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Making London Porcelain—A Multidisciplinary Project Connecting Local Communities with the Technological and Innovation Histories of London's Early Porcelain Manufacturers

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Abstract: This collaborative multidisciplinary pilot project involving the Victoria and Albert Museum (V&A), the Ashmolean Museum, and Newham Borough of London, examined the composition of a selection of eighteenth-century porcelain objects by two of London's first porcelain manufacturers, Bow and Chelsea. As the first science-based public engagement project to be piloted by the V&A, it succeeded in bringing together young Londoners and their communities to investigate local histories of scientific and artistic innovation through the analysis and remaking of eighteenth-century porcelain. Scientific object analysis informed activities with local sixth-form students, revealing the intimate link between art and science, and showcasing the V&A Science Lab as a national hub for heritage science. Public outreach activities, including an exhibition at Stratford Library and workshops for Newham Heritage Month also provided hands-on learning, including curatorial and object-handling experience, and the embodied practices of remaking. Ultimately, this project stimulated new ways of engaging with ceramics collections and explored how the creativity and ingenuity of eighteenth-century ceramics pioneers can provide inspiration for the next generation of makers.

Keywords: English porcelain; Chelsea; Bow; public engagement; scientific analysis; ceramic heritage

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1. Introduction

In Europe, the necessary skill and knowledge to make white porcelain successfully—a much-desired import from China and Japan in the early modern period—remained a mystery for several centuries. Artists and scientists in many countries attempted to replicate the process, and through trial and error, several of them eventually succeeded. In England, two of the first manufacturers to do so were the Chelsea and Bow factories, established in London in the mid-eighteenth century. Can the technical innovation, creativity, entrepreneurship and determination of these two London porcelain factories still inspire scientists, artists, curators, young people and London communities today? This was the leading question behind *Making London Porcelain*, an ambitious 6-month pilot project between the Victoria and Albert Museum (V&A), The Ashmolean Museum, and the London Borough of Newham, which sought to demonstrate the ways in which science-led analysis (until now confined to laboratories largely operating behind the scenes) [1,2] can generate new understandings of ceramic heritage through public engagement. This project, entitled in full '*Experimentation and Placemaking: connecting communities with the technological and innovation histories of London's early porcelain Manufacturers*' ran from January to July 2022 and was supported by UK Research and Innovation (UKRI) through the Arts and Humanities Research Council (AHRC) Capability for Collections (CapCo) fund [3].

'For us to be able to conduct research in any shape or form we have to have that magical word 'trust'. Which means that public engagement is, above all else, a two-way street. It's a way of listening to what the public have to say, as well as trying to inform the public of where opinion may be going' [4]. Making London Porcelain was the first science-based public engagement project to be piloted by the V&A Museum. In uniting science, curatorial research, and public engagement action-led research, it embraced a collaborative knowledge-sharing approach with sixth-form students and locals from the London Borough of Newham. The objects chosen for the scientific analysis included two virtually identical Chelsea porcelain busts, both portraying the head of a laughing child [5,6], as well as a range of glazed and unglazed Bow porcelain objects from both the V&A and Newham Borough of London (Figures 1 and 2, and Table 1) [1].

Figure 1. The two laughing children on display at the V&A side by side. The V&A one is on the left (C.37-2019) and the Ashmolean Museum's is on the right (WA1965.8).

Figure 2. Selected Bow porcelain pieces at one of the object handling sessions led by Dr Caroline McCaffrey-Howarth in the Ceramics Study Room at the V&A as part of the Schools Workshops. Photography: Grace Santry.

The scientific analysis provided information on the likely original ingredients and possible recipes that were followed, thereby helping us to follow the development of the porcelain-making technique in the various factories, and at the same time informing the choice of ingredients to use in the making workshops. Two schools participated in *Making London Porcelain*. Harris Chobham Academy and Cardinal Vaughn Memorial School were both chosen thanks to their close geographical links to the historic sites of the Chelsea Porcelain Factory and Bow Porcelain Factory. They also map closely onto the London sites of the V&A at South Kensington, and the new V&A East Museum and Storehouse opening in 2025. As well as bridging geographic separation, the project brought together 20 students, half of whom were taking science A-levels, with the other studying arts subjects. The project became a rare meeting point for these students and their teachers in a collaborative classroom setting, as the divide between art and science subjects continues to grow in many schools, frequently reinforced by timetabling restraints which streams students into one side or the other. Exposed to the new scientific research undertaken by Domoney, Burgio and the V&A Conservation Science team, these students and their local communities participated in a series of workshops led by McCaffrey-Howarth and Haseldine, during which they gained knowledge about London's complex ceramic heritage, engaged in object handling, and undertook material experiments by remaking the early Bow and Chelsea porcelain recipes. Throughout, participants were invited to learn from innovative scientific analysis in order to consider the urban historical landscape of London by thinking more about its ceramic traditions and about their impact today. One of the main outputs for this project was a co-curated exhibition at Stratford Library in the heart of the London Borough of Newham, for Newham Heritage Month. Yet, as this article explores, *Making London Porcelain* also managed to facilitate meaningful change by demonstrating that multidisciplinary collaborative research across a range of institutions and communities can enable curatorial practice, heritage science and public engagement practices to expand knowledge of eighteenth-century London, where artistic innovation, creativity, entrepreneurship and scientific experimentation co-existed to create significant pieces of ceramic art.

Table 1. Objects selected for analysis and workshops.

Object No.	Description	Factory	Date	Location	Components Analysed	Technique
WA1965_8	Head of a Laughing Child	Chelsea	c. 1746-1752	Ashmolean Museum	Paste, glaze, enamels	µXRF
C.37-2019	Head of a Laughing Child	Chelsea	c. 1746-1749	V&A Museum	Paste, glaze	µXRF
2864-1901	Inkwell	Bow	1751	V&A Museum	Glaze	Raman
PROV.466-2022	Shell salt	Bow	c. 1747-1749	Newham Archive	Paste, glaze	µXRF, Raman
PROV.467-2022	Pickle dish	Bow	c. 1747-1749	Newham Archive	Paste, glaze	µXRF, Raman
PROV.469:1	*Tamerlane* bust, Timur	Bow	c. 1750	Newham Archive	Paste, glaze	µXRF
PROV.469:2	*Tamerlane* bust, Aspasia	Bow	c. 1750	Newham Archive	Glaze	µXRF
PROV.475:1-2022	Waster, flower shard	Bow	c. 1750	Newham Archive	Paste	µXRF, Raman
PEM.16705	Lion figure	Bow	c. 1750	Newham Archive	Paste, glaze	µXRF
PEM.16706	Lion figure	Bow	c. 1750	Newham Archive	Paste, glaze	µXRF
PEM.LDLHAA0001_4017	Lion figure	Bow	c. 1750	Newham Archive	Paste, glaze	µXRF
PROV.463-2022	Ink pot	Bow	c. 1750	Newham Archive	Glaze	µXRF, Raman
PROV.468:1-2022	Ink pot lid	Bow	c. 1750	Newham Archive	Glaze	µXRF
PROV.468:2-2022	Bowl	Bow	c. 1750	Newham Archive	Glaze	µXRF

'Should Be Part of the History Curriculum'

It is now over two hundred and fifty years since the earliest dated pieces of Bow and Chelsea porcelain were produced in London. Part of an early wave of British porcelain manufactories which emerged after porcelain was first showcased at the Royal Society in 1743, both enterprises produced decorative and utilitarian wares for affluent and aristocratic clientele, as well as the more middling classes, especially at Bow [7]. In fact, the sixth edition of Daniel Defoe's *A Tour Through the Whole Island of Great Britain* published in 1761 notes that the Bow factory made all 'sorts of useful Porcelain; which, though not so fine as some made at Chelsea, or as that brought from Dresden, is much stronger than either, and, therefore, better for common Use; and, being much cheaper than any other China, there is a greater Demand for it' [8].

Based in East London, to the north of Stratford High Street, Bow was founded by the artist Thomas Frye (1710–1762) and the merchant Edward Heylyn (1695–1765) who filed their first patent in 1744 [9]. They had finally succeeded in making porcelain which they declared 'equal to, if not exceeding in goodness and beauty, china or porcelain ware imported from abroad' [10]. This recipe included the use of unaker, a clay indigenous to the Cherokee nation of South Carolina [11]. However, most existing wares from the Bow factory have usually been dated following the second patent, which Frye filed by himself on 17 November 1749 [12]. This new patent described the use of 'virgin earth' and pipe clay as a flux. 'Virgin earth' is widely interpreted as calcium phosphate deriving from calcined animal bones, which research indicates came from a local piggery in East London. The financial success of this second patent was extraordinary, with takings almost doubling between 1750 and 1755, from £6500 to £11,500 per annum [13].

Concurrently, in South West London on the other side of the city, the Chelsea porcelain factory was established in 1744 by Nicholas Sprimont (1716–1771), a well-known silver designer, and his business partner, the jeweller Charles Gouyn [14]. Following Gouyn's subsequent departure, the factory was managed primarily by Sprimont, his wife Ann, and his sister-in-law Susanna Protin [15]. Based in Church Lane East and Lawrence Street, Chelsea, the factory succeeded in satisfying the elite clientele of London and further afield. Within only two years they successfully produced sculptural porcelain to rival European counterparts at Meissen and Doccia, including a sleeping child now in the British Museum incised with the date 1746, and a remarkable figure of William Hogarth's dog Trump, based on an original terracotta model by the sculptor Louis-François Roubiliac (1702–1762), now in the V&A [16].

From the very inception of this Making London Porcelain project, our chosen case study for the Chelsea factory focused on one of the most significant pieces of early English sculptural porcelain, the Head of a Laughing Child. Only two examples are known. One, discovered in 1938 [17], held by the Ashmolean Museum since 1965 and once described by Nicholas Penny as 'the most celebrated piece of porcelain in the Ashmolean Museum' [18], and the second, discovered ten years ago and acquired by the V&A in 2019 with generous support from the Art Fund, V&A Members and funds from the Hugh Phillips and the Murray Bequest [19]. Both examples of *slipcast* porcelain, these artworks are testament to the artistic quality and sculptural ambition of the Chelsea factory during its earliest and most experimental phase, when they, just like Bow, were working to perfect the efficiency and quality of their production. For almost the full duration of this project the two busts were displayed side-by-side in a case dedicated to ceramic sculpture in the Ceramics Galleries at the V&A, which was fully accessible to all museum visitors [2]. Currently, the dating of the two Laughing Child busts is solely based on aesthetic value and the visual perception of the porcelain body. This project performed a comparative scientific analysis of the two busts for the first time. It also spurred academics, curators and professionals working in ceramic heritage to finally pay due attention to the materiality, attribution and art historical importance of these two unique busts [3].

Our chosen case study for the Bow porcelain factory focused on the celebrated collection owned by the Newham Borough of London. Fifteen pieces were removed from storage to play a central role in the project, and this also granted an opportunity for us to share our knowledge and resources with colleagues working across Newham Archives who are responsible for the day-to-day management of the collection [4]. In order to shine a greater light on this little-known collection, a range of ornamental and functional pieces were chosen, including sculptural busts, candlesticks, sugar bowls and an inkwell, many of which underwent scientific testing (Figure 3), played a key role during object handling workshops, inspired the project's remaking practices, and ultimately provided the thematic content for our co-curated exhibition entitled *Making East London Porcelain*, held at Stratford Library in June 2022.

Figure 3. Scientific analysis of a Bow porcelain inkwell from London Borough of Newham. Photography: Valentina Risdonne.

2. Materials and Methods: '*Without Science Art Cannot Be Successful*'

Three non-destructive scientific analysis techniques were used for the examination of the objects: micro X-ray fluorescence (μXRF), Raman microscopy, and digital microscopy. The aim of the analyses was to broaden our understanding of the materials and techniques used to produce early forms of porcelain at Chelsea and Bow and provide key chemical insights to help direct the public engagement programme.

μXRF and Raman were selected to provide elemental and molecular information, and digital microscopy was intended to evaluate surface features prior to analysis. Chemical information would inform our work in estimating the original ingredients, and the possible recipes that were followed. In turn, this may allow us to follow the development of the porcelain-making technique in the various factories.

μXRF analysis was performed using a Bruker Artax 800 equipped with a rhodium X-ray tube. The experimental conditions were set at 50 kV, 600μA, 100 s live time and working distance of 12 mm. The instrument was operated in an air environment which provided an elemental detection range of between Al (Z13) and U (Z92). The area examined in each experiment was approximately 100μm in diameter. Three spot analyses were taken on the flattest areas of paste and glaze of each object, with each analysis taken in a different region.

Bruker Artax 7.2.0.0 software was then used to identify the elements within each sample and calculate elemental peak areas. An empirical calibration, using primary and secondary glass and porcelain reference standards comprising of a span of concentrations common to Chelsea and Bow porcelain bodies and glazes, was performed in order to convert elemental peak area data into approximate oxide weight percentages [5]. Details on the standards and regression data are presented in Table S1. An initial XRF screen of the glazes indicated they were of a high lead type. This was important to note as it meant that surface analysis was restricted to around the top 50 μm [20]. As English leaded glazes generally have an average thickness of around 350 μm (varying from 170 to 1300 μm depending on shape) [21], we could be confident that results were limited to the glaze and did not reflect the body composition beneath.

A Horiba XploRA Raman spectrometer equipped with three diode lasers (532, 638 and 785 nm) and an Olympus microscope was used, although only the 532 nm laser was employed for the experiments in this study. The ×50 objective was used, providing an overall magnification of 500. The power at the sample was always kept below 25 mW. Total accumulation times varied between 30 s and 5 min, and no spectral manipulations were used. The laser was focused on the surface of the objects first, and then the glaze was depth-profiled until the laser reached the underlying porcelain body (usually within 130 mm from the surface). This ensured that the composition of the body could be investigated even if no areas of damage (exposing the body under the glaze) were present. Two unglazed Bow porcelain wasters were also analysed, providing direct access to the composition of porcelain bodies.

Digital microscopy was performed with a benchtop Hirox HRX-01digital microscope with an H-2500E lens (×20–×400 magnification). The Hirox microscope was used by the scientists to evaluate the characteristics of the surface of the objects before the analysis. It also featured prominently during the pupils' workshops, providing them with first-hand experience with the examination and evaluation of museum objects, and was used to elucidate specific points about the manufacture and characteristics of porcelain.

3. Results

3.1. XRF Analysis

The results are presented in Figure 4 and Figure S1 as XRF spectra, and Table 2 as average oxide percentages.

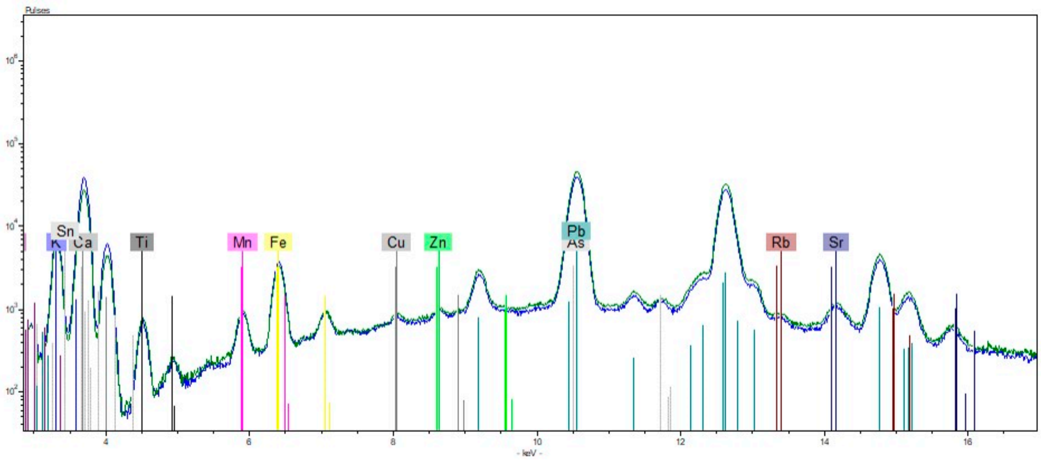

Figure 4. XRF spectra of representative body analyses from WA1965_8 (blue line) and C.37-2019 (green line), logarithmic view.

Table 2. XRF analysis of Chelsea and Bow bodies and glazes expressed as average weight oxide percentages. -, below detection; –, nq, present but not quantified due to peak deconvolution issue within the software.

Object No.	*Description*	*Date*	*Factory*	*SiO_2*	*K_2O*	*CaO*	*Al_2O_3*	*FeO*	*P_2O_5*	*TiO_2*	*MnO*	*CuO*	*CoO*	*NiO*	*ZnO*	*SrO*	*ZrO_2*	*SnO_2*	*PbO*	*SO_2*
Porcelain bodies																				
WA1965_8	*Laughing Child*	1746-52	Chelsea	61.1	4.6	10.0	0.6	0.3	-	0.1	0.1	0.6	-	-	0.2	-	0.01	-	10.7	-
C37-2019	*Laughing Child*	1746-50	Chelsea	52.1	3.3	6.7	0.5	0.3	-	0.1	0.1	0.6	-	-	0.03	-	0.01	-	8.3	-
PROV466-2022	Shell salt	c. 1747-49	Bow	44.6	0.7	29.2	7.1	0.4	22.8	0.2	0.1	0.6	0.04	0.02	0.03	0.1	0.002	-	<0.01	nq
PROV467-2022	Pickle dish	c. 1747-50	Bow	48.1	1.2	33.1	6.8	0.4	24.1	0.3	0.1	0.6	0.05	0.02	0.03	0.1	0.01	-	<0.01	nq
PROV469_1	*Tamerlane* bust, male	c. 1750	Bow	63.6	0.9	31.6	9.3	0.5	29.1	0.3	0.1	0.6	0.03	0.01	0.03	0.1	0.007	-	<0.01	-
PROV.475:1-2022	Waster	c. 1750	Bow	57.8	1.9	27.4	4.7	0.4	26.1	0.2	0.1	0.6	-	0.01	0.03	0.1	0.004	-	<0.01	-
PEM.16705	Lion figure	c. 1750	Bow	57.6	2.0	25.1	7.3	0.4	28.2	0.2	0.1	0.1	-	0.04	0.04	0.1	0.004	-	<0.01	-
Porcelain glazes																				
WA1965_8	*Laughing Child*	1746-52	Chelsea	40.5	2.1	3.0	1.6	0.1	-	0.004	0.1	0.6	-	-	-	-	-	3.8	41.5	-
C37-2019	*Laughing Child*	1746-49	Chelsea	45.6	2.6	4.6	1.6	0.2	-	0.03	0.1	0.6	-	-	-	-	-	2.0	40.0	-
PROV466-2022	Shell salt	c. 1747-49	Bow	41.5	0.8	2.2	2.1	0.1	2.4	0.01	0.1	0.6	-	-	-	-	-	-	52.7	-
PROV467-2022	Pickle dish	c. 1747-50	Bow	44.3	1.0	2.3	2.4	0.1	2.4	0.01	0.1	0.6	-	-	-	-	-	-	57.3	-
PROV469_1	*Tamerlane* bust, male	c. 1750	Bow	42.9	1.6	1.7	1.9	0.1	0.7	0.02	-	0.6	-	-	-	-	-	-	44.1	-
PROV469_2	*Tamerlane* bust, female	c. 1750	Bow	48.0	1.8	2.1	2.4	0.1	1.3	0.01	-	0.6	-	-	-	-	-	-	53.0	-
PEM.16705	Lion figure	c. 1750	Bow	49.7	2.1	2.2	1.9	0.1	-	0.01	-	0.6	-	-	-	-	-	-	54.2	-
PEM.16706	Lion figure	c. 1750	Bow	52.1	1.7	2.6	0.9	0.1	0.03	0.02	-	0.6	-	-	-	-	-	-	58.4	-
PEM.LDLHA A0001/4017	Lion figure	c. 1750	Bow	48.9	2.5	2.4	1.3	0.1	-	0.01	-	0.6	-	-	-	-	-	-	52.0	-
PROV.463-2022	Ink pot	c. 1750	Bow	47.2	2.1	2.0	1.1	0.1	1.01	0.02	-	0.6	-	-	-	-	-	-	52.3	-
PROV.468:1-2022	Ink pot lid	c. 1750	Bow	51.9	2.3	2.0	2.5	0.1	1.42	0.02	-	0.6	-	-	-	-	-	-	59.8	-
PROV.468:2-2022	Bowl	c. 1750	Bow	48.9	2.1	2.3	1.9	0.1	1.13	0.02	-	0.6	-	-	-	-	-	-	55.2	-

3.1.1. Chelsea, Head of a Laughing Child Sculptures

The bodies of both *Laughing Child* sculptural busts were found to have the same range of elements and in consistent proportions. This is illustrated in Figure 4 by representative XRF spectra from each object that feature a similar spectral pattern. Average compositions were in the region of 52–61% SiO_2; 7–11% CaO; 8–11% PbO; ~4%K_2O; <~1% Al_2O_3, CuO and FeO; and trace levels (<~0.01%) TiO_2, MnO and ZrO_2 and SnO_2. Zinc was detected at trace levels in the V&A example (<0.1% ZnO) and trace-to-low levels (0.1–0.5% ZnO) in the Ashmolean example, with the higher levels likely due to derive from residual restoration material, such as zinc white, on crack lines adjacent to the target area.

The compositional data were in good agreement with previous analyses of early Chelsea glassy porcelain dating to 1745-1750 which have significantly higher lead content (4–10% PbO) and lower lime content (8–13% CaO) than later raised anchor and red anchor pieces dating to 1755-1765 (at around 2% PbO and 21% CaO) [22,23]. In comparison with previous SEM-EDS and XRD analyses [22], the results indicated that a mixture of quartz sand, ball clay and crown glass (lime, lead oxide and potash) were used as the principal raw materials, giving an overall lead–alkali glass content of around 25–35%.

The glazes on both objects were of a high-lead type with around 41–46% silica (SiO_2), 40–42% lead (PbO), 3–5% lime (CaO), 2–3% potash (K_2O), 1–2% alum (Al_2O_3), 2–4% tin (SnO_2), and less than 1% FeO, MnO, TiO_2 and CuO. The high lead formulation was consistent with previous analyses of early Chelsea which recorded lead in the region of 44% PbO [21]. The presence of tin in the glazes on both sculptures indicated cassiterite was added as an opacifier to create a whiter tone to the glaze. Although tin was not found in previous work on Chelsea, it had been detected in other high lead glazes on English porcelains at the same levels observed on the sculptures, such as those produced at Longton Hall, and inconsistently on bone ash porcelains at Bow, Worcester and Vauxhall [22].

The enamel decoration on the Ashmolean's *Laughing Child* sculpture was analysed in order to help understand if the decoration was applied at the same time as the body and glaze, or applied at a later date. Results showed the pink enamels on the cheeks and lips consisted of iron, a common eighteenth-century pigment used in red, orange and pink enamels and typically produced from iron ore, such as hematite (Fe_2O_3), magnetite (Fe_3O_4) or iron sulphide (FeS_2) [24–26]. The purple/brown enamel decoration depicting the hair was found to consist of manganese, iron, copper, gold and tin. The presence of iron and manganese was indicative of the calcined pigment, Burnt Umber, which was commonly used in the manufacture of brown porcelain enamels. The presence of copper may indicate toning with copper oxide green. Gold and possibly tin were also detected, which suggested the use of purple of Cassius, a pigment developed in the late seventeenth-century by Andreas Cassius prepared from a precipitation of a mixture of gold trichloride and tin salts [24,25,27].

3.1.2. Bow Porcelain

The bodies of the Bow objects were all found to be phosphatic with average compositions in the region of 45–63% SiO_2; 25–33% CaO; 23–29% P_2O_5; 1–2%K_2O; <~7% Al_2O_3; <1% FeO, TiO_2, CuO and MnO; and <0.01% NiO_2, ZnO, PbO and ZrO_2. The bodies of the shell salt and pickle dish also had trace levels of cobalt and arsenic.

Quantified results were in good agreement with previous analyses of Bow bone ash porcelain dating to 1750–1760 which have on average 45–50% silica (SiO_2), ~24% lime (CaO), 16–19% P_2O_5, 6–9% alum (Al_2O_3) and ~1% K_2O [21]. The cobalt and associated nickel and arsenic found in the dishes, in combination with iron impurities in the clay, may have accounted for the 'mushroom' tone of the paste.

In comparison with the two Bow patents, the results here strongly correlated with Frye's patent of 1749. The patent described the use of 'virgin earth' as a flux, consisting of 'all animal substances, all fossils of the calcareous kind, such as chalk, limestone . . . ', which was calcined, ground and mixed with sand or ground flint pebbles and fired to make a lime alkali glass [21]. The glass was then ground and mixed with pipe clay in a ratio of 2:1. 'Virgin earth' is widely interpreted as calcium phosphate deriving from calcined animal bones, which is supported by previous analyses of Bow porcelain dating to this period [22,28]. The presence of sulfur at around >1–2% SO_3 in the salt and pickle dish reflected the addition of gypsum or alum to the paste [6]. This correlated with results from the analytical study of Bow porcelain pastes by Ramsay and Ramsay (2007) [21] who identified five compositional groups relating to the second patent output that can be separated by date (c. 1746; c. 1747-53; c. 1754; c. 1755-69; c. 1770-74), with all but one group (c. 1747-53) including the addition of gypsum or alum. The absence of sulfur in the *Tamerlane* bust, waster, and lion figure, correlated with analyses of objects from the second group ('New Canton', c. 1749-53), thereby supporting the assigned date of these objects to circa 1750.

The glazes applied to the Bow objects are broadly consistent, with on average 42–52% SiO_2, 44–59% PbO, ~2% CaO, 1–2% P_2O_5, 1–2% K_2O, ~2% Al_2O_3, <1% FeO and CuO, with the addition of <0.1% MnO in the salt and pickle dish. This was in good agreement with previous analyses of Bow glazes by Ramsay et al. who found that over a thirty-year period, lead gradually decreased from 44–58% PbO in the Developmental period (c. 1742-1743) to 40% PbO in the Tidswell period (1770–1774) [22,29]. Throughout this time, potash steadily rose from 1% to 4% K_2O. Tite and Bimson further found that Bow glazes dating after 1755 had the addition of tin at around 2% SnO_2 [22]. The lead and potash contents and absence of tin in the Bow glazes analysed in this study, therefore, fit well compositionally with objects dating to the Defoe/New Canton period (c. 1744-1753) which further supported their assigned dates.

3.2. Raman Analysis

Only some of the Bow objects were analysed, as the two Chelsea heads were too large to fit under the Raman microscope. A selection of relevant Raman spectra collected during this study is shown Figure S2, and additional references can also be found in the literature [28,30–34].

The similar results obtained from the Bow salt cellar (PROV.466-2022), inkwells (2864-1901 and PROV.463-2022) and pickle dish (PROV.467-2022) confirmed their common factory provenance. Unsurprisingly, the two Bow wasters were also similar to one another (PROV.475:1-2022 and PROV.475:2-2022).

The Raman experiments detected the presence of a form of calcium phosphate, various silicates and aluminosilicates, two silica polymorphs, and rutile, the most common natural form of titanium dioxide. The detection of rutile was significant, as it is indicative of a high temperature of firing: anatase, another form of titanium dioxide, is a naturally occurring impurity in kaolin clays, and above about 800–900 °C in the kiln is converted into the high-temperature stable form of rutile.

The wasters also occasionally showed the presence of broad carbon bands; this was likely caused by the deposition of soot from the burning of organic matter in the kiln.

The Raman data, combined with XRF evidence, strongly suggested that the Bow porcelain examined was phosphatic and contained a significant amount of lead glass. The presence of mullite and cristobalite in the Raman spectra indicated that the objects would have been fired at a high kiln temperature (>1200 °C). Unsurprisingly, the Raman bands were rather broad due to the contributions of several key minerals with fundamental bands of similar energy.

The powerful combination of μXRF and Raman provided key insights into the materials, recipes and firing conditions used to produce these early examples of English porcelain, and by cross-referencing with previous analytical studies and early patents, were able to reaffirm the art historical assigned dates. These key findings were then fed directly into the public engagement programme including remaking workshops, handling sessions and interpretative material for the exhibition design.

4. Discussion

Public Engagement: 'Please Make the Bow Porcelain Factory 2.0'

Students from Harris Chobham Academy and Cardinal Vaughn Memorial School, alongside intergenerational local communities from London Borough of Newham, participated in making, curatorial and scientific workshops in May and June 2022 (see Figure 5).

Figure 5. Students testing historic porcelain recipes at V&A. Photography: Grace Santry.

The programme began with 20 art and science sixth-form students attending a day-long workshop at the V&A. Of the students travelling from East London, only two out of the ten students had visited the museum before. Students visited the labs and were involved in setting up and viewing the results of X-ray fluorescence taken on a Bow Porcelain pickle dish with Burgio. The results were presented to the pupils qualitatively. The students were shown spectra and instructed on the type of information that can be obtained from scientific experiments; the implications of the results were evaluated, and there were discussions on the relationship between the scientific analysis data and the porcelain composition and manufacturing processes. Students were able to handle objects from the London Borough of Newham's collection and learn about the history of London's early porcelain manufacturers with McCaffrey-Howarth. Finally, they took part in a remaking workshop where they tested porcelain recipes developed by Haseldine based on the scientific findings of Burgio and Domoney, and practiced using plaster press moulds made from Bow porcelain objects by Haseldine (see Appendix A).

Several weeks later, once their test tiles had been bisque fired, glazing and curating workshops were held at their schools, facilitated by Haseldine and McCaffrey-Howarth. These workshops were crucial for understanding how the students wanted to represent their historical, material, and scientific investigations. They also worked on how to present the scientific findings of Burgio and Domoney to the general public. For the students from Harris Chobham Academy in Newham, their exhibition went on to be installed at Stratford Library, entitled *Making East London Porcelain*. Their colleagues at Cardinal Vaughn Memorial School held their exhibition in the school assembly hall. As part of the exhibition at Stratford Library, two emerging practitioners, Maria Dragoi and Astrid Walker, were commissioned to respond to the scientific, material and historical research into the Bow Porcelain project. Their final piece titled *Investigations into Material Geographies*, *Exploring the Colonial Legacies of Unaker* sat within the display curated by students from Harris Chobham Academy (Figure 6).

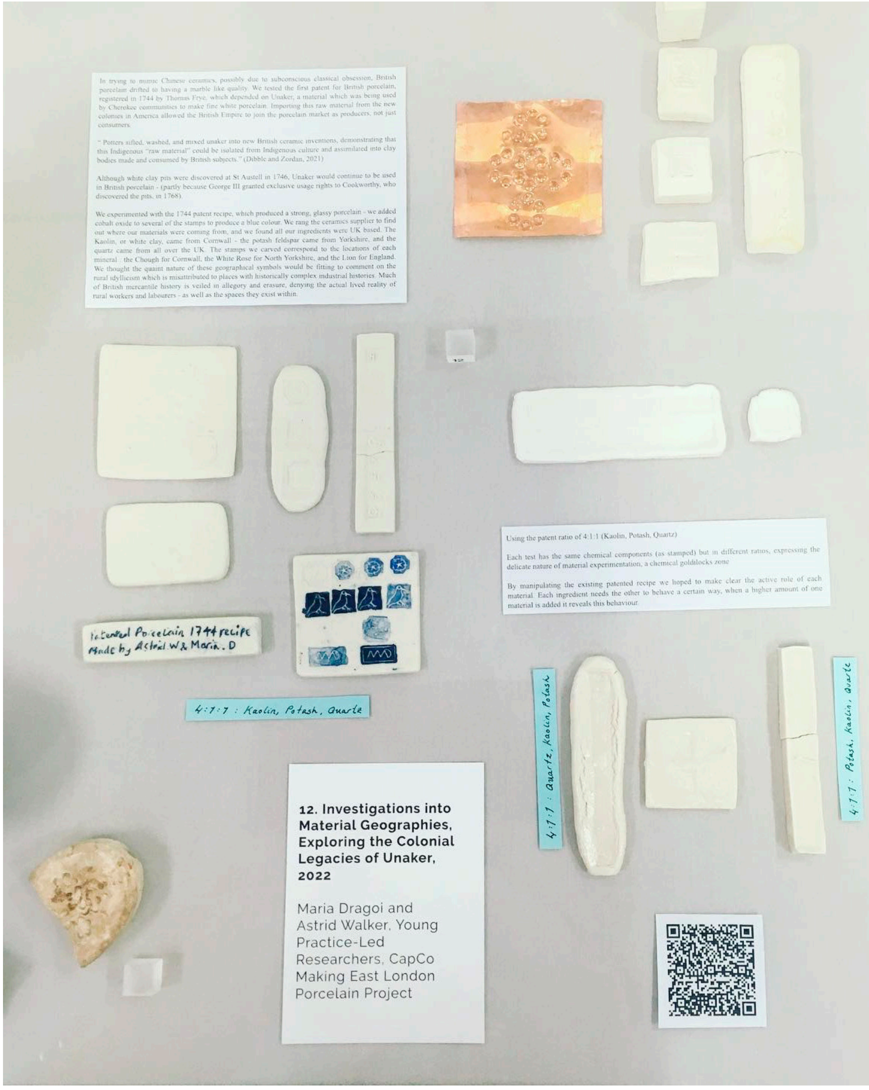

Figure 6. Investigations into Material Geographies, Exploring the Colonial Legacies of Unaker by Maria Dragoi and Astrid Walker. Photography: Georgia Haseldine.

In June, hundreds of local residents encountered the exhibition in the bustling community hub of Stratford Library (Figure 7). In addition, 51 individuals attended a talk and handling session, providing them with a physical connection to their ceramic heritage. At Cody Dock, 63 attendees joined porcelain-making workshops where they also learned about the role of the River Lea in the Bow Porcelain Factory's trading success.

Figure 7. Handling session at Stratford Library, 2022. Photography: Keith Martin.

The key findings from these outreach activities related to the public perception of science in the museum, the role of remaking in communicating scientific research and technical skill, the sensorial and intellectual importance of handling, and the power of curation to give voice and space to young people minoritized by society. The presence of scientists and labs within a museum of art, design and performance was a surprise to all of the students we worked with (Figure 8). When asked if they thought if scientists worked in the museum, all the students replied negatively. The perceived separation of art, technology and science that is perpetuated in the secondary education system was carried by the students to their first workshop at the V&A. Of the students studying science A-Levels, six out of the ten expressed their desire to learn more about careers in heritage science. This is also a call to action that museums should be showcasing the work of heritage scientists in permanent displays, rather than their work taking place behind closed doors.

Figure 8. Students in the V&A Science Laboratory. Photography: Grace Santry.

The remaking workshops proved popular for both the sixth-form students and local communities. They were designed as a practical way for the new scientific understanding of the material composition of Bow and Chelsea porcelain to be communicated and understood. Many participants had never considered the materials that comprise porcelain or bone china. Indeed, the use of animal bone ash in ceramics was shocking for almost all participants. Many reported interest in how circular economies today could be inspired by the use of waste products to make useful domestic wares. The labour and skill needed to create one's own soft-paste porcelain and the complexity of using press moulds was also revelatory. In fact, the practice of making one's own porcelain is only rarely engaged with by even the most experienced ceramics artists. The workshops format encouraged a greater understanding of the scientific and chemical composition of the clays (Figure 9). This process also invited experimentation. One popular experiment was the addition of small quantities of cobalt oxide to the clay bodies to emulate the characteristics of early 'mushroom tone' Bow Porcelain. The thrill of learning a new skill led one student to ask: 'Please Make the Bow Porcelain Factory 2.0′.

Figure 9. Young boy learning to mix historic porcelain recipe. Photography: Keith Martin.

Handling sessions facilitated a rare opportunity for audiences to engage in a sensorial and material encounter with the fifteen pieces of Bow porcelain. As Glenn Adamson and others have noted, the ability to cultivate and strengthen one's material intelligence and literacy enables us to engage in a tangible manner with heritage [34]. Conversations emerged surrounding their craftmanship and their patina, whose hands had these pieces already passed through during the last two centuries? How did the porcelain feel, were the objects weighty, light, rough, smooth, soft or creamy? What would they have been used for? And what can be gained from a closer examination of the colours and glazes?

Throughout all of our *Making London Porcelain* workshops, we encouraged participants to think carefully about the stories that could emerge from these ceramics: from their meaning, value and function, to their journey from East London where they were produced originally, to the fact that they have now travelled back home to Bow, where they are owned by Newham Borough of London, but unfortunately in storage due to lack of display space. Some of these pieces were especially fascinating, including a rare pair of busts, thought to depict characters in the play by Nicholas Rowe (1674–1718), *Tamerlane*, published in 1702. The tragedy tells the story of Timur or Tamerlane (*r*. 1370–1405), Emperor of the Tartars, falling in love with the Sultan's daughter (Figure 10). In a performance in 1751 at the Theatre Royal, Covent Garden, the female lead of Aspasia was played by Peg Woffington (1720–1760) [35]. Interestingly, these objects were not modelled in the round such as for the Chelsea Laughing Child Heads, and would have been displayed instead on mantlepieces or wall pedestals. Objects such as these enabled us to think together about larger ideas of celebrity and the function and cultural value of porcelain during the mid-eighteenth century in London. They also revealed wider questions about stereotypical racial representation and its homogenous portrayal in English ceramics. In particular, a Bow porcelain sugar bowl, with a sculptural allegorical, naked figure of Africa was another object that we selected to discuss and handle with students (Figure 11). This choice was informed by the desire not to hide the complex, global systems of trade and exploitation which ceramics production actively participated in. Sugar, a product which was only made possible by the massive importations and labour of enslaved people, was typically added to sweeten drinks and food by Western consumers during the eighteenth century [36]. Sugar bowls such as this would have sat on the table during dinner in wealthy homes in Britain. This historical context enabled students to connect this object to structural racism today, whilst drawing on their knowledge of the transatlantic trade in enslaved people. As one student observed: ‘we can’t change our past, so it’s important that we talk about it’.

Figure 10. Bow Porcelain Factory busts of Timur and Aspasia. Photography: Georgia Haseldine.

Figure 11. Sugar bowl handled by students at V&A museum. Photography: Grace Santry.

An interrogation of the complex histories of these decorative art objects also enabled all participants to fully understand the history of the Bow and Chelsea porcelain factories and situate these firmly within a wider socio-cultural context. A new appreciation also emerged for their own local neighbourhoods, notably London's strong economic and creative position at the centre of eighteenth-century global trade, specifically, the Bow or 'New Canton' factory. Insurance policies show that by 1760, Bow was a large-scale operation, with 300 employees, the factory building being modelled on 'that of Canton in China'. This marketing ploy to connect the manufacture of their wares with porcelain's origins in China also extended to the business referring to themselves frequently as 'New Canton' and was even branded on key pieces produced by the factory, including a fascinating inkwell dating to 1750, of which only six are still known. This fairly modern-day strategy resonated with the students and public alike. Reflecting on one of the Schools Workshops, one student advocated strongly that *Making London Porcelain* 'should be part of the history curriculum'. Similarly, feedback compiled from workshops during Newham Heritage Month indicated that the public relish any opportunity to engage more with London ceramic history. Ultimately, these fruitful discussions and observations provided rich curatorial interpretative material for the co-curated exhibition.

The students from Harris Academy Chobham relished curating the exhibition *Making East London Porcelain* which featured their work alongside fifteen pieces of Bow Porcelain from the London Borough of Newham's collection. The students divided the exhibition into three areas: material and scientific investigation; the global inspiration and reach of Bow Porcelain; and finally, a section on celebrity. This last section was sparked by an interest in the figure of a Bow porcelain boxer, and a quote from one student was enlarged to become a crucial part of the interpretation: 'Who was the boxer? What kind of person was he? Who was he interacting with?' Throughout the process of curating, the students wanted to find ways to stimulate discussion for visitors. They also took the Bow collection as their main inspiration for the look of the display which they based on the floral motifs on a small leaf pickle dish and the cobalt blue and white of the branded inkwell (Figure 12).

Figure 12. Exhibition at Stratford Library in June 2022. Photography: Caroline McCaffrey-Howarth.

The public engagement activities demonstrated how heritage science and remaking practices can help us better understand the places we live in today, and inspire us to innovate and experiment tomorrow. This resonated with the students we worked with, who stated that from ‘Learning about the Bow Porcelain Factory I now know that Newham has a great history and that we are part of a global history’. For one attendee at the Newham Heritage Month making workshops, they wrote in their feedback that they could ‘*now see how history connects to our modern-day community*’.

5. Conclusions

A group of local sixth-form art and science students stood in a circle in the airy space of the V&A Ceramics Gallery. The question was asked, ‘Who knew that museums had scientists?’ and for the most part, heads were shaken. This was a moment that encapsulated the *Making London Porcelain* project, whose main objective was to foster a better understanding of the links between science and art in order to deepen the knowledge of objects linked to London’s ceramic heritage. Ultimately, this was a pilot project, undertaken over six months, which included the analysis of a handful of objects and a finite number of outreach and public engagement activities. At its core, it intended to demonstrate the potential of a multidisciplinary approach, in order to create the blueprint for a larger scale science-based public engagement project. The pilot was successful: not only did it provide the opportunity for experts in their fields to interact and exchange knowledge, but it also unlocked public engagement opportunities.

First and foremost, the project provided an opportunity to open the doors of a high-end, museum-based scientific laboratory, the activities of which usually occur behind the scenes and far away from the public eye. It provided local communities with a taster of practical scientific research activities and curatorial approaches, and informed their knowledge of London’s ceramic heritage, linking the local to the global. The enthusiasm and spark shown by the students, carried through into their exhibition *Making East London Porcelain*, was testimony of the success of the project, and this alone should provide ammunition to expand such a project in future.

Furthermore, the interdisciplinarity at the heart of this public engagement project insisted that historically scientific understanding and technological skill were fundamental to the production of ceramic wares at the Chelsea and Bow porcelain factories. The project afforded participants the opportunity to fully embrace the symbiotic connections between science and art in the eighteenth century, as well as today. Additionally, students had the unique opportunity to refine their material literacy skills by embracing object handling and remaking practices, and engaging in careful scientific experiments which they united with their artistic skills as they produced their own porcelains, test tiles and sculptural forms. Today, perhaps more than ever, we need to consider if separating the two subject areas of art and science is seriously impeding innovation and creativity. Design and Technology is a crucial subject which offers a potential solution as it bridges STEM subjects with the creative and heritage industries, yet it has been in steep decline with the number of students taking the subject between 2010 and 2022 reducing by 71% at GCSE and 41% at A-Level [36]. As one student from Harris Chobham Academy summarised: ‘without science art cannot be successful’. If nothing else, *Making London Porcelain* has clearly enabled the participating students and their teachers to resituate the significance of London porcelain and its histories.

Overall, collaborative projects such as *Making London Porcelain* show us that through art history, heritage science and public engagement practices, we can continue to expand our knowledge of eighteenth-century London, where artistic innovation, creativity, entrepreneurship and scientific experimentation came together to create such innovative porcelain pieces. Much more than this, by opening up world-leading curatorial and scientific research to local communities and young people today, we can create meaningful change amongst all participants involved in the ‘two-way street’ of public engagement practice.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/heritage6020105/s1, Figure S1. Additional XRF spectra; Figure S2. Selected Raman spectra; Table S1. Composition of XRF standards and regression analysis data.

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

Appendix A. Making Bow and Chelsea Recipes

Recipes based on scientific analysis, used during the 'making' workshops. These materials are dangerous: make sure you are wearing gloves and a dust mask.

- Bone ash—calcium phosphate derived from calcined animal bones;
- Potash feldspar—mineral derived from decomposed granite which is used as a flux;
- Ball clay—very fine particle sized clay, named after the 30 lbs 'balls' it was shaped into in Dorset for transportation, which is a 'secondary clay' formed into deposits from eroded granite rocks;
- Alkaline frit—ground glass;
- Kaolin—clay high in alumina, named after *kao ling*—high mountains—it is a 'primary clay' washed from the rock face with water;
- Quartz—a natural crystalline silicon oxide;
- Flint—a natural silicon oxide, but not as pure as quartz;
- Flux—an oxide that lowers the melting point of a glaze and helps a clay body vitrify.

Heylyn and Frye's 1744 patent

- 40 g kaolin;
- 10 g potash feldspar;
- 10 g quartz.

Bow 'New Canton' porcelain, 1749/1750

- 15 g ball clay;
- 15 g quartz;
- 28 g bone ash;
- 2 g high alkaline frit;
- Optional: 0.01 g cobalt oxide.

Chelsea 'Glassy'

- 30 g ball clay;
- 7.5 g quartz;
- 6 g flint;
- 6 g high alkaline frit;
- 3 g potash feldspar.

Notes

[1] This work and the scientific analysis would not have been possible without the excellent work conducted by Dr Valentina Risdonne and Dr Lucia Noor Melita in the V&A Science Lab.

[2] We are especially grateful to Matthew Winterbottom, Curator of Sculpture and Decorative Arts at The Ashmolean Museum for helping to facilitate this loan.

[3] Two key events were held as part of this discussion, including a Knowledge Sharing Workshop and Discussion Group at the V&A in May 2022, and a Public Lunchtime Lecture at the V&A in November 2022.

[4] London Borough of Newham, see also ref. 12 by Gabszewicz.

[5] As surface topography was not always completely flat, quantified results are used as an indication or approximation of concentration.

[6] Estimated sulfur content based on comparison of the SKα peak areas with those in glass standards Corning A and Corning B (which have similar levels of lead to the porcelain) due to issues with Artax software deconvoluting SKα lines and PbMα lines.

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