved by dipping the leather-hard body in diluted clay that is rich in iron-oxide, which could reach a high degree of sintering, and could vitrify in a shorter time and at a lower temperature than the clay used for the body itself (Mirti & Davit, 2001, p. 20). This gives the vessel a deep black color and a shiny appearance after firing.⁷

Related to the Greek colonization of Southern Italy, the earliest Italian black gloss products are close imitations of Attic Greek examples. By the end of the fourth century BC, many regional production centres in Central Italy had specialized in the production of this ware and developed a morphological and decorative repertoire inspired by indigenous traditions distinct from the Southern-Italian/Greek ones. Production reached its peak in the third century BC, coinciding with a growing trend towards fragmentation of production between urban centres.

The first comprehensive and systematic black gloss studies published focused on typo-chronological and stylistic analysis, either aiming at a better definition of the chronology of the larger, internationally traded productions, or recognizing the hand of different (groups of) painters and identifying and locating production centres. Fundamental typologies have been established by scholars such as N. Lamboglia and J-P. Morel, who named this class ‘Campana’ initially, a clearly misleading term especially when it comes to provenance issues. In the following decades, these typologies have been continuously refined, adapted and complemented with technological data. It is increasingly acknowledged that these traditional classificatory studies disproportionately emphasized higher quality, internationally traded black gloss pottery, which makes them of limited value for regional analyses (Gliozzo & Memmi Turbanti, 2004). Despite these limitations, much recent literature continues to use the analytical tools and terminology of these traditional studies. They attribute the difficulty in identifying different productions of black gloss pottery in Central Italy to a profound homogeneity in the material culture of the larger Etrusco-Latial area, often explained in a historical framework centred on the Roman political and military expansion in Italy. Recently, however, there is a growing trend in black gloss studies to focus on regional productions and to apply an integrated approach, according to which this pottery is no longer treated as a separate class, but is studied from different angles in the framework of the local/regional context. And this is also the direction in which the digital analysis of the selected bodies of black gloss bowls has been undertaken.

Many black gloss bowls and plates feature a stamped decoration mostly associated with open shapes (bowls). The production of stamped bowls starts at the end of the fourth century BC, also in this case inspired by Attic models. From the third century BC onwards, the pots were produced by a large number of workshops spread throughout Central Italy (*Gruppo dei Piccoli Stampigli*, Stanco, 2009), for a regional as well as a supra-regional market. Due to the apparent homogeneity in the morphological and stylistic repertoire, the identification of the various production centres is still subject to debate: detailed local studies have only recently started, as for a long time Rome was considered/assumed to be the main production centre (the so-called *Atelier des Petites Estampilles*, Morel, 1969).

The actual punches, by contrast, are hardly attested in the production sites identified across the peninsula thus far. Some terracotta punches were found at several black gloss workshops in Greece, especially at Corinth, thus their general lack from Italian sites seems to point towards a different practice. It could be argued that the punches, being part of the potter’s toolset, were considered personal belongings, and therefore less easily found within production areas as opposed to domestic contexts. Some imprints on black gloss bowls seem to indicate that they were realized with incised gems (from rings), which may support the hypothesis that punching tools were indeed personal belongings. Another explanation might

⁷ For a detailed overview on the *status-quo* in research to black gloss ware see Di Giuseppe (2012).

be that the punches were made of perishable material, such as wood, or metal (usually remelted and transformed into something else), and therefore invariably lost.

The general lack of stamping tools in Italy makes the case of Scoppieto (Umbria) particularly exceptional. In this settlement, showing traces of occupation from the early third century BC, several punches related to the manufacturing of black gloss vessels have been unearthed from a workshop site. Unfortunately, no further evidence to reconstruct the complete set of operational sequences for early black gloss ware production was recovered; only plaque moulds, punches, wasters and clay waste dated to the Imperial period have been recorded (Di Giuseppe, 2012, p. 26). It is interesting to note, however, that the petrographic analysis showed that most of the moulds were made at Scoppieto, whereas the punches were produced elsewhere (Di Giuseppe, 2012, p. 26). This might indicate that the punches were brought along by itinerant artisans (corroborating the hypothesis of these tools being strictly personal) or that a trade that specialized in punches existed. Both options are not mutually exclusive. Equally relevant to our research is the site of *Cales* (present day Calvi Vecchia, Caserta, Campania), very well known for its black gloss production, where several stamping tools have been recovered during survey investigations in the area. All the specimens are made of fine light brown clay and are wheel-thrown in the shape of a flared truncated cone to allow for a better grasp. The larger base of these punches features a complex incised decoration, in all probability used to create the characteristic relief stamped decoration on large bowls (*paterna mesomphalica* type) dated to the third century BC (Pedroni, 1989). Although these artefacts have not been found in a production context, as have the specimens from Scoppieto, they do provide additional evidence to reconstruct the morphology of the stamping tool connected to a specific type of black gloss vessel.

As this brief overview of the extant evidence already illustrates, pottery punches are fundamental to answering questions about social practices in pottery production (Di Giuseppe, 2012, p. 28). J-P. Morel regarded stamps as the distinctive signs of individual artisans (Morel, 1981, p. 85), but more recently other scholars tend to interpret the same stamps as reflections of internal workshops' organization, possibly indicating different lines of production within the same atelier (Di Giuseppe, 2012, p. 31). Detailed analysis of stamps and their distribution could provide information about networks of artisans, their movement and subsequent diffusion of technologies, and ultimately the level of social complexity of a community.

Despite its ubiquity and being the object of increasing attention by archaeologists, black gloss ware is hardly showcased in museum collections: often entire assemblages never leave the storerooms or are simply displayed in piles amongst other material.⁸ Against the overall trend, the exhibition launched by the Allard Pierson Museum (APM) in 2015, brought several black gloss objects outside their boxes to allow the visitors to observe them. The initiative of the APM curators provided us with the unique occasion not only to acquire and analyse additional material for our project, but also to do it outside a depot, amid the public. In this way, we had the chance to interact with museum's visitors and engage them with our research on the technology of black gloss ware vessels. As noted earlier, we wanted to assess the potential of 3D surface scanning for detecting specific macrotraces related to the production process otherwise invisible to the naked eye because of the black layer of slip. In particular, we aimed to highlight one aspect within the *chaîne opératoire* of stamp-decorated black gloss bowls: the sequence of gestures needed to imprint a single or a composition of several symbols right in the center on these vessels (Fig. 1). When was this action exactly done during the production process, in what way, using what type of tool and possibly by whom? The integration of 3D surface scanning, 3D reconstruction and 3D printing, in combination with the participation of local audiences performing the actual stamping sequence on sets of experimental bowls and clay paste, was the strategy developed to address these issues.

⁸ With the notable exception of the Capitoline Museums in Rome that in 2014 launched the project *Hidden Treasure of Rome* in collaboration with the Museum of Art and Archaeology of the University of Missouri in order to study black gloss ceramics using cutting-edge technologies such as 3D surface scanning, XRF and isotope analysis. These vessels have never been studied or fully catalogued before. Unfortunately, aside from a webpage and some movies, the local and American public have not been informed about the research, nor were they invited to participate in the ongoing investigations. (<https://maa.missouri.edu/hidden-treasure-rome-project>).

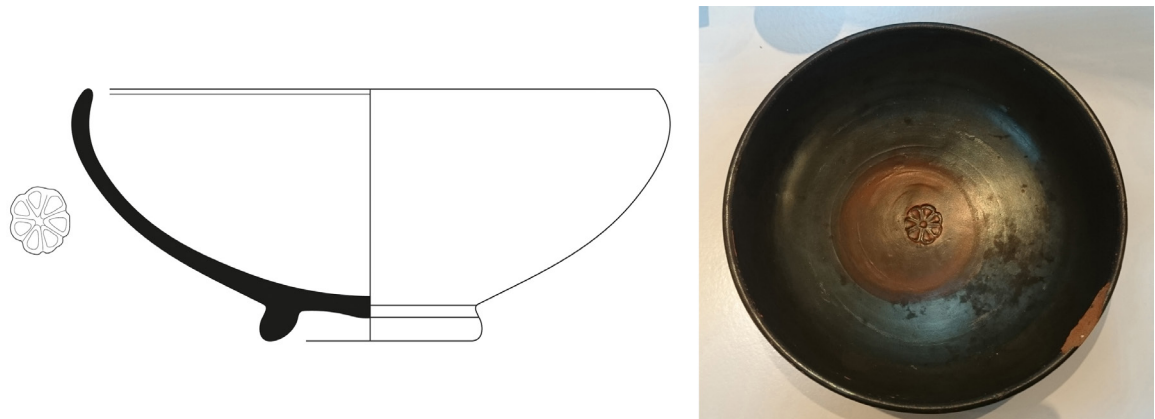


Figure 1. Drawing and photo of a black gloss bowl from the Capistello shipwreck (after Bernabò Brea & Cavalier, 1985, fig. 41, 36. Photo by L. Opgenhaffen).

1.3.2 Case-Study 1: Black Gloss Bowls from the Secca di Capistello Shipwreck

The Secca di Capistello shipwreck, sunk near Lipari (the largest of the Aeolian Isles situated north of Sicily), was discovered in 1957 by divers who first identified a significant concentration of amphora fragments while looking for corals in the deep waters between Lipari and Vulcano (Burgersdijk et al., 2015, p. 75). At a depth of 60 m, the ship, buried under a tumulus of sand and water plants, appeared uncontaminated. The rescue of the cargo, wrecked on a steep slope reaching more than 100 m of depth, appeared immediately quite complex and dangerous. In the following years several amphoras and black gloss ware vessels were recovered randomly, but not all artefacts made it to the museum: unfortunately, a vast part was looted and sold illegally on the art market. It was not until the late 1960's that scientific research was carried out to locate the precise position of the ship and to try to rescue what was left of the hull. In 1976, thanks in part to the contribution of the American Institute of Nautical Archaeology and its cutting edge equipment, it was finally possible to survey in detail the entire shipwreck and its cargo, both largely still intact. Based on the amphora type (mostly Graeco-Italic – type V Vanderersch), the ship could be dated to ca. 300 BC. Following a well-known sea route, the ship departed most likely from one of the Greek centers in the Bay of Naples and was heading to the southernmost coast of Sicily and from there to North Africa, in all probability Carthago (Bernabò Brea & Cavalier 1985, pp. 53–64; Olcese 2012, p. 573). The hundreds of black gloss vessels stacked between the amphoras (plates, bowls, kylikes and oil lamps) all show the same clay and slip and have been identified as Campana A ware. Twelve vessel types were identified and among those were roughly a dozen bowls with stamped rosette decoration on the inside (Blanck type 1–3 and 4–7) (Blanck, 1978, pp. 108–109; Morel, 2004, pp. 81–87), which were chosen to be displayed for the exhibition *Sicily and the Sea* at the Allard Pierson Museum (Burgersdijk et al., 2015).

The stamped black gloss bowls recovered from the deep waters of the Secca di Capistello and temporarily exhibited in Amsterdam opened up the rare opportunity to study an apparently very coherent and homogeneous assemblage of objects. Having been found in a closed context (the cargo of a ship), these bowls were loaded and shipped jointly and presumably produced in the same workshop. Therefore, one would expect to find a perfectly identical decoration on each artefact, most likely imprinted by the same stamp. As we will see in the final part of this paper, the integration of 3D imaging recording added greater depth to the usual documentation practices, providing new, unforeseen evidence.

1.3.3 Case-Study 2: The Black Gloss Stamped Ware from Satricum

Due to its favourable location in the Pontine plain, bordering the Tyrrhenian coast and lying at the crossroads of routes running from Rome to the south and from the Apennine hinterland to the coast, ancient *Satricum* developed into a major proto-urban centre in the Archaic Period. Three centuries later, historical sources report how *Satricum* was destroyed in 346 BC after a long-standing political struggle with the Romans. Extant evidence suggests that after these turbulent times the settlement of *Satricum* continued only on a small scale, and activities were supposedly centred on the main sanctuary of Mater Matuta as indicated by the so-called Hellenistic Votive Deposit (hereafter HVD), which contains objects that can be dated predominantly to between the fourth and second centuries BC. The objects suggest that, despite the demise of the settlement, the temple continued to play an active role in the exchange of objects at a supra-regional level (Maaskant-Kleibrink, 1999, pp. 109–111).

Based on extensive re-excavations conducted by the University of Amsterdam in the 1980–90s, the deposit could be interpreted as an ancient water cistern dating to the Iron Age that was subsequently re-used as a votive deposit in the Mid-Republican Period. Furthermore, it was confirmed that the bulk of the objects were dumped into the cistern in a fairly short period of time and that this event probably occurred between the end of the third and the beginning of the second century BC (Maaskant-Kleibrink, 1999, p. 109).

Many of the objects recovered from the HVD are black gloss. Amongst the thousands of ceramic objects recovered from the HVD, black gloss ware represents a major portion of the items. Approximately 300 black gloss vessels feature stamped decoration. With regards to shape, generally the bowls are all of the *echinus* type, whereas the overall finishing technique is slipping by immersion, as is evident from the finger and nail prints visible at the base, left by the potter during the dipping process. With regards to the stamps, there are 126 different motifs, many of which are unique, with the dominant depictions consisting of rosettes and palmettes. The bowls bear either one or four stamps, with different stamping orientations. The imprints of the stamps left either a negative impression in the bowl or a relief (positive) pattern on the surface of the bowl, with various degrees of detail and different stamping orientations.

From a chronological viewpoint, the stamped ware found at *Satricum* falls into all Stanco's phases, though the bulk of pottery is dated to Phase III (290–260 BC) (Stanco, 2009, pp. 1022–25). This correlates to a peak in the overall black gloss pottery production in Central Italy, which also saw the start of its distribution not only on a regional but also an international scale. The black gloss bowls from the HVD were either produced locally or imported from other regional production centers in Latium, Campania and Southern Etruria. Only on very rare occasions can a stamp be linked to a specific production center, and unfortunately none of those retrieved from the HVD provides information in this direction. Hence, we rely on other data such as the macroscopic analysis of shape, gloss and fabric in order to determine a vessel's original production center (Louwaard, 2007, pp. 176–179).

Based on the results discussed above, the contribution of 3D technologies may ease the process of comparing and matching different datasets concerning shape morphology, surface macrotraces, as well as possibly automate the recognition of stamped decorations features, adding important information to the existing record.

2 Research Methods and Strategies

2.1 Workflow

In order to carry out research on location with all necessary equipment, but also to show audiences the modern archaeological tool-set in action, we set up a mobile lab consisting of a large touchscreen, two types of 3D scanners (NextEngine UltraHD laserscanner and DAVID SLS-1 structured light scanner),⁹ notebooks to process data, and a 3D printer (Builder Dual-feed).

⁹ For a detailed description of the workflow of 3D scanning see Revello Lami et al. (2016).

In order to assess if the stamps on the black gloss bowls were actually identical and to explore what additional features we could automatically extract and analyse, we experimented with the open source software CloudCompare. This software proved to be helpful in integrating point clouds derived from different scanners, but the greatest advantage is that CloudCompare is able to measure the differences and compute large quantities of 3D models at once. This means that the analysis of black gloss stamped vessels could be upscaled to perform comparative analysis, ultimately enabling scholars to trace (possibly travelling) artisans and connections between workshops on an intra-regional level. By first aligning and then comparing to what extent 3D scans of different impressed decorations overlap, two at a time, the differences in stamp erosion, angle, depth and motif become explicit. Computing a signed cloud-to-model distance (i.e. the distance from each point to its ‘counterpart’ on the second stamp model) gave us a single-number representation of the level of difference between two stamps. Visual analysis of the overlap between the stamp models showed the locations of stamp wear and, as mentioned above, differences in depth and angle and differences between stamp motifs.

Central to the study carried out on black gloss ware was to assess whether automated identification of stamps based on geometry and detection of specific features could provide new insights on the internal organization of labour in a pottery workshop. Since features such as depth and orientation (i.e. obliquity of imprint in z-axis) are relevant to the very act of stamping, it might be possible, with experimental and comparative analysis (see section 2.3), to identify different levels of experience (e.g. apprentices) and male, female or child involvement in the production sequence.¹⁰

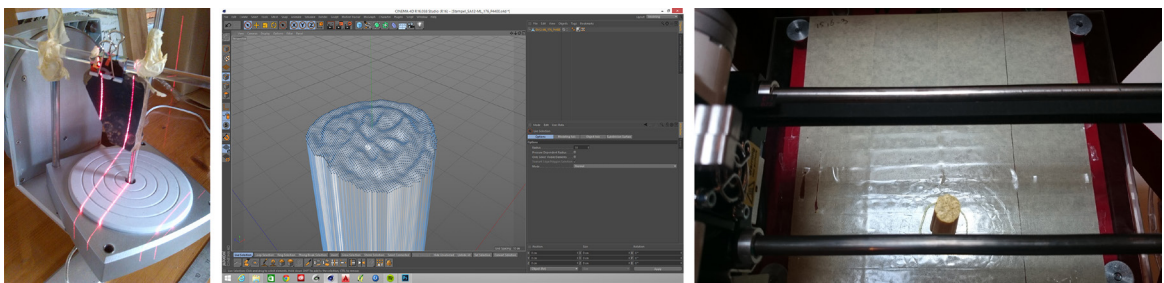


Figure 2. The reconstruction process of a stamp. Left: 3D scanning of a black gloss fragment with stamped decoration in *Satri-cum*. Center: 3D modelling of the stamp in Cinema4D. Right: the 3D print with the Builder of the stamp is ready. All photos by L. Opgenhaffen.

Maxon Cinema4D, a 3D modelling software (free educational licenses), was used to reconstruct a 3D model of the punch from the 3D scans of the stamp. This operation was relatively easy, since the negative of the imprint was just reversed to form a positive: the punch (Fig. 2). Regarding the original possible shape of a punch used for pottery decoration we draw on evidence of terracotta tools found at production sites in Spain and Greece. However, a note of caution needs to be made about the shrinkage of the clay and the layer of slip. In the operational sequence of black gloss stamped ware, the stamp was impressed on leather-hard clay *before* it was completely dry and the slip was applied, whereas the modern punch was modelled and then recreated after a stamp bearing a layer of slip. If the percentage of shrinkage is known, a more reliable reproduction could be modelled, also by digitally removing the layer of slip. Likewise, the type of material used to realize the punches may influence the appearance and handling of these objects: they could have been made in wood, clay or metal (the printer can print both materials), but again the presence of a layer of slip may blur the vision of the different traces left by a wooden, ceramic or metal punch.¹¹

¹⁰ For an overview on the contribution of ethnoarchaeology for tracing the social identity of artisans see Costin (2000, pp. 394–395) and more recently Bolger (2014).

¹¹ In this sense, the possibility of recording unfinished specimens retrieved from production sites (for instance a stamped ware buried right before being slipped and fired) could provide decisive evidence.

2.2 Between a Co-Creation and a Contributory Project

Thanks to the cooperation and support of the Allard Pierson Museum staff we had the chance not only to include in our experiment the material recovered from the *Secca di Capistello* shipwreck, but also to perform our research amid the public. Specifically, we conducted our research at the *ArcheoHotspot*, a new initiative launched in 2014 by the museum in collaboration with the *AWN - Vereniging van Vrijwilligers in de Archeologie* (Volunteers in Archaeology) and the *Erfgoed Brabant* (Heritage Brabant) that aims to make archaeology accessible for everyone through a network of labs in several locations across the Netherlands.¹² Working at the *ArcheoHotspot* was a very inspiring experience because of the enthusiasm of the volunteers involved in the initiative as well as the possibility of establishing a direct dialogue between different stakeholders all contributing differently to the construction of a shared heritage and past.



Figure 3. The 3D printed stamping tools and sheets of clay with stamp imprints of museum visitors. Photo by L. Opgenhaffen.

In line with the scope of our project, we chose to reproduce a punch with the 3D printer to illustrate at least one stage of the production process to the museum's visitors, and to let them have a hands-on experience of past potting practices by stamping clay with a 3D printed, reconstructed stamp (Fig. 3). At the *ArcheoHotspot*, what started as a very simple strategy to better interact primarily with the youngest visitors evolved into a bigger experiment triggering a very active public participation in our research into past pottery manufacturing techniques. In hindsight, the unplanned enthusiastic response of the audience greatly influenced our research design, turning it from a contributory project into a co-creation.

Practically, the hands-on experience offered to our visitors became an ethnographic survey of different stamping practices. For each stamp realized by one person, several parameters were recorded:

- Gender
- Age
- Left/right handed
- Previous experience in potting

¹² See below section 2.3.

At the same time, we could run several experiments on the drying process of the clay to understand at what point the stamp should be punched for a better result: imprinting the punch on clay that was too dry resulted in fissured stamps, whereas stamps punched on clay that was too wet were rather irregular and blurry. Knowing and recognizing the correct leather-hard condition takes some expertise.

The 3D models obtained from modern stamps combined with the basic parameters registered would form the basis for developing algorithms that will ultimately enable us to postulate hypotheses about the gender, age, motor skills and level of specialization of ancient potters. It may also be possible to distinguish sets of objects attributable to the same individual. All these data are important indicators for reconstructing the social organization of ceramic workshops.¹³

2.3 Public Presentation

Crucial to the project was the possibility to work at two different locations and to involve different parties into our line of inquiry. It was equally important to present Dutch archaeological research in the Netherlands, which normally is carried out in the Mediterranean. As briefly mentioned earlier, we were invited to conduct our research in one of the *ArcheoHotspots* spaces situated at the Allard Pierson Museum of Amsterdam, the archaeological museum of the University of Amsterdam. The objectives of *ArcheoHotspots* are very close to our aim of fostering more systematic public participation in the interpretative process elaborated by archaeologists. The main point is to display not only end-results, but also the whole research process, or in other words, to let people in and make archaeology a more tangible experience in order to bridge the gap between academia and society.

The second opportunity for reaching out to a different type of public was provided by an excavation directed by the Department of Archaeology of the University of Amsterdam at a small village in Italy, Le Ferriere (ancient *Satricum*). This allowed us to engage the local audience with our specific project and more widely with the longstanding research conducted on the site by several Dutch universities. For over 40 years every summer a team of international archaeologists has come into this small town of approximately 200 inhabitants to excavate, survey and study the material remains of the ancient pre-Roman city of Satricum.¹⁴ A relevant part of the local population has and still is contributing in different ways to the ongoing research: many men are hired to carry out the hard labour on the excavations and to set up the building that hosts the staff and the students; others have been fundamental to the establishment of the town's archaeological museum and to cultivating the active participation of local authorities and volunteers by organizing tours and events on the site and in the museum. Moreover, a decisive factor in fostering the continuity of the research has been the commitment of a local entrepreneur, Antonio Santarelli, owner of a renowned winery and also the field where the actual archaeological investigation takes place, who has sponsored the excavations for years.

However, to what extent are these parties really involved in the interpretative process of the site, in the construction of their own local history and identity?

At the *ArcheoHotspot* lab we explained in person, with the artefacts in our hands, how they were once produced and then used as household items. We showed how archaeologists are able to identify manufacturing techniques of pottery based on the observation of all visible surface macrotraces. Unlike the sample material investigated within the framework of PGD, black gloss bowls are generally wheel-thrown. At the lower back side of the bowls, traces of fingerprints and fingernails left by the potter while dipping

¹³ See more recently Wendrich (2012) on how to recognize apprenticeship, knowledge transfer and community of practice in the archaeological record.

¹⁴ Dutch excavations started in 1977 by the Dutch Institute in Rome and the University of Groningen. Since 1991, the University of Amsterdam has been responsible for the excavations directed by Prof. Dr. M. Gnade. (For an overview of the archaeological evidence unearthed at Satricum over the years see Gnade, 2007).

the vessel in the slip can sometimes be distinguished.¹⁵ Clearly, the lower back cannot be observed when the object is displayed in a showcase, where preference is given to the visibility of the internal stamped decoration. Luckily, the curators allowed us to open the showcases and handle the ancient vessels in front of the visitors. By doing so, we were able to position our fingertips exactly on the ancient fingerprints still perfectly visible on the ring-bases of several bowls and illustrate to the museum visitors how the slipping process happened: pots were held upside-down from the base and then dipped into the black slip (Fig. 4). Some fingerprints are really small, which may indicate that children, acting as apprentices, were at some point involved in the production sequence. A very useful tool to elucidate further the artisans' techniques and gestures in making ceramic vessels was the use of several videos showing present-day potters captured while making different types of pots. For instance, the case of the Icheon Masters reproducing the traditional Korean ceramic manufacture was particularly illuminating: here artisans still dip their vessels in the same fashion as the ancient black gloss ware potters, using wooden punches with rosettes to decorate the outer surface.¹⁶



Figure 4. Black gloss bowl from *Satricum* showing the fingerprints left by the potter in the clay slip while dipping. Photo by A.E.M. Dekker (courtesy of *Satricum* Research Project).

Many black gloss bowls within both the *Secca di Capistello* and *Satricum* assemblages show a circular discoloration or an encircling impression on the inside. This macrotrace points to two different stacking methods of the batches of artefacts into the kiln before firing: the bowls were either directly piled onto each other inside the firing chamber, or spacers were placed between the bowls, leaving different impressions on the inner surface of the stacked bowls (Fig. 5).

The touchscreen was a useful aid to better explain the stories behind the objects under analysis. As mentioned, ethnographic movies broadcasted on screen greatly helped to clarify the meaning and importance of the surface macrotraces usually investigated by a ceramic analyst, and they added a deeper human dimension to our scientific description. The 3D models visualised on the touchscreen could be

¹⁵ It is worthwhile noting that by analysing the macrotraces left on black-gloss bowls from *Satricum* we could identify an alternative dipping technique. Alongside the practice of dipping by holding the vessel from the base with all fingers (made evident by the presence of fingerprints and nail marks), which allows the bowl to be completely immersed in the diluted clay to be slipped, another strategy was also practiced. In some cases, in fact, there are no fingerprints visible on the base, and therefore we need to infer the existence of some other tool used to hold the object while dipping, which usually leaves the lower outer part of the bowl unslipped.

¹⁶ The exhibit “Icheon: Reviving the Korean Ceramic Tradition” was on display at the American Museum of Ceramic Art, AMOCA from October 12th to December 29th, 2013 (www.amoca.org).

played with and manipulated by all the museum's visitors to help them understand the geometry of the vessels. The 3D printer was used to reproduce black-gloss shapes, as well as some other artefacts on display in the Allard Pierson Museum, in order to give the public a tangible experience with artefacts that are otherwise not allowed to be touched. The opportunity to observe the objects from all angles may fire the imagination of any museum visitor, triggering the curiosity necessary to learn more about the past as well as about the work of archaeologists thanks to the direct exchange with the researchers (Fig. 6).

A community Facebook page was also created to communicate live the latest developments of PGP at the *ArcheoHotspot* and to share events and new findings.¹⁷ Although social media like this are not the same as a fully operational online platform with access to data, nor do they “create collective action” (Morgan & Eve, 2012, p. 524) to construct local pasts or “emancipate marginalised communities” (Hodder, 2003, p. 65) such as *Satricum/Le Ferriere*, they enable us to share instant news about finished 3D prints and to keep people updated about our work in progress.



Figure 5. Black gloss bowl from the Capistello shipwreck showing a discolouration in the center (reddish brown instead of black), due to stacking in the kiln. Photo by L. Opgenhaffen.



Figure 6. The PGP team performing research at the *ArcheoHotspot*. To the left the red 3D printer, on the right the touchscreen and just at the forefront a glimpse of the DAVID SLS-1 3D scanner. Photo by L. Opgenhaffen.

¹⁷ <https://www.facebook.com/Pottery-goes-Public-839376166111474/>

3 Research Outcomes

3.1 Academic Results

The macroscopic observations regarding shape and ware of the ceramic material selected for this study coupled with 3D digital geometric analysis of surface features have revealed valuable information from which we can start to infer the possible technological choices in the acquiring, manipulating, shaping, finishing and firing of these pots, and the practices behind those choices.

The stamps with *rosette* motifs from the Secca di Capistello shipwreck were thought to be identical, since they have been found in a closed context: a cargo loaded with piles of shiny black gloss bowls coming from a workshop situated in all probability in Campania. When we set up our mobile 3D lab at the *ArcheoHotspot* and started scanning and processing the 3D models, we already suspected, after examining an enlarged representation of the stamps on the computer screen, that these stamps probably did not derive from the same punch (Fig. 7). Out of curiosity, we manually aligned 3D models of four stamps in Cinema4D, a modelling software. After this operation, it turned out that none of the impressed *rosettes* perfectly overlap: the petals are all different, confirming that the *rosettes* derive from different stamping tools (Fig. 8). Further processing of the scans with software such as CloudCompare reinforced our manually derived conclusions (Fig. 9).

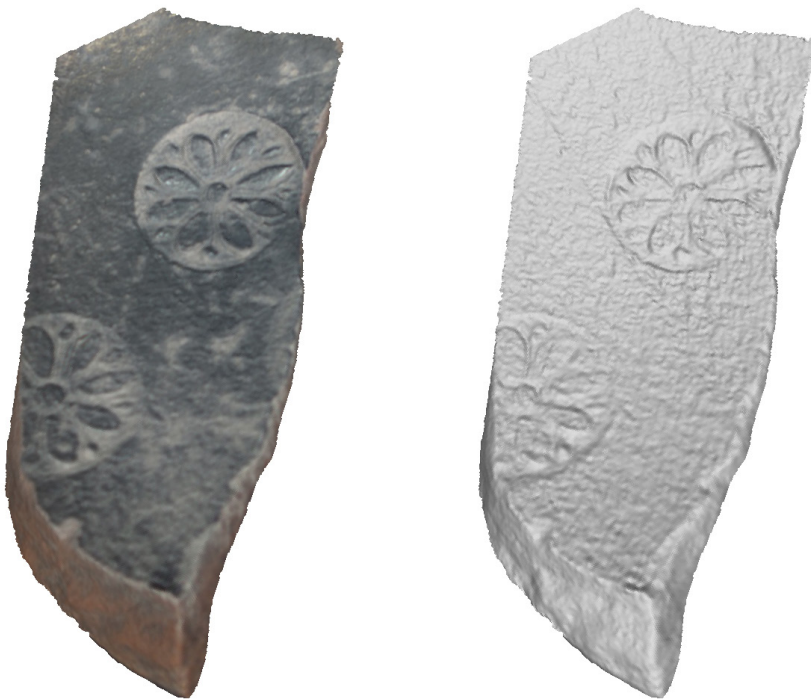


Figure 7. Scan result from the NextEngine UltraHD. Illustration by L. Opgenhaffen.

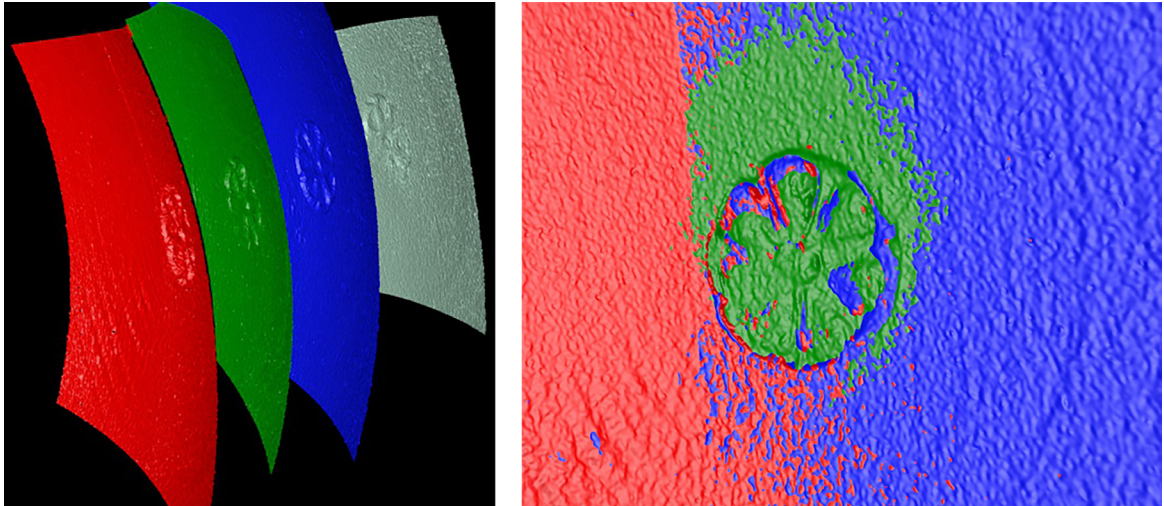


Figure 8. Matching *rosettes* of the Capistello shipwreck manually in Cinema4D. Each impression is characterized by different colours. The green and blue stamps show the biggest difference, which certainly indicates different punches, whereas red and green differ less and only on the edges. Illustration elaborated by L. Opgenhaffen.

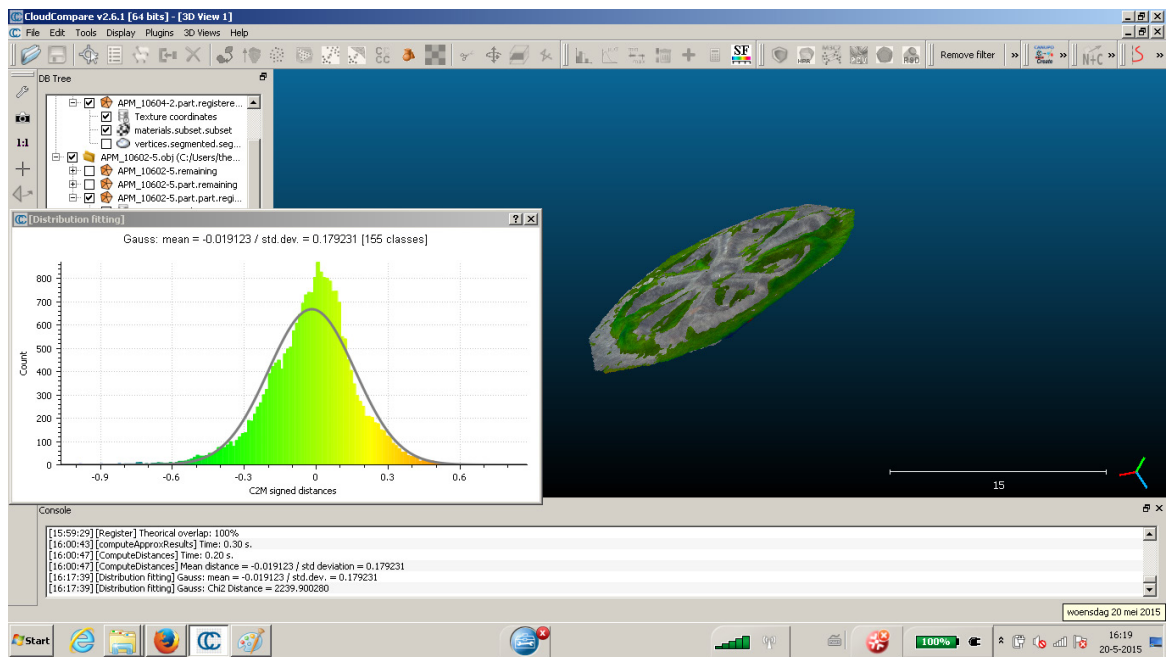


Figure 9. Visualizations of comparative analysis of stamps in CloudCompare. Illustration by I. Kisjes.

With regards to the Satricum votive deposit assemblage, the supposed homogeneity of black gloss stamped bowls is proven less evident after closer digital examination of the rims, bases and overall body-shape/thickness as well as finishing techniques. If the variations in shape, metrics and decoration can be related to other parameters (surface treatment – with particular reference to the slipping procedures – and fabric), thus revealing a consistent pattern, this observation could point towards different shaping traditions within this body of pottery that in the future could help identify a specific technological style and possibly the provenance, too. Moreover, additional analytical approaches (such as petrographic analysis and morphometrics) may depict a more dynamic picture of the manufacturing practices of this ceramic class.

We were successful in reproducing a working tool, a punch for realizing stamped decorations before firing, of which no archaeological examples are attested in the geographical area under examination. Although the first trial-punches have been printed in plastic and some adaptations should be made in the next reproductions, such as digitally removing the layer of slip from the 3D model, we can already ascertain that research on black gloss ware is one small step further towards the reconstruction of the *chaîne opératoire* for the production of stamped ware. Additional information may be inferred from the creation of punches in alternative materials (wood, ceramic or metal) in order to implement data on stamping motor habits as well as to assess if punches of different materials leave different traces.

3.2 Performing Public Outreach. Towards Pottery Goes Digital & Public 2.0

Archaeologists and ceramic analysts performing research with local audiences can restore the social dimension in which pottery production took place and transform the public perception of pots on display in museums from exalted art back to the everyday items they were meant to be.

Thanks to a research design based on reflexive stances and supported by the use of 3D technology, museum visitors could hold 3D printed replicas of the vessels in their hands, while at the same time interacting with archaeologists. Since we were presenting our work-in-progress, the dialogue with the various parties involved at different sites (museum visitors in the Netherlands and local inhabitants in Italy) was central in shaping our presentation and interaction strategies and also added fresh insights into the interpretation of the material. For example, when the public was invited to stamp, we did not have an elaborate plan for the parameters to record, since we were not entirely sure whether we would be successful in reproducing a stamping tool. One visitor suggested to record information about left- and right-handed participants, a criterion that at first we had not included in our list. As explained above (section 2.4), left or right handed could leave different traces in the stamping orientation.

Although it was the presence of a 3D printer that drew the most attention from the museum visitors and local inhabitants of Le Ferriere, everyone, young or old, paid attention to the archaeologists illustrating the reasons for the project and describing ancient potting methods. Working amid the public placed us in a privileged position to observe people's different attitude towards the possibility of taking part in a scientific project: children immediately started playing with the 3D models on the touchscreen, whereas adults stayed at a safe distance from the touchscreen, only using it to watch the ethnographic documentaries. Yet few people were – to our surprise – actually interested in the 3D scanners and software, the basis of our research. We learned first hand that people prefer to be engaged by the specialist, in this case an archaeologist acting as an interpreter of the past (Hodder, 1991, p. 15). The most successful part of our public outreach was the replica of the punch for decorating black gloss. The 3D printed stamping tool as well as other 3D prints turned out to be real magnets to any audience. In fact, everybody, without exception, joined the stamping experiment enthusiastically. The 3D printed reproductions of vessels on display at the Allard Pierson Museum and the excavation had the same success. People could hold the replicas in their hands, comment on their possible original uses, and also bring back home miniature, colored versions. It might be just a passing phenomenon, but 3D prints do possess fascinating, at times mystifying, properties: at both our locations, the museum in Amsterdam and the excavation in Satricum, people kept holding the replicas in their hands while staring, spellbound, at the 3D printer in action (Fig. 10).

Pottery Goes Digital was born as a pilot study designed to explore the potential of 3D imaging techniques for the study of archaeological ceramics, to determine to what extent they can contribute to the retrieval of additional types of data, and to define new avenues of research previously unavailable. We aimed to move beyond the traditional, documentative application of 3D technologies in order to accelerate and automate parts of the analytical process, or to use Tringham and Lopez words, to “empower them to go beyond what they did before” (Tringham & Lopez, 2001, p. 272).

When we started PGD we had no protocol: *we were learning by doing*. We call this approach “Performing Public Outreach,” and thanks to the many interactive tools today at our disposal we could invite scholars as well as non-specialists to join our research. To answer the question of Colleen Morgan and Stuart Eve (2012), “What are you doing to participate?”, this is what we did to contribute, even though with a small-scale project, to the creation of a more open, reflexive archaeology.



Figure 10. Left: Inhabitants from Le Ferriere portrayed when stamping. Right: Everybody loves 3D prints. Photos by L. Opgenhaffen.

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