THE TRANSMISSION OF TECHNICAL KNOWLEDGE IN THE PRODUCTION OF ANCIENT MEDITERRANEAN POTTERY

Proceedings of the International Conference at the Austrian Archaeological Institute at Athens
23rd–25th November 2012

Österreichisches Archäologisches Institut
Sonderschriften Band 54
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POTTING SKILL AND LEARNING NETWORKS IN BRONZE AGE CRETE

ABSTRACT

Much is known about the potter’s wheel in Bronze Age Crete, but less well developed remains our understanding of how pottery production was organized locally, how skills were acquired, advanced, and transmitted, and how interaction between different potting communities was structured. Using experimental archaeology, ethnographic case studies, cognitive psychology, and macroscopic analyses of Cretan Bronze Age pottery, this article makes a first tentative attempt to explore how Cretan Bronze Age potters learned to use the potter’s wheel and expanded their skill set through time. Based on the homogenous application of forming techniques across the island, it will be argued that Cretan potters constituted a highly interactive “community of practice” where regular sharing of knowledge resulted in common potting practices and a common understanding of how a particular shape should be conceptualized.

INTRODUCTION

Thanks to work by S. Xanthoudides and D. Evely¹, we have a detailed list of evidence for turning devices, including bats, supports, pivot sockets, and wheel heads (fig. 1). The design and throwing capabilities of the potter’s wheel have been clarified following experimental work by Evely, Politakis, Morrison, and Park². Their research found that, because the light wheel head could not store momentum for long periods of time, the wheel could act as a fast rotating device only to raise small- to medium-sized pots. In addition, the wheel could serve as a turntable-like device to assist with coil building larger vessels. While the potter could work unaided, an assistant was desirable to maintain and regulate wheel speed (fig. 2). These observations mirror experimental work on potter’s wheels from the Levant and Egypt (fig. 3) that attained speeds of ca. 60–105 rotations per minute, sufficient for making small pots, and often requiring the aid of an assistant³. Contemporary Egyptian tomb paintings and later Archaic and Classical Greek vase paintings support these conclusions and invariably show potter’s wheels with a single large wheel head located close to the ground, either operated by the potter or by an assistant⁴. Larger and closed vases are formed by hand. No archaeological or pictorial evidence exists for a double or kick wheel in the Bronze Age that would have permitted the potter to develop fast, continuous rotation without the aid of an assistant.

In addition to wheel remains, the most overwhelming evidence for a rotational device comes, of course, in form of the characteristic “rilling” on the interior and exterior of vessels. The first appearance of “rilling” in Greece can be dated to the “Lefkandi I” and Tiryns cultures of the EH IIB and III periods and Lerna IV⁵, thus predating the appearance of the wheel on Crete. On Crete, fully wheel thrown pots make their first appearance during the MM IB period. However, initial experimentation with a rotating device can already be detected in EM III/MM IA, when rotative kinetic energy (RKE) was applied to part of a “combination” vessel allowing for its

¹ Xanthoudides 1927; Evely 1988; Evely 2000.
⁵ Wünsche 1977, 27; Rutter 1995; Choleva 2012.
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1: Chronological development of mats, bats, and wheel heads in Bronze Age Crete (after Evely 1988; Evely 2000)

base to be wheel thrown, while its walls were built up with coils and then lightly shaped on the wheel\(^6\). This observation correlates well with statements by a range of scholars\(^7\) who all refer to the existence of wheel-throwing features on pottery dated to EM III/MM IA, although Knappett considers the evidence too slim and ambiguous to detract from the MM IB watershed\(^8\). Day and Wilson have offered a helpful way to bring the existing evidence together and to allow for a more fluid development of this innovation by arguing that it is the »marked intensification of its use which is the significant point«\(^9\). Once introduced, wheel-thrown pottery becomes more popular over time. Evidence of wheel coiling also begins in MM IB (but note the above evidence of experimentation with a rotating device already in EM III/MM IA) and continues into the Late Minoan period. Handmade techniques also continue in use. Thus, the potter’s wheel – once utilized regularly – did not lead to an immediate replacement of handmade modes, but was incorporated gradually\(^10\).

Our knowledge of Cretan potters is based on evidence from 15 potential pottery workshops\(^11\) and 33 kilns found in palatial (e.g., Phaistos, Knossos, Zakros) and nonpalatial (e.g., Mochlos, Gouves, Zou, Kommos, Vathypetro) contexts dated between MM III and LM III\(^12\). More circumstantial evidence is provided by Linear B tablets and steatite prism seals\(^13\).

However, by far our best and most reliable evidence for Cretan potters comes from the pots themselves. Here, we have ample evidence that potters made clay vessels by using a variety of primary techniques: from purely handmade to fully wheel-thrown vessels, with an almost infinite variety of combination (multiple techniques are used on different parts of the vessel) and hybrid (a fusion of two or more methods) techniques in the middle\(^14\). The most common techniques are pinching, drawing, coiling, slab building, molding, wheel coiling, and wheel throwing (tab. 1), with each leaving behind unique physical attributes that can be identified by visual inspection\(^15\). If the skill of the potter is such that no obvious traces of the primary forming technique remain, or if secondary forming techniques obliterated all primary attributes, then scientific techniques such as x-radiography, optical microscopy, or thin-section analysis can provide answers\(^16\).

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\(^{6}\) Berg 2009, 146 no. 1.


\(^{8}\) Knappett 2005, 156.


\(^{10}\) See also Betancourt 1985; Betancourt 1990; MacDonald – Knappett 2007; Knappett 1999.

\(^{11}\) Hansen Streily 2000.

\(^{12}\) Hasaki 2002.

\(^{13}\) Traunmüller 2009, 56–62.

\(^{14}\) For general overviews, see Rice 1987; Rye 1981.

\(^{15}\) For differences in archaeologists’ expertise, however, see Berg 2009, 165 f.

Table 1  Characteristics of common handmade and wheelmade forming techniques (general: Rice 1987; Rye 1981; wheel coiling: Courty – Roux 1995; Roux – Courty 1998)

<table>
<thead>
<tr>
<th>Type</th>
<th>Name</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handmade</td>
<td>Pinching</td>
<td>Squeezing a clay ball between fingers and thumb, and then thinning the walls. Mostly used for small open vessels; can also be used to begin the base of larger vessels or as a finishing technique to even out walls.</td>
</tr>
<tr>
<td></td>
<td>Drawing</td>
<td>Starting from a lump of clay, the walls are pulled or squeezed upwards with the hands to create the desired shape. Frequently combined with coiling where coils are pulled up in stages.</td>
</tr>
<tr>
<td></td>
<td>Coiling</td>
<td>Rolls of uniform thickness are created and then used to build up the vessel shape. The pot may vary in wall thickness along the horizontal and/or vertical axis and coil seam junctures. Often combined with other techniques, such as drawing or wheel throwing.</td>
</tr>
<tr>
<td></td>
<td>Slab building</td>
<td>A vessel built up of joined flat slabs. Particularly suitable for large vessels.</td>
</tr>
<tr>
<td></td>
<td>Molding</td>
<td>A flat ‘pancake’ of clay is prepared and placed into a plain or decorated mold. As the clay shrinks away from the mold, it retains the desired shape.</td>
</tr>
<tr>
<td></td>
<td>Wheel coiling</td>
<td>Rotative kinetic energy (RKE) is applied to a vessel originally made of coils. According to Roux and Courty, RKE can be introduced at 4 different stages of the forming process. At its most basic, pots are made by coiling and then thinned or smoothed on the potter’s wheel. At its most advanced, a coil is added and ‘thrown’ (viz., ‘Thrapsano technique’). Common features mirror those of wheel-thrown pots, but are less continuous and regular.</td>
</tr>
<tr>
<td>Wheelmade</td>
<td>Wheel throwing</td>
<td>The potter’s wheel runs at speeds sufficiently high to develop RKE which is used by the potter to pull up and shape the clay with bilateral movements. Common features are concentric striations on the base, compression ripples near the neck, and regular undulating ridges (i.e., ‘rilling’) on the interior and/or exterior.</td>
</tr>
</tbody>
</table>
SKILL ACQUISITION IN BRONZE AGE CRETE: THEORY AND PRACTICE

Theory

As may be expected, different techniques require the development of different potting skills and take different lengths of time to acquire. Hand-building techniques, broadly speaking, are more similar to existing motor habits, such as baking, and can be mastered within one or two years\textsuperscript{17}. Wheel throwing, by contrast, requires a completely new set of skills that can only be developed over a long time period. Based on experiments with potters of different levels of competence and a control group of nonpotters, Roux and Corbetta\textsuperscript{18} were able to demonstrate that acquisition of the necessary skills is very time consuming: potters must master one stage before they can advance to the next level of difficulty. The authors estimated that it takes 10 to 15 years for an apprentice to become fully proficient. Biomechanical and physical constraints, as well as the opportunity for daily deliberate practice, ensure a long apprenticeship in wheel throwing. It is therefore of universal relevance to skill acquisition\textsuperscript{19}. Cultural differences may shape the social organization of an apprenticeship but do not substantially influence its duration\textsuperscript{20}. Wheel coiling is a commonly used set of hybrid techniques that combines coiling and wheel throwing at different stages of the forming process and hence occupies an intermediate stage in skill\textsuperscript{21}.

Concerning wheel throwing, Roux and Corbetta’s ethnographic and experimental work has demonstrated that progress in learning wheel throwing is expressed by an increase in pot size as the potter becomes more and more competent\textsuperscript{22}. Table 2 identifies the five skill stages in wheel throwing: Stage 1A includes vessels up to 0.03 m, with potters using only simple thumb/index finger pressure because they do not yet know how to center a lump of clay on the wheel. In Stage 1B potters have learned to apply simple pressure along with some vertical displacement. In Stage 2A the potters know how to throw with both hands in asymmetrical movements. Stages 2B (up to 0.20 m) and 3 (above 0.20 m) are characterized by competent centering of the clay and increasing vessel size. Stage 3 potters are the most experienced.

While progression from beginner to expert potter is primarily indicated by vessel height, there is far-reaching diversity among the most experienced potters reflected in the repertoire of shapes they are capable of producing. Through further experiments with modern Indian potters, Roux and Corbetta established a sequence of increasing difficulty in manufacturing wheel thrown pots above 0.20 m tall\textsuperscript{23}. They concluded that an advanced level of expertise is expressed in the relationship between pot height, diameter, and profile. Specifically, unrestricted vessels of any height are almost always easier to manufacture than restricted vessels. Within the category of unrestricted vessels, the difficulty increases when the base diameter becomes considerably smaller than the rim diameter. The difficulty is increased further when this development also entails a reduction in height. Restricted vessels are governed by the relationships of height, base, and rim diameter as well as widest diameter: the wider the body diameter in relation to height and base diameters, the more difficult the vessel is to manufacture (fig. 4).

\textsuperscript{17} Budden 2008; Roux – Corbetta 1989; see Cardew 1969 for a contrasting view.
\textsuperscript{18} Roux – Corbetta 1989.
\textsuperscript{19} For comparative studies on apprenticeship in the world of sports, chess, and the »10-year rule«, see Ericsson – Lehmann 1996.
\textsuperscript{20} Roux – Corbetta 1989, 88, 140–143.
\textsuperscript{22} Roux – Corbetta 1989, 40–90; see also Kamp 2001.
\textsuperscript{23} Roux – Corbetta 1989, 102–123; see also Gandon et al. 2011.
Table 2  Potting skill stages identified by Roux – Corbetta 1989

<table>
<thead>
<tr>
<th>Stage</th>
<th>Stage 1A</th>
<th>Stage 1B</th>
<th>Stage 2A</th>
<th>Stage 2B</th>
<th>Stage 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total vessel height</td>
<td>0.03 m</td>
<td>0.06 m</td>
<td>0.10 m</td>
<td>0.20 m</td>
<td>0.30 m</td>
</tr>
<tr>
<td>Skill acquired</td>
<td>Thinning by simple thumb/index finger pressure</td>
<td>+ some vertical or horizontal displacement</td>
<td>+ two-handed asymmetrical movement</td>
<td>+ competent centering of clay</td>
<td>+ larger quantities of clay</td>
</tr>
<tr>
<td>Type of pot made</td>
<td>Little fairy lamp</td>
<td>Big fairy lamp; small and large lids</td>
<td>Flower pots up to 0.10 m</td>
<td>Flower pots up to 0.20 m</td>
<td>Flower pots up to 0.30 m</td>
</tr>
</tbody>
</table>

Sequence of increasing difficulty when manufacturing restricted and unrestricted vessel shapes (after Roux – Corbetta 1989, 111). Difficulty increases from left to right. Numbers indicate rim diameter. To scale.

Development of handmade vessels in Bronze Age Crete. N = 292. Vertical lines indicate range, boxes indicate standard deviation.
Potting Skill and Learning Networks in Bronze Age Crete

Practice

While different sites follow different local trajectories throughout the Middle and Late Bronze Age, the overall impression is one of an analogous development across the island. The pattern that stands out most prominently is that each forming technique appears to have been applied with remarkable consistency to specific vessel classes. The categories are initially divided into handmade and wheelmade; the latter is subdivided further into wheel thrown and wheel coiled.

As expected, the category of handmade vessels covers the full height range. Mean heights vary between 0.025 and 0.54 m depending on the functions of vessels present in the catalogued assemblage. While handmade techniques are popular also among small vessels, the large standard deviation highlights the persistent use of handmade techniques for the whole range of vessel sizes, including the very largest shapes (fig. 5).

Wheelmade techniques involve the use of rotary momentum at an earlier or later stage of the forming process. This category thus incorporates both wheel throwing and wheel coiling. As few scholars distinguish between these two techniques, we have to consider the category “wheelmade” a mixed one. Wheelmade vessels are characterized by a mean height of around 0.06 to 0.07 m throughout all periods. Total vessel heights vary from 0.015 m for the smallest cup to 0.425 m for the tallest jug (fig. 6).

6 Development of wheelmade vessels in Bronze Age Crete. N = 1605. Vertical lines indicate range, boxes indicate standard deviation

This section is based on a synthesis and analysis of the author’s X-radiography study of Knossian pots (Berg 2009) as well as publications from Palaikastro (Knappett – Cunningham 2003; Knappett – Collar 2007), Knossos (MacGillivray 1998; MacDonald – Knappett 2007), Malia (Poursat – Knappett 2005), Zominthos (Traunmüller 2009), and Kommos (Betancourt 1990; Shaw et al. 2001) that include data on forming techniques. Data from Mochlos and Pseira could unfortunately not be included as assemblages were too fragmentary and forming technique was not, or was only inconsistently, recorded. As may be expected, the level of detail provided varies considerably between reports. For example, most scholars merely distinguish between handmade and wheelmade: thus the category of handmade may disguise a considerable variety of techniques, such as coil built, slab built, and molded, and the category of wheelmade does not differentiate between wheel throwing and wheel coiling. By contrast, Poursat – Knappett 2005 distinguish four distinct manufacturing types that combine hand building and wheel throwing (viz., Ia [wheel thrown], Ib [wheel coiled], Ia [coiled with the help of RKE], Ib [coiled with the help of rotary momentum]). The different datasets are therefore not fully comparable, although every effort has been made to standardize the information derived from them. To be included in this database, information on both forming technique and height had to be present. Imports (where indicated) were excluded from the analysis. Where a height range is provided for a vessel type, the average was recorded.

For a more in-depth look at Knossos, for example, see Knappett 1999. The Kommos dataset, for example, includes several large pithoi which skew the MM III data.
When distinguishing the two techniques that constitute the ›wheelmade‹ category, their respective height patterns become very distinct: wheel throwing is used for the smallest vessels only, with the mean height for both Knossos and Malia concentrated around 0.06 to 0.07 m. Only 3% of vessels are taller than 0.12 m; the tallest is only 0.192 m. The standard deviation is small, indicating that vessels cluster together tightly at similar (low) heights (fig. 7).

Wheel-coiled vessels have only recently begun to be identified in the Aegean. Where data exist, this technique always displays height values that fall between fully wheel-thrown pots and completely handmade pots. However, their position along this spectrum is different for each site: at Knossos they are more closely allied with wheel-thrown production but at Malia they resemble the handmade techniques. At Knossos, the mean height is around 0.05 m and the small standard deviation shows that most vessels clustered tightly around this low mean value – similar to our wheel-throwing production. There is only one MM IIB example from Knossos that is over 0.09 m in height. Large Knossian vessels appear to have been made using hand-building techniques (fig. 8).

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A contrasting pattern is visible at Malia, where the wheel-coiling technique is used to make large vessels. Here, the categories Ib (‘élaboration aux tour/ wheel fashioning’), IIa (‘fabrication aux columbins avec lissage à l’aide d’énergie cinétique rotative/coiled with help of RKE’), and IIb (‘fabrication aux columbins avec lissage à l’aide d’un movement rotatif/coiled with help of rotative momentum’) are all grouped together in our category ‘wheel coiled’\(^2\). Regardless of the terminology employed, the larger the vessel, the less rotary kinetic energy is applied and the greater the reliance on hand-building techniques. This observation is evident in the steadily increasing height of vessels from Ib to IIa to IIb. Thus, wheel coiling and related techniques (Ib, IIa, IIb) are predominantly associated with the manufacture of medium to very large closed vessels while wheel throwing is reserved for small open vessels (fig. 9).

Of particular interest are vessels that have been built up utilizing two or more forming techniques. For example, the lower 0.16 m of a jar at Kommos was wheel thrown, while the upper 0.28 m was handmade\(^3\). A similar observation has been made for a Knossian amphora in the British Museum collection. The bottom third (ca. 0.15 m) was wheel thrown, the middle section was coiled and drawn, and the upper third was coiled\(^4\). Two important points emerge from these examples. First, when the wheel is employed on these large vessels, it is utilized for the base and lower body section, which are comparatively easy to make. Second, the height of the wheel-thrown section is around 0.16 m, signalling that this was the height that potters could comfortably achieve, comparable to the heights recorded for wheel-thrown vessels from across Crete. For taller vessels, they employed combinations of techniques or straightforward handmade methods.

Drawing on the experimental work presented by Evely and his colleagues, it has become apparent that the design of the potter’s wheel limited its speed and momentum, and thus prevented the throwing of large vessels\(^5\). As a result of this in-built limitation, it would be inappropriate to assess the skills of Minoan potters according to the maximum wheel-throwing height as proposed in Roux and Corbetta’s experiments\(^6\). Such an approach would underestimate the potters’ achievements and only establish minimum skill levels. One point, however, is worth

\(^{28}\) Poursat – Knappett 2005.

\(^{29}\) Roux – Court (1998) presented four different methods within the wheel-coiling technique. These techniques can be distinguished through increasing use of rotative momentum at progressively earlier stages of the forming process. Category Ib equates to Method 4 – and possibly Method 3 – while IIa and IIb are comparable with Methods 2 and 1, respectively (see table 1).

\(^{30}\) Betancourt 1990, 108 no. 598.

\(^{31}\) Berg – Ambers 2011, 373 no. 6.


\(^{33}\) Roux – Corbetta 1989.
Ina Berg

emphasizing: because wheel coiling allowed manufacture in stages, it was an ingenious technique that produced medium and large vessels while utilizing the wheel within its limitations.

EXPLORING THE SOCIOCULTURAL CONTEXT OF SKILL ACQUISITION:
NEW AVENUES OF RESEARCH

Recent work by Budden\textsuperscript{34} on the settlement and cemetery assemblages of Dunaújváros in Hungary opens new avenues for exploration of skill in the Aegean context. Budden’s skill methodology incorporates all aspects of the manufacturing sequence, from clay preparation to forming, firing, and decoration, and assesses the degree of skill applied to each aspect. The methodology is based upon the assumption that the technological and visual aspects of every vessel type are produced to a certain skill standard. Using this concept as her starting point, Budden investigates to what extent potters were able to replicate this standard. Over- or underperformance against the standard provides information on manufacturer and consumer priorities, how skills are acquired, and how learning was structured.

At Dunaújváros, Budden observed that skill standards varied considerably depending on the type of vessel. Cups in both settlement and cemetery contexts indicated low skill investment, while fine wares displayed low skill in the cemetery assemblage but high skills in the settlement; a high degree of skill was utilized for urns in both contexts.

Budden interprets the observed patterns as follows. As cups are easy to make and were used in one-off drinking events, they did not require advanced skills and any failures in the production were inconsequential. Therefore, they made ideal learning objects for beginners. Fine wares are utilitarian objects that are technologically complex. In the settlement context, their function and prestige were important so they were made by expert potters. By contrast, because only their visual aspects were desired in the cemetery, advanced skills were only invested in the decoration; shape manufacture was in the hands of nonexpert potters. In most cases, urns were used as storage vessels before becoming burial objects: because they needed to perform functionally and visually, they were always made with great skill.

To test the potential of the skills methodology for Aegean ceramics, the author analyzed ca. 600 handleless cups from Phylakopi on Melos. The results are only preliminary and do not yet include a comparison with other types, but they demonstrate the value and great potential of the approach.

Melian handleless cups are made to a comparatively low skill standard at all stages of the manufacturing sequence (tab. 3). All cups, for example, show errors in clay preparation. Moreover, firing conditions do not exceed the minimum requirements for the cups’ short lifespan and functional requirements, and the lack of surface treatments or decoration indicates a lack of investment in visual aspects of the cup. Thus, their (low skill) production was perfectly suited to their functional and social requirements: none of the skills used in their manufacture exceeded the minimum requirements. In contrast, some imported conical cups (most likely from Kea) appear to have been produced to a much higher standard.

Despite an overarching impression of low skill investment, variation between different types of handleless cups can be recognized. Bell-shaped cups show the highest level of skill, followed by carinated cups and bowls; conical cups have the lowest skill investment. Interestingly, this skill sequence relates to average height, with taller cups displaying increasing skill levels. This progression mirrors the advancing skill-height relationship observed by Roux and Corbetta in their experiments with modern Indian potters\textsuperscript{35} (tab. 2).

Bell-shaped cups had to perform most closely to a particular vessel standard as is indicated by a narrowly defined rim and wall type. By contrast, conical cups show the greatest variation

\textsuperscript{34} Budden 2007; Budden 2008.

\textsuperscript{35} Roux – Corbetta 1989.
in base types, rim types, and wall types\(^{36}\). At this point it is impossible to determine whether the variability was the direct result of using apprentices for the manufacture of conical cups or whether the lack of an exact conical cup standard inevitably made this type the learning object for inexperienced potters. Regardless of the underlying cause, it is likely that potters progressed in their skill development from the least defined type to the most conceptually rigid pot.

**COMMUNITIES OF PRACTICE AND LEARNING NETWORKS**

Our meta-analysis of pottery from excavations across Crete showed the great homogeneity of practice – that is, an accepted ›way of doing‹ – that extended across the entire island during the Bronze Age. This desire by potters to conform to a particular tradition has also been noted in other case studies.

Van de Moortel studied the changing labor and skill investment in pottery manufacture visible in the Mesara and Knossos between the MM IIB and LM IA periods\(^ {37}\) (tab. 4). In the MM IIB period each region followed its own respective tradition: Mesara potters invested considerable labor and skill into both fine and utilitarian wares, while Knossian producers devoted much time and effort into fine wares but practiced a low-cost and low-skill approach for utilitarian wares. However, as time progressed, the Knossian cost-cutting and skill-poor approach spread from utilitarian wares to high quality wares and, more tellingly, this practice gradually infiltrated pottery production also in the Mesara. It appears that Mesara potters abandoned their meticulous traditional ways in order to adopt labor-saving strategies similar to those practiced at Knossos\(^ {38}\).

Another example of the progressive homogenization of practices is the adoption of specific wheel-coiling techniques on Bronze Age Crete\(^ {39}\). In the MM IB/MM II period, potters at Knossos, Palaikastro, and Myrtos Pyrgos utilized three or four different wheel-coiling techniques (see tab. 1). By LM IA, however, the techniques used had been reduced to one or two. Method 3, in

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\(^{36}\) It is unlikely that this pattern is simply due to sample size. While conical cups are the most numerous type, bell-shaped cups, carinated cups, and bowls are present in numbers that are not correlated with the above pattern.

\(^{37}\) Van de Moortel 2002.

\(^{38}\) Van de Moortel 2002, 204.

\(^{39}\) Jeffra 2011.
Table 4  Changing labor investment in coarse and fine ware pottery at Knossos and in the Mesara between MM IIB and LM IA (Van de Moortel 2002)

<table>
<thead>
<tr>
<th>Period</th>
<th>Mesara</th>
<th>Knossos</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine wares</td>
<td>Fine wares</td>
</tr>
<tr>
<td></td>
<td>Utilitarian wares</td>
<td>Utilitarian wares</td>
</tr>
<tr>
<td>MM II B</td>
<td>High investment</td>
<td>High investment</td>
</tr>
<tr>
<td></td>
<td>Reduced investment</td>
<td>Low investment</td>
</tr>
<tr>
<td>MM III</td>
<td>Further reduced investment</td>
<td>Further reduced investment</td>
</tr>
<tr>
<td>LM IA</td>
<td>Low investment</td>
<td>Low investment</td>
</tr>
</tbody>
</table>

particular, had taken over as the most common technique for the making of small, medium, and medium-large pots.

In both case studies, we are witnessing a progressive standardization of potting practices across the island over time. In the Mesara, potters gradually reduced their investment to emulate the low-cost and low-skill Knossian approach. At Knossos, potters who originally utilized multiple techniques converged upon one technique. Interestingly, these potters did not converge on the lowest skill denominator, but preferred Method 3 – a method that requires greater skill than Methods 1 or 2.\textsuperscript{40}

All the evidence presented hints at a high degree of communication within local potting workshops and between potters across the island. While not instantaneous, this communication nevertheless results in a very homogenous and unified approach to pot making across Crete. As we have examples both of skill reduction and skill increase, it is unlikely that skill-related factors were an immediate concern of potters. Instead, it seems that this gradual convergence was related to adhering to accepted ways of doing and the social expectations of how a pot should look or be made. In van de Moortel’s case study, the Knossian manufacturing style became the standard, resulting in Mesara potters adjusting gradually to Knossian practices. By contrast, no particular locality can be identified for the development of wheel coiling and it appears that the convergence towards Method 3 occurred simultaneously across the island. Thus, potting practices were governed by sociocultural rules and beliefs, rather than by economic or technological considerations. The example from the Mesara demonstrates that expectations of what a pot should look and feel like can change over time. Initially, it was of great importance that all pots – regardless of their function – were produced with care, skill, and high labor investment. However, over time it became acceptable to reduce energy and skill expenditure because the desire to comply with accepted island-wide traditions was greater than the pressure to adhere to local styles. Whether these adjustments were a consequence of consumer demand, producer desire, or other sociocultural dynamics and attitudes, remains to be explored.

Wenger has called these shared social experiences »communities of practice«. Communities of practice are united through the sharing of daily practice, learning, teaching, and knowledge which foster a common identity and meaning among members\textsuperscript{41}. This shared enterprise may be explicit, codified, and institutionalized, but more frequently it is tacit, assumed, and embodied. Whether explicit or implicit, the resulting outcome of this common experience will be a shared repertoire of motor habits, styles, stories, tools, actions, and/or concepts. Membership is therefore not dependent on social categories, age, gender, ethnic group, or colocation, but is created through mutual engagement.

As abundant ethnographic case studies have demonstrated, potters have ample opportunity to engage in shared practice as many stages of the manufacturing process require assistance, collaboration, or teamwork\textsuperscript{42}. These stages normally include clay selection, extraction, pro-

\textsuperscript{40} Jeffra 2011; Roux – Courty 1998; Courty – Roux 1995. By contrast, at Lerna IV Method 1 (i.e., the most simple method) is most popular (Choleva 2012).

\textsuperscript{41} Wenger 1998.

\textsuperscript{42} For an overview, see Rice 1987.
cessing, and firing. In addition, many techniques are clearly visible on the pot’s surface and can thus be understood and reconstructed by others. These techniques include tempering or mixing clays, secondary forming techniques, decoration, certain firing techniques, and most postfiring treatments. Less visible are primary forming techniques, especially when they have been obliterated by secondary forming treatments. In order for primary forming techniques to be shared, direct communication or even demonstration may be required. The more complex the technique, unfamiliar the motor skills, and extensive the use of (new) equipment or tools, the greater the need for hands-on demonstration, observation, and instructions.

Here, let us pause for a moment and remind ourselves what constitutes a ›forming technique‹. Being proficient in a forming technique requires two components to merge: ›knowledge‹ and ›know-how‹. Knowledge (connaissance) is an intellectual concept that can be passed on by means of words. By contrast, know-how (savoir-faire) is experiential learning that can only be acquired through doing43. The same distinction between information transfer (discursive knowledge) and bodily, performative knowledge (nondiscursive knowledge) is made by Budden and Sofaer44. Referencing Mauss’ concept of ›homme total‹ the authors argue that the human body becomes its own tool through skeletal, muscular, and neurological changes. Potters thus, literally, create themselves »through the act of potting«45. As apprenticeship is situated in a cultural milieu, motor skills therefore embody both corporal knowledge and sociocultural identities. The transfer of motor skills (i.e., savoir-faire or nondiscursive knowledge) therefore requires direct contact between teacher and learner, as demonstrated by Minar in relation to cordage twist direction46. The transfer of motor skills can be enduring, as demonstrated by Sandy Budden, a modern potter, who is right-handed but undertook her apprenticeship with a left-handed potter. As a direct result of her training, she has always made pots as if left-handed47. This example does not suggest that motor skills cannot be altered or superimposed with new skills. However, this process requires conscious effort and deliberate practice.

Although microlevel analysis of the underlying performative, bodily knowledge has not yet been undertaken in relation to Cretan Bronze Age pottery, the homogenizing trajectory of techniques and manufacturing practices hints at a high degree of communication and the sharing of technological information (i.e., connaissance or discursive knowledge) within and between potting communities in Bronze Age Crete. However, a shared intellectual knowledge base will not on its own result in these observed homogenizing tendencies. Instead, it is more likely that practical as well as verbal instructions generated the complex set of new bodily gestures that had to be acquired progressively over a long period of time, and thus also included the sharing of bodily knowledge (savoir-faire or nondiscursive knowledge). In fact, Anderson emphasizes that the efficiency of verbal communication reduces considerably when skills are predominantly of a practical nature48. The value of observation or hands-on demonstration over verbal instruction is also highlighted by Crown’s metastudy into the learning processes underpinning pottery making in 25 societies49. Therefore, although extensive communication among potters is highly likely, knowledge transfer must have had a considerable practical dimension. We can only speculate about the precise activities that permitted the exchange of motor skills. They probably included itinerant or seasonal potters, visits between potting communities (based on kinship ties, teacher-apprenticeship networks), or the movement of practitioners as a result of marriage.

43 Pelegrin 1990.
44 Budden – Sofaer 2009; Budden 2007; Anderson 1982; Anderson 1983; Anderson 1987 terms these stages ›declarative‹ and ›procedural‹, respectively.
47 Budden, personal communication 2012.
48 Anderson 1987, 204.
EXPLORING THE STIMULUS FOR NEW POTTING SKILLS

Having explored the transmission of existing skills, let us now turn to investigate the first appearance of a new skill or technique. The introduction of the potter’s wheel at Knossos was discussed by Knappett over a decade ago when he proposed that it can only be understood in light of its perceived Near Eastern origin, as part of wider social transformations in Minoan society around MM IB. He argued that the existence of attached specialist potters – quite possibly nurtured by skilled artisans from the Near East – enabled the aspiring Minoan palatial elites to associate with distant cultures and the symbolic capital that could have provided them with new means to consolidate and express authority. Kamares Ware, in particular, with its colorful and naturalistic designs, came to epitomize this initial period of technological change.

However, scientific investigations into the production and organization of Kamares Ware (as well as earlier research into EM pottery production), and a more nuanced understanding of architectural and administrative changes around the time of the emergence of the first palaces, throw doubt on the proposed relationship between the emergence of Minoan elites and the potter’s wheel. These changes hint at a more gradual development within the context of regional craft specialization, rather than a top-down approach by the palatial elites.

Over the last 15 years, researchers have recognized the existence of pottery specialists already in the Early Bronze Age. Macroscopic, chemical, and petrographic analyses of 2,000 vessels from EM IIB Myrtos Fournou-Korifi established that roughly half of the pottery was produced locally (South Coast tradition). The remaining ca. 50% were drawn from the Mirabello and Vasiliki traditions originating from the Isthmus of Ierapetra, located at a distance of ca. 20–25 km. These three production traditions consistently differ in fabric composition, shape specialization, forming techniques, finishing, and firing conditions, leading the researchers to identify producer specialization. In a separate scientific study by Day and colleagues of ca. 1,200 samples of EM I and II pottery from Eastern and Central Crete, the authors were able to place the results from Myrtos in a broader Cretan-wide context. Their analysis indicates that resource, product, site, and producer specialization already existed in the Early Minoan period – well before the emergence of the palaces and before the emergence of wheelmade pottery.

These production centers continued to exist independently of the palaces in the Protopalatial period, as recent work by Day and colleagues on Kamares Ware has shown. Originally, the contemporaneous emergence of the palaces, the potter’s wheel, and Kamares Ware, as well as the exclusive palatial distribution of Kamares Ware, allowed Cherry to argue for specialist production under the control of (and colocated at) the palaces of Knossos and Phaistos. However, recent discoveries and scientific analysis of Kamares Ware have led to a reassessment. First, it is now accepted that the distribution of Kamares Ware is less socially restricted than previously assumed, and includes private domestic contexts. Second, raw material sources, paste recipes, and the technical knowledge used demonstrate «a continuation of tradition of high-quality special ceramics going back to Prepalatial times», predominantly centered on the Mesara Plain. The scale of production may have changed as a result of the palace elites, but the location and organization of production did not.

The palace as innovator and prime mover for change has been questioned also by a more nuanced understanding of administrative and architectural developments. Work by Schoep, in

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54 Cherry 1986, 35–38.
55 Van de Moortel 2002, 204; Day et al. 2006, 32.
57 Driessen et al. 2002.
particular, has highlighted the existence of a (possibly uniform) administrative system that was based on direct object sealings and noduli already in EM. Use of Linear A and hieroglyphic scripts, in contrast, is connected with palatial activities, but the coexistence of different scripts at a single site argues against a top-down process for its introduction\textsuperscript{58}. Similarly, the existence of ambitious building programs at Knossos, Vasiliki, Palaikastro, Tylissos, and Malia hints at some kind of central authority already in the Prepalatial period, while the construction of the palaces occurred at different points in time following local or regional trajectories\textsuperscript{59}.

Taken together, the evidence suggests that palaces (most certainly in the Old Palace period) were primarily consuming pottery, rather than controlling or overseeing its production. While it is conceivable that the impetus for change and innovation may have come from the demands or desires of emerging elites or new consumer groups (possibly inspired by Near Eastern practices), regional potting centers and local craft specialists (albeit drawing on long-established traditions of craft production) were the actual practical innovators.

CONCLUSION

While pottery production was probably organized differently at each site, these contrasts are not as distinct as one might expect and do not obscure the overall impression of homogeneity of practice at the macrolevel. Instead, the overall picture is one of relative parity between production centers, the organization of production, and the skill of the practitioners: wheel throwing was used for small vessels only, hand-built techniques were applied to the full range of pots, and wheel coiling covered the intermediate range – sometimes more closely allied with wheel-throwing techniques (Knossos), sometimes more with hand building (Malia). More importantly perhaps, wheel coiling proved to be a technique perfectly adapted to the limitations of the potter’s wheel and permitted the making of vessels of any size, in principle.

The stimulus for this skill and technique development has often been viewed in light of the newly emerging palatial elites. If such a stimulus existed, it was most likely only indirect. Instead, case studies by Jeffra and van de Mortel demonstrate that the potters’ desire to create vessels of a particular appearance and skill level was not driven by a top-down approach to technical improvement. Rather, it was the consequence of a commonly shared concept of how particular pottery types should look and how they should be made.

This degree of homogenization in potting practice and vessel appearance can only be achieved through regular and deep interaction among potters and between different potting communities across the entire island. As the acquisition of wheel-throwing and wheel-coiling skills requires direct interaction between potters, we can safely assume that knowledge (connaissance) transfer was supplemented with the transmission of actual motor skills (savoir-faire) through direct observation or even personal instruction.

ACKNOWLEDGEMENTS

The x-ray project was undertaken during my sabbatical leave in 2006–2007 and was support by the AHRC (Research Leave Scheme), British Academy (Small Grant), and University of Manchester (Research Support Fund). I am grateful to Valentine Roux, Sandy Budden, Don Evely, Stuart Campbell, and Dean Arnold for the many discussions on pottery-related matters, and the participants at the ‘Distribution of Technological Knowledge’ conference for their thoughts and feedback. A big thank you to the organizers of the conference for creating such a wonderful conference with many stimulating papers on topics from across the Mediterranean. Aspects of this research have been presented at several research seminars and lectures since 2010 and I

\textsuperscript{58} Schoep 1999; Schoep – Knappett 2004.

would like to thank participants for their comments. I am grateful to Robin Barber for inviting me to study the conical cups from the original excavations at Phylakopi.

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