Gwendoline Pepper

Time looms over us:

Observations from an experimental comparison of medieval English loom-types

Abstract

The organisation of textile production in medieval England underwent a dramatic transition between roughly the tenth and 12th centuries. These changes, which include the formation of weaving guilds and the evolution of weaving as a male-dominated trade, are typically attributed to the adoption of a new, more efficient style of loom. In order to critically examine the role of technology during this transitional period, an experiment was designed to compare the relative efficiency of two different types of loom in use during the Middle Ages. The experiment yielded interesting timed results and experiential observations, which indicate a difference in the skill level required by each loom, suggesting a complicated relationship between gender, new technology, and the perception of skill in medieval England.

Key Words: Medieval England, weaving, time, gender, labour, looms, experimental archaeology, technology

Introduction

The process of weaving cloth is a task with heavily gendered connotations. Weaving has been viewed at different points in history as primarily a female or male activity depending on the cultural context. This paper is concerned with a point in medieval English history during which the previous association of women with weaving was switched to men.

For the purposes of this discussion, it is important to acknowledge that biological sex and gender identity are not one and the same, and neither biological sex nor gender exist as a rigid binary (Gilchrist 1997, 43; Parker Pearson 2010, 95). There is a risk of projecting assumptions about a gender binary and also in assuming which roles are carried out by a particular gender in archaeological study. The negative impact of assuming particular gender roles in a society has been discussed by Conkey and Spectre (1984), among other researchers. Written sources and archaeological material from medieval Britain and Europe do indicate a societal concept of male and female gender roles (Fell 1984, 39-40; Gilchrist 2012, 114). Even so, the rigidity of this gender binary is uncertain and burial evidence from early medieval England in particular indicates some fluidity of the gender associations of certain grave goods (Lucy 1997, 162-163). Furthermore, it is clear that there was enough flexibility in gender roles for a major shift in gendered work to take place concurrent with the industrialisation of textile production between the early and late Middle Ages.

A key variable in this transitional time for medieval English cloth production was the equipment used in the weaving process. There is substantial evidence indicating that between the tenth and 12th centuries, two new styles of loom were introduced to the British Isles and employed to produce cloth: the two beam vertical loom (fig. 1); and the horizontal treadle loom (fig. 2). The horizontal treadle loom is the better known of these two styles of loom. It is understood to have dramatically increased the speed with which a weaver could produce cloth. The increased efficiency of this loom, in contrast to its predecessor, the warp-weighted loom (fig. 3), is typically connected to the adoption of weaving as a profession by men and the commercialisation of cloth production on an international scale (Hoffmann 1974, 258; Walton Rogers 1997, 1827). While this technological transition has been the topic of previous research (Endrei 1968;

Fig. 1: A mid-12th century depiction of two-beam vertical loom in use. Cropped detail from *The Eadwine Psalter* R.17.1, f263r (Image: © The Master and Fellows of Trinity College Cambridge, reproduced with permission)

Fig. 2: A 13th century depiction of the horizontal treadle loom in use. Cropped detail from the *Romance of Alexander* O.9.34, f032v (Image: © The Master and Fellows of Trinity College Cambridge, reproduced with permission)

Henry 2005; Øye 2016), there is very little information on exactly how much more efficient this new type

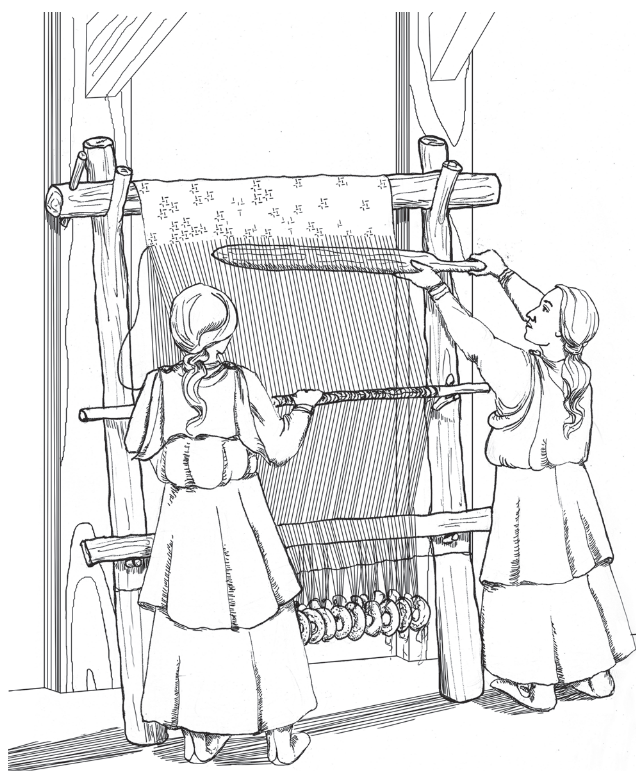

Fig. 3: Artist's interpretation of the Anglo-Saxon warp-weighted loom in use (Image: Gwendoline Pepper)

of loom might have been. A previous estimate that the horizontal treadle loom produced cloth at three times the rate of the warp-weighted loom was made by Endrei (1968, 37-38) based on his own research and recorded weaving times from the early modern Icelandic *Bùalög*, which are also described by Hoffmann (1974, 215-216). Endrei's research was well reasoned using the resources available, but his estimates were not based on a direct comparison and are therefore missing crucial information, which can only be obtained by observing both looms working under similar conditions.

Experimental archaeology is the ideal way to address the question of weaving efficiency and it was with the goal of closing this gap in information that an experimental programme was developed to compare the weaving speeds of the warp-weighted loom and the horizontal treadle loom. The experiment described in this paper cannot be used to interpret the precise number of hours it would have taken a medieval English weaver to produce cloth, as there are too many variables to replicate the process accurately. However, the experimental results did provide some useful efficiency ratios, which highlight key differences between these two looms. These observed differences in efficiency have, in turn, underscored some important considerations concerning the relationship between the introduction of new technology and changing gender roles during the Middle Ages.

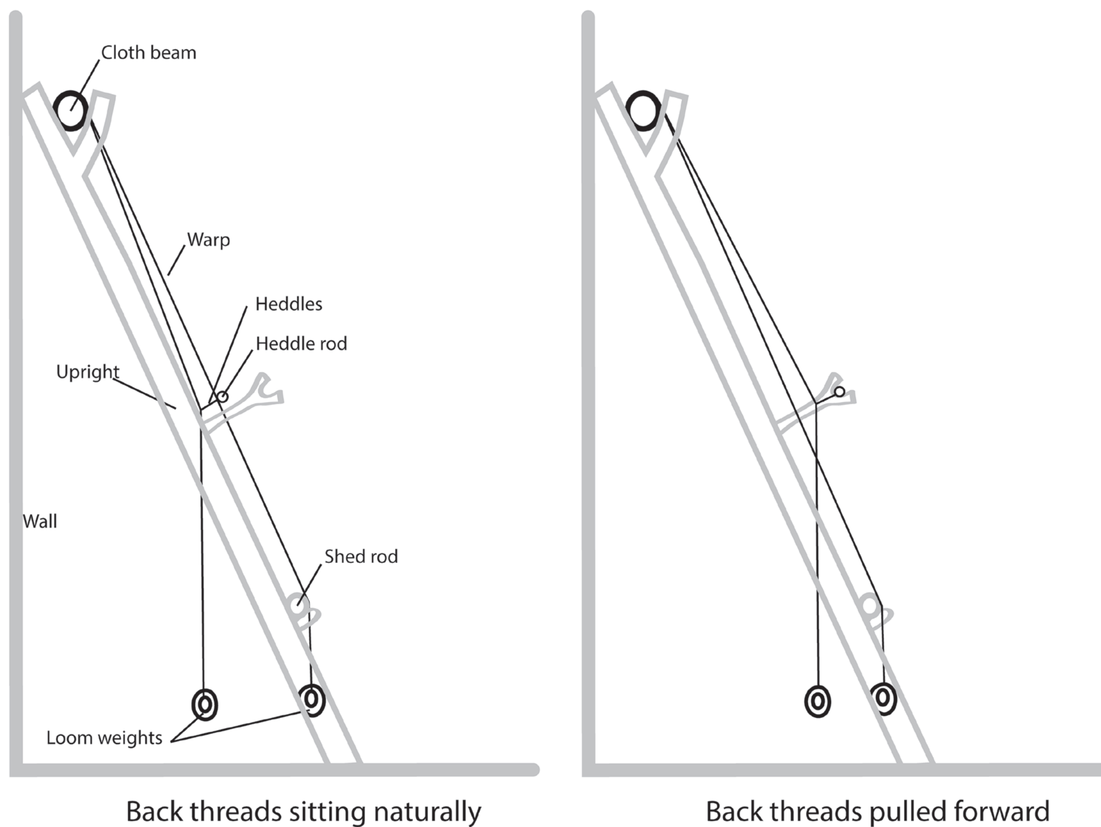

Fig. 4: Side view of tabby weave set up on the warp-weighted loom (Image: Gwendoline Pepper)

Historical context

Textile production in early medieval England is understood to have been organised and carried out primarily by women (Henry 2005, 52; Walton Rogers 2014, 253-54). This does not necessarily mean that men never participated in textile production at this time, but rather that there seems to have been an established practice in Anglo-Saxon England of women as the key textile producers (Fell 1984, 40). Cloth would primarily have been woven on the warp-weighted loom during this early period (Walton Rogers 2001, 161). This style of loom is simple in construction (fig. 4) and is often associated with the weaving of relatively wide cloth. Many surviving Scandinavian looms from the 18th and 19th centuries have widths of between 190 cm and 241 cm (Hoffmann 1974, 24-29), while a find from medieval Greenland included a beam of a warp-weighted loom measuring 188 cm (Øye 2016, 5). Øye, however, has recorded clusters of loom weights varying from one to two metres long as indications of the varying potential widths of cloth woven on this type of loom (Øye 2016, 5). Within Anglo-Saxon villages, there is extensive evidence for the practice of weaving in communal buildings, or *Grubenhäuser*, up to the tenth century. This is suggested at settlement sites including Mucking, Essex, and West Stow, Suffolk (United Kingdom), by the concentrated groupings of loom weights in specific areas of the settlements, usually inside one or more *Grubenhaus* (Walton Rogers 1997, 1823). Walton Rogers suggests that weavers would likely have worked collaboratively in this setting with multiple women working together at one loom (Walton Rogers 2014, 258).

The development of economic centres and the formation of prototowns from the ninth century onwards indicate a transition towards more commercial craft production (Henry 2005, 55). There is clear evidence of textile production in these emerging urban centres (Walton Rogers 2014, 267). Archaeological evidence from the Coppergate site in York (United Kingdom) provides fascinating insight into the changing organisation of textile production in a developing urban setting. The ninth century evidence at Coppergate indicates that textile production occurred in communal locations separate from other activities, which appears to have been a typical rural pattern for this time (Walton Rogers 1997, 1824). During the tenth century, the distribution of weaving tools indicates that production

had transitioned from communal buildings to taking place within separate households. This change occurs within the same context in which loom weights are missing so it seems that this is concurrent with the introduction of the two-beam vertical loom (Walton Rogers 1997, 1824). Weaving activities appeared to concentrate in two of the tenements around the 11th century, contemporaneous with the earliest evidence for the introduction of the horizontal treadle loom in England. This indicates craft specialisation (Walton Rogers 1997, 1827) that is consistent with the suggestion that this area of the city was one of increasing commercial activity (Walton Rogers 1997, 1829). The example of Coppergate illustrates the development of an urban setting in which weaving as a specialised trade began to flourish.

The horizontal treadle loom was likely introduced to medieval England around the year 1000 CE, contemporaneous with evidence for the introduction of this loom to western Europe (Hoffmann 1974, 258; Walton Rogers 2001, 162; Øye 2016, 6). This loom was more complicated in construction and featured new developments including a built-in reed for spacing threads evenly and foot-powered treadles with which to change the shed (fig. 5). The adoption of the treadle-operated loom is also associated with the evolution of weaving into a guild-regulated trade (Hoffmann 1974, 258).

The earliest records for established weaving guilds in England date to the 12th century. The 1130 pipe roll identified five weavers' guilds in London, Winchester, Lincoln, Oxford and Huntingdon, while York's weaving guild appeared later in the pipe roll of 1165 (Carus-Wilson 1944, 42). This suggests that these organisations had already begun to form prior to the mid-12th century, potentially concurrent with the introduction of the horizontal treadle loom. The theorised connection between early weaving guilds and the introduction of the horizontal treadle loom is often accompanied by the assumption that these guilds were formed by men (Munro 2003, 195; Karras 2004, 94). This appears to be due at least in part to an association of the horizontal treadle-loom with male weavers.

There is no clear explanation of why this new type of loom is so strongly linked to male weavers, but historical sources do suggest that this was the case. One often-cited piece of written evidence for this

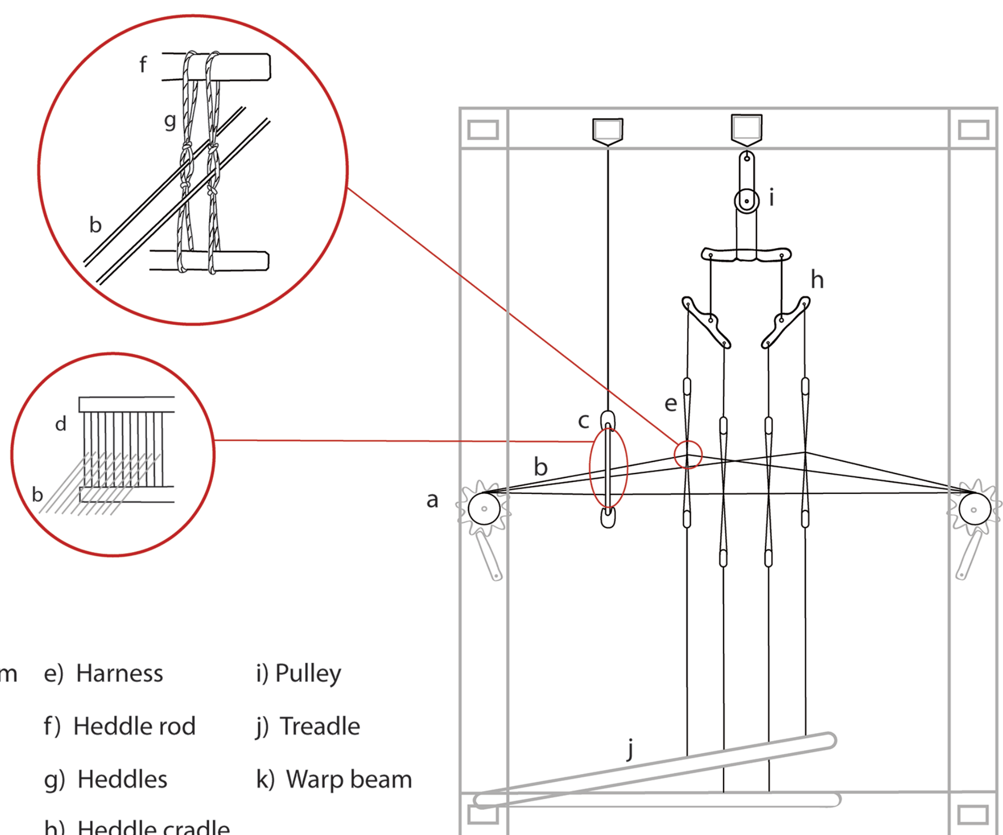

Fig. 5: Diagram of the mechanics of a horizontal treadle loom (Image: Gwendoline Pepper)

association is a 12th century account by Rashi of Troyes of a foot-powered loom, described in contrast to a loom controlled by the hands and used by women (Munro 2003, 194; Øye 2016, 2). There are records of women operating independently as weavers in the late Middle Ages (Salzman 1923, 217; Kowaleski & Bennett 1989, 476-477) and the proportion of female weavers seems to have been higher in rural areas of England (Goldberg 1992, 29). However, it seems that the most common way in which women participated within medieval weaving guilds was as the wives, daughters or widows of male weavers and they were rarely awarded the same status and privileges as their male counterparts (Kowaleski & Bennett 1989, 476-478; Goldberg 1992, 48). In this way, the roles women played in weaving guilds were largely dictated by their relationships to male guild members. That does not mean there was no autonomy to be gained by female weavers during this time period. In a survey of female occupations in late medieval Yorkshire, Goldberg found a significant number of women occupied independently as weavers, although their relationship to guilds is uncertain, and the proportion of weaving households that were headed by women was in the minority, particularly in urban centres (Goldberg 1992, 9-18). There is also European evidence of some women occupying higher ranking roles in textile production, including the esteemed role of draper in late medieval Leiden (Netherlands), although interestingly there is no evidence of female weavers or fullers in the city during this time period (Howell 1988, 71-72). There were also three women's guilds in Cologne (Germany): the yarn makers, gold spinners, and silk makers in which women held the role of mistress in their own right (Howell 1988, 124). Likewise, there were at least five such guilds in medieval Rouen, and seven in Paris (France) primarily focused on luxury textiles or linen (Kowaleski & Bennet 1989, 481). Despite this, there were still harsh restrictions on women's involvement in many other male-run guilds in Cologne, including the wool weaver's guild (Howell 1988, 134).

Essentially, while there are multiple examples of enterprising women making space for themselves in the late medieval textile industry, there is also ample evidence of dominant male-run guilds placing restrictions on women's roles within the guild structure. More to the point, while women continued to weave in late medieval England, and in fact played an important role even within the guild structure, they were no longer the main organisers of cloth production, as they seem to have been during the early Middle Ages. Furthermore, there was no parallel English formation of female-run textile guilds, even in London (Kowaleski and Bennet 1989, 485). The crucial activities of spinning and fibre preparation remained the domain of women, either as side work, or a sole occupation, but the work was not particularly lucrative (Goldberg 1992, 47). It seems to be because of these economic factors that past researchers such as Salzman treated female involvement in textile production as a mere footnote, at best, or assumed that female dominated activities such as spinning involved less skill, at worst (Stabel 2014, 52; Salzman 1923, 215). Despite the work of many researchers challenging these assumptions, this way of thinking left its own scars on the subject of medieval textile production, and the association of low status work with low skilled work can at times be observed even in research which has sought to illuminate the importance of female economic contributions during the Middle Ages (Karras 2004, 95; Howell 1988, 76).

Despite its relatively low status during the later Middle Ages, the activity of spinning yarn is an important aspect of medieval textile production. A competent spinner must possess the skill and understanding of raw materials required to spin strong yarn that will not easily fray and break during the weaving process. Therefore, the importance of skilled spinning should not be underestimated. The distinction between the tasks of weaving and spinning due to craft specialisation is important to consider when discussing transitions in textile processing. In the Anglo-Saxon period, the weaver and spinner would likely be the same person; she would understand what sort of yarn was required for the cloth she would weave, and would know how to produce this yarn. The evidence for specialisation at Coppergate reflects the development of the early household workshops that provided a foundation for guild organisation and gradual separation of these tasks. The archaeological evidence from Coppergate also demonstrates the link between different styles of loom and different approaches to textile production, which further indicates that the introduction of the horizontal treadle loom, and by inference the efficiency of this loom, was a key factor in the evolution of the medieval English cloth industry.

Methodology

This experimental programme had three main aims:

1. To better understand how the time invested by medieval weavers would have been impacted by the introduction of a new style of loom circa 1000 CE by determining the difference in time it takes to weave fabric on the warp-weighted loom and the horizontal treadle loom.

2. To record experiential observations over the course of the experiment, including ease of weaving on each loom, and any physical impact the weaving process has on the weaver's body.
3. To observe any physical differences between the cloth samples resulting from the process of weaving on each loom, including variations in the final dimensions and/or thread count of the cloth.

Two out of the three looms from this transitional period in medieval English cloth production were selected for comparison, as they: 1) represent the two extremes of time and gender division in weaving; 2) are most frequently compared by scholars discussing this transition; and 3) have been subject to previous time estimates.

The following parameters were established to eliminate as many variables as possible and to allow for a more accurate comparison of the differences between the looms:

1) The cloth produced in this process was not intended to be an exact replica of any specific medieval cloth fragment as a comparison of time was the primary concern;
2) The cloth to be woven was to be set up to the same width, length, weave structure and thread count on each loom; and
3) In recording the time it took to set up and weave on each loom, the process was broken down into comparable steps, wherever possible, and timed with a stopwatch. The actual weaving was conducted with an hour-long timer, and the quantity of cloth woven each hour was measured in centimetres.

It was decided not to correct any errors in threading or weaving unless it would ultimately affect the mechanics of the process. This was because the primary focus of this experiment was the evaluation of production time rather than producing a perfect piece of cloth. Therefore, a broken thread was to be fixed because too many broken threads would result in an inability to weave the cloth. However, threads threaded in the wrong order were to be left in place, as long as they did not interfere with the changing of the shed. This decision was also supported by evidence of threading errors found in surviving medieval cloth fragments (Pritchard 1984, 55; Walton 1989, 352).

Equipment

The warp-weighted loom and warping frame were constructed several years ago by Penelope Walton Rogers, who also commissioned the clay loom weights. The weights are all of consistent size and weight but are not specific replicas of an archaeological find. Since the key goal was to compare the basic mechanics of this loom, rather than observing differences in potential variations of the warp-weighted loom, this was not of particular concern. In order to more closely replicate the Anglo-Saxon method of weaving, a double-ended pin beater was fashioned from a piece of wooden doweling. This experiment did not have the resources to construct looms from scratch, therefore, the horizontal treadle loom used in this experiment was a countermarche loom loaned by Ruth Gilbert along with a warping board, shuttle and other pieces of equipment necessary for the setup and weaving process. The loom is not a replica of a medieval loom but matched the vital mechanics of the medieval horizontal treadle loom, namely, treadle operated harnesses, a suspended beater and reed, and a front cloth beam and back warp beam. These two looms permitted a reasonable comparison of these two loom types.

Rulers, a measuring tape, tapestry needles, and glass-headed pins were also used during the setup, weaving, and recording of the pieces of cloth. Cotton seine twine was used during various stages of setup. This is a material that would not have been used during the Middle Ages, but was the most economically viable option available. A phone with a stopwatch and timer app was used to record the times.

Rationale for the dimensions, fibre and structure of the cloth

In order to ensure the experiment reflected weaving practices that could have occurred on both looms, the cloth needed to be of a structure and fibre that would have been commonly produced in both early and late medieval England. This presented a problem of continuity with wool cloth, which was usually woven in 2/2 twill during the Anglo Saxon period but by the tenth century was more commonly woven in 2/1 twill (Walton Rogers 2007, 73). This practice continued into the 13th century when 2/1 appears to have become the most common structure for wool cloth (Crowfoot et al. 2006, 27). It has been suggested that, in England, the switch to 2/1 twill is connected to the use of the two-beam vertical loom, as the evidence for the use of this loom is contemporary with the rise in production of this type of cloth (Walton Rogers 2001, 166). It should be noted that the origins of this trend in cloth structure has been the subject of some debate. Hoffmann (1974, 202-04) has argued that the warp-weighted loom is not ideally suited to the weaving of a 2/1 cloth structure and considered the production of 2/1 twills to have been something of a mystery. There has been a suggested association with the use of the horizontal treadle loom (Øye 2016, 10),

but Crowfoot et al. argue that the horizontal treadle loom is also ill-suited for weaving an unbalanced structure (Crowfoot et al. 2006, 27). It is important to note that neither Crowfoot et al. nor Hoffmann have claimed that it would be impossible to weave a 2/1 twill on a warp-weighted loom or a horizontal treadle loom. It certainly is possible on both looms. They have simply pointed out that an unbalanced twill is not ideally suited to these looms since both function optimally with a balanced weave and therefore the 2/1 twill is not a logical structure to have emerged from the use of these looms. Comparing the process of weaving a 2/1 twill across different types of loom is an interesting potential experiment. However, it is beyond the scope of this project and would have distracted from the main research question of efficiency.

Linen cloth, in contrast to wool, seemed to change little in connection with the introduction of new weaving technology to medieval England. While a small number of linen twills have been found from the early Anglo-Saxon period (Walton Rogers 2007, 70), and from later Anglo-Scandinavian Coppergate, York (Walton 1989, 354), the overall trend was for linen to be woven in a tabby with z-twisted yarn (Walton Rogers 2014, 268). Evidence from London indicates that this continued into the high Middle Ages (Crowfoot et al. 2006, 80). Linen tabby cloth was therefore an ideal control test for the comparison of the two looms, as it eliminated an additional variable of changing cloth structure and, given the broad date range during which this type of cloth was produced, linen tabby could certainly have been woven on both the warp-weighted loom and the horizontal treadle loom. The linen thread for this experiment was ordered from Borg's Vävgarner, a company based in southern Sweden. This yarn is z spun, single ply and the gauge of thread was 28/1, approximately 0.4 mm to 0.5 mm in diameter. This yarn weight falls within the range of thread diameters from linen textiles found in York and London (Pritchard 1984, 64; Walton 1989, 432-443).

Thread count

Thread counts varied broadly throughout the medieval period, depending on the quality and purpose of the cloth. Linen tabby weaves, the primary concern for this experiment, tended towards slightly finer thread counts than their wool counterparts, ranging from 8/7 to 44/22 during the Early Anglo-Saxon period.

The majority of Early Anglo-Saxon linen fragments fall between 10/10 and 24/24 threads per cm (Walton Rogers 2007, 67), which is a broad range. Linen fragments from urban York and London dating from the tenth to the 12th centuries are closer to 10 to 20 threads per cm (Walton 1989, 439-443; Crowfoot et al. 2006, 80). However, while some of the fragments are perfectly balanced, there is an overall tendency for slightly higher warp counts than weft counts.

A warp and weft count of approximately 14 threads per centimetre was chosen for this experiment as it fell within the range of warp thread counts from linen textiles throughout the Middle Ages and was most likely to produce a balanced cloth based on the gauge of the linen thread.

Width

It was important for this experiment to approximate the medieval experience of weaving linen yardage by setting up a width of cloth that could be reasonably woven on both looms. However, interpreting the weaving width of cloth in medieval England is a somewhat daunting task. The association of the warp-weighted loom with relatively wide cloth widths as well as the possibility of narrower widths being woven has already been discussed. Cloth widths in the transition from the warp-weighted loom to the horizontal treadle loom are difficult to determine, although they likely started out fairly narrow. Early depictions of horizontal treadle looms (fig. 2) suggest fairly narrow weaving widths. Archaeological evidence for loom widths is scarce, but in tracing the origin of the horizontal treadle loom, Carroll discusses some surviving reeds of probable "Coptic" origin which give an idea of the maximum fabric widths which could be produced on early horizontal looms in Egypt. The three examples measure 27, 29 and 26 inches wide (Carroll 1985, 169), or approximately 68.5 cm, 78.5 cm and 66 cm, respectively. As part of her study of the way cloth widths might influence the cut and construction of garments, Burnham estimated an even narrower cloth width, asserting that the tunic of St Louis, dated to the 13th century was constructed from fabric 22 inches, or 56 cm wide. It should be noted that Burnham was unable to make a "proper examination" (Burnham 1973, 12) and so this measurement should be considered with caution.

By the late 12th century, regulations on the width of cloth for import and export in England began to appear and these are far wider than the measurements provided by Burnham and Carroll. A royal proclamation from 1196 stated that cloth woven should be two ells in width (Walton 1991, 328). Unfortunately, it is difficult to interpret the equivalent modern-day measurement, as the study of early medieval measurements is a field rich of

ambiguity and disagreement. According to Prior, the ell was equivalent to the yard (which was originally a cloth measure) from the Norman conquest up to the reign of Richard II (Prior 1924, 142). However, we cannot be sure that the medieval yard was the same as the modern yard, or even that it remained consistent throughout the medieval period. Fernie cited evidence for the English yard measuring 91.5 cm. He also referenced William of Malmesbury, who described the length of a yard as equivalent to the king's own arm (the king in question being Henry I) but argued that this may have been more of a symbolic statement than a literal one and could actually imply that the yard measured from the king's nose to finger tips, or his arms would have been peculiarly long (Fernie 1985, 252). Gelsinger, working from the same source, stated that an ell was equivalent to the forearm of the king, and that two ells made a yard (Gelsinger 1981, 128), which suggests a similar measurement for the yard, but implies a very short ell in contrast. Around 1100, the early Icelandic ell was apparently replaced by a shorter ell, which equalled the length of the English ell (Hayeur Smith 2014, 36). Dennis et al. suggest in their 1980 translation of the Grágás (early Icelandic laws) that the Icelandic ell was initially 49 cm but was replaced by an ell of 54 cm to 57 cm (Dennis et. al. 1980, 244), which seems to contradict the suggestion that the ell was shortened to match English standards. It is a little unclear how these measurements were determined but, if nothing else, this further emphasises the variability of this measurement. From these sources alone, the width of the English yard/ell potentially measured anywhere from 54 cm to 91.5 cm, suggesting that in England during the high Middle Ages, a two ell width of cloth might have measured anywhere from 104 cm to 183 cm. Regardless, this range of measurements does suggest a gradual widening of woven cloth during the later Middle Ages. That being said, there are late medieval records of fines paid in order to continue weaving a narrower width (Walton 1991, 328). This makes sense, as transitioning to produce wider cloth would require investing in a wider loom (Salzman 1923, 218). Essentially, while the set standard cloth width by the 12th century was 2 ells, this does not necessarily reflect what all professional weavers produced. It is therefore possible for medieval English cloth to have been produced in a variety of widths from as narrow as 56 cm to upwards of 180 cm, and these higher widths would primarily be limited individually by the width of loom in use. Bearing in mind the potential range of fabric widths throughout the Middle Ages, it was decided early on that a narrower width within this range would be preferable for this experiment, as the horizontal loom to be used would not be able to accommodate the same cloth width as the warp-weighted loom, and time constraints needed to be taken into consideration. Ultimately a starting width of 66 cm was selected for this experiment as this was one of the middling measurements of the previously discussed Coptic reeds and seemed both wide enough to produce a useful piece of cloth, yet narrow enough that the cloth could fit both loom width and be woven easily by one person.

Length

A 2 m warp length was chosen as this guaranteed multiple hours of weaving on both looms, yet was short enough to be woven within the three month time frame of this experiment.

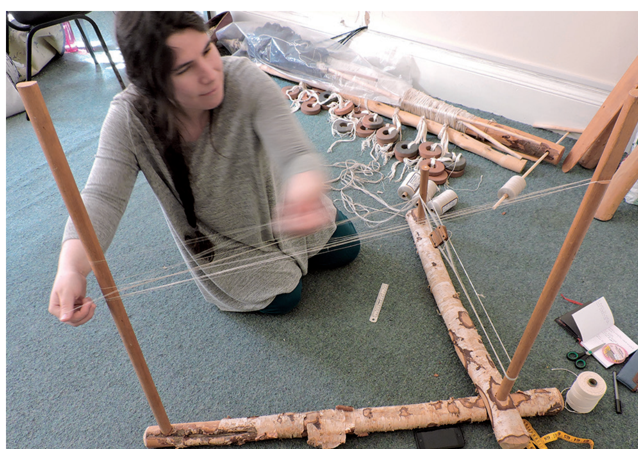

Fig. 6: Warp for the warp-weighted loom being wound on a warping frame (Image: Ellie March)

Fig. 7: Detail of the tablet-woven starting band showing the easy division of alternating threads (Image: Gwendoline Pepper)

Fig. 8: Lashing the warp to the warp beam (Image: Ellie March)

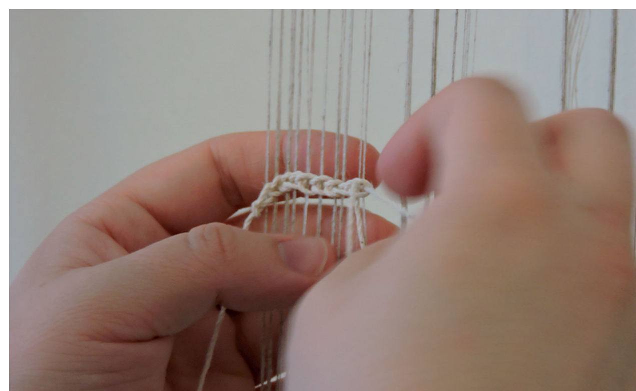

Fig. 9: Chaining the spacing cord around the warp threads (Image: Janet Finlay)

Process

Warp-weighted loom

The warp was made with a tablet woven starting band on a warping frame (fig. 6) to ensure consistent spacing of the warp threads and prevent tangling. This method also allowed for easy division of alternating threads (fig. 7). The separated thread bundles were tied in slip knots to prevent tangling while the warp was lashed to a dowel, which was then lashed to the warping beam (fig. 8). The divided warp was arranged with half of the alternating warp threads placed in front of the warp beam, while the remaining were left

Fig. 10: Tying the heddles around alternating threads (Image: Gwendoline Pepper)

Fig. 11: Arranging the weft into place with a double-ended pin beater (Image: Penelope Walton Rogers)

Fig. 12: Beating the weft with a weaving sword (Image: Penelope Walton Rogers)

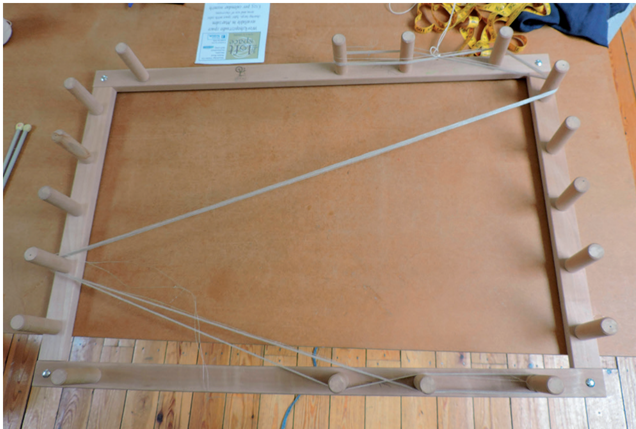

Fig. 13: The warp for the horizontal treadle loom wound on a warping board (Image: Gwendoline Pepper)

to hang behind. To keep the spacing of the threads consistent, a cord was then chained across the warp, looping around every three threads (fig. 9) and shifted to the bottom of the loom. The heddles were tied around every back thread, spaced with a rod, which was placed in the shed and tied into place against the loom uprights (fig.10). Before weaving, the weft was wound on the end of a wooden dowel to keep it from tangling and was then inserted with each change of the shed and arranged into place using a double-ended pin beater (fig. 11). At first, the weft was beaten with the weaving sword (fig. 12) every shed change but after about five hours of weaving, this switched to beating every other shed change and at this point the pin beater was also used to help separate the shed. When running out of room to weave, the cloth was rolled on to the cloth beam, the weights removed and

Fig. 14: The warp separated by lease sticks, attached to the warp beam, and spaced in the raddle ready for winding (Image: Gwendoline Pepper)

Fig. 15: Winding the warp on the horizontal treadle loom (Image: Ruth Gilbert)

Fig. 16: Threading the heddles on the horizontal treadle loom (Image: Ruth Gilbert)

Fig. 17: Beginning the weaving on the horizontal treadle loom with the starting band just visible (Image: Gwendoline Pepper)

tied lower on the warp. This was done twice before the weaving was finished.

Horizontal treadle loom

The warp was wound on a warping board, crossing threads to keep the yarn organised (fig 13). The cross-end of the warp was attached to the back beam after lease sticks were inserted into the cross and the warp was then spaced across the raddle (fig. 14). The warp was then wound on to the back beam while under tension (fig. 15) and warp sticks were inserted at intervals to keep the warp winding evenly. Each thread was fed through a string heddle (fig. 16). After this, the thread was pulled through the reed in a process called sleying. Three threads per dent ensured the desired thread spacing. After this, the warp was lashed on to the front beam, tensioned evenly, and a short starting band was woven to establish thread spacing. The cloth was woven using a boat shuttle, beating the weft after every shed change (fig. 17). The warp was wound off the warp beam and the cloth was wound on to the front beam as the weaving progressed, which, due to the speed of weaving, was done multiple times per hour.

Cloth finishing

The ends of both samples were finished with a simple whipstitch to keep the cloth from unravelling. It was then washed to relax the threads. The appearance, thread counts and dimensions of the cloth produced were recorded before and after washing.

Results and observations

The results of this experiment (table 1) confirm that it is possible for a weaver to produce cloth significantly faster on the horizontal treadle loom than on the warp-weighted loom. The total time for cloth production on the warp-weighted loom was 37 hours and 1 minute. The total time for cloth production on the horizontal treadle loom was 19 hours and 27 minutes. Therefore, in terms of total production time, this means that the weaver was able to produce cloth with the horizontal treadle loom at approximately 1.9x the rate of production on the warp-weighted loom. That being said, the total setup times for both looms were nearly identical, and threading the horizontal treadle loom took more than twice as long compared to the warp-weighted loom, which demonstrates that the newer style of loom is not actually more efficient at every stage of textile production.

The experiential aspect

A significant difference between the two looms, which became immediately apparent during the experiment, was the skill and experience required. The

	Warp weighted loom	**Horizontal treadle loom**
Time spent making warp	4 hours 16 mins	2 hours 46 mins
Time spent putting warp on the loom	5 hours 38 mins	1 hour 04 mins
Time spent threading loom/spacing threads	5 hours 06 mins	11 hours 14 mins
Total time setting up loom for weaving	**15 hours 1 mins**	**15 hours 04 mins**
Average # of cm woven/hour	5.8 cm	29.8 cm
Highest # of cm woven/hour	8.9 cm	42.5 cm
Least # of cm woven/hour	2.3 cm	18.7 cm
Total time spent weaving	**22 hours**	**4 hours 23 mins**
Total time spent making cloth	**37 hours 1 mins (37.02)**	**19 hours 27 mins (19.46)**

Table 1: Timed results from each stage of weaving a linen tabby fabric, 66 cm width on a 2 m long warp made of z twisted yarn (z/z) with a 0.4 cm to 0.5 cm thread diameter, and a thread count of 14 threads/cm in each direction (14/14)

warp-weighted loom, being simpler in construction, required more skill and care in order to weave consistent cloth. Essentially, simpler equipment results in more work for the weaver. At the time of the experiment, the weaver had six years of experience weaving cloth on multiple types of loom.

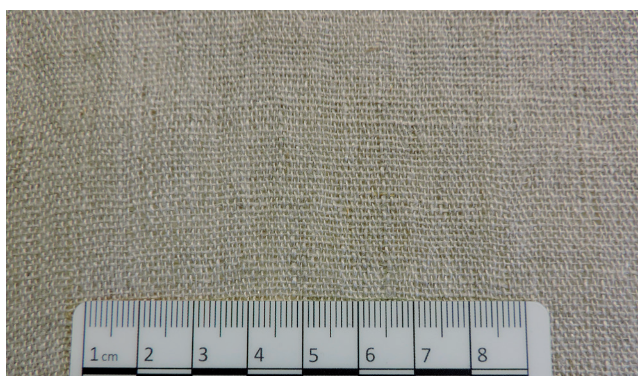

Fig. 18: Detail of the cloth woven on the horizontal treadle loom showing the even spacing of weft threads (Image: Gwendoline Pepper)

Fig. 19: Detail of the cloth woven on the warp-weighted loom showing minor inconsistencies in weft spacing (Image: Gwendoline Pepper)

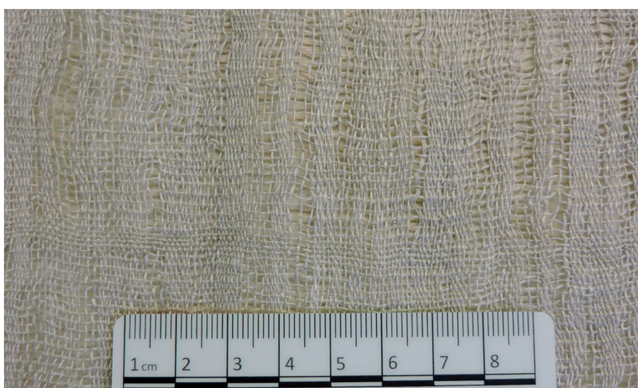

Fig. 20: Detail of the cloth woven on the warp-weighted loom showing more dramatic inconsistencies in weft spacing (Image: Gwendoline Pepper)

Therefore, their skill level was such that they could weave a reasonably consistent piece of fabric on the horizontal treadle loom, where the reed ensured consistent spacing of warp threads, while the built-in beater (fig. 5) made it fairly easy to space the weft evenly at a 90º angle to the warp threads (fig. 18). In contrast, the weaver struggled at times to keep the spacing of the weft consistent and to beat the weft evenly from edge to edge while working with the warp-weighted loom (fig. 19). The level of care required by the warp-weighted loom is an important factor in the time it takes to weave, as can be seen in sections of cloth where more centimetres were woven per hour, but consistency was sacrificed (fig. 20). Another aspect of this inconsistency, which should be noted, is that the weaver had more experience weaving with wool than with the linen used in this experiment, particularly on the warp-weighted loom. Linen is less forgiving than wool due to its lack of elasticity. Should this experiment be repeated, it would be worthwhile to weave a practice cloth on each loom that would not be timed. This recommendation for practice time before measuring is a precedent set in the experimental practice for the Centre for Textile Research's *Tools and Textiles - Texts and Contexts* project (Mårtensson et al. 2006, 3). There was not enough time to run a practice session within the schedule of this project; in future, this would help ensure that the weaver was carrying out the experiments with an established level of comfort on the specific looms to be used.

Aside from skill and experience, stress may have also been a factor, as the days which produced particularly inconsistent lengths of cloth were usually days during which the weaver was feeling distracted or pressured. Interestingly, during this experiment the same feelings of distraction and pressure did not appear to have the same impact on the cloth woven on the horizontal treadle loom as there was very little variation in the thread density of the finished cloth. Since archaeology is a material study of human activity, it is worth considering how the mental state of a craftsperson may be reflected in a finished object. While the impact of emotions on craft practice may be impossible to interpret from the archaeological record alone, it can be argued that this is still a factor worthy of reflection. For example, in relation to the weaving process, the horizontal treadle loom acts as an intermediary between weaver and cloth, which is a useful role for a loom used to weave large quantities of cloth commercially, and further emphasises that an Anglo-Saxon weaver using a warp-weighted loom would likely have needed to exercise more control,

both of themselves, and of the threads throughout the weaving process.

The previously mentioned difference in the ratio of setup time to weaving time between the two looms resulted in another interesting observation related to the experience of weaving: it is commonly said by modern hand-weavers that setting up a loom takes longer than the weaving process. This experiment demonstrates the truth of this in relation to the horizontal treadle loom, while demonstrating that, in contrast, weaving using the warp-weighted loom takes significantly longer than setting up the warp. Over the course of the experiment, this discrepancy resulted in a difference in the levels of satisfaction for the weaver while weaving on each loom: after spending so long setting up the warp, weaving on the horizontal treadle loom felt as though it was over nearly as quickly as it began, and, as a result, the weaver felt more focused on finishing the cloth, than being immersed in the experience of weaving.

In contrast, the weaving stage on the warp-weighted loom dominated their experience because it took more time than setting up the warp. In addition, the weaver was more aware of the full sensory experience of the weaving process, from the clacking of the loom weights, to the feeling of the linen thread between the fingers as the shed was changed. This difference is interesting to consider when thinking about how an early medieval weaver may have experienced the process of making cloth in comparison to a late-medieval weaver. Extrapolating further, it is possible that the experienced early medieval weaver may have had a calmer, more immersive sensory experience during the cloth weaving process than the late medieval weaver, who may have been pushed into a higher-stress production mindset due to the increased efficiency of weaving on the horizontal treadle loom.

That being said, it is possible to set up longer warp lengths on the horizontal treadle loom in contrast to the warp-weighted loom (Øye 2016, 6), which is a factor not accounted for in this experiment. It would be worth running a series of tests weaving different lengths of warp on the horizontal treadle loom, in order to determine where the equalisation point might be between setting up the length of warp and weaving. It is likely that while a longer warp takes more time to weave, it also takes more time to set up. Figuring out where these lengths of time intersect would contribute to an understanding of how weaving to maximise cloth production may have been approached in a workshop setting during the late Middle Ages.

Analysis

This experiment has allowed for an assessment of the impact technology has on the time it takes to weave cloth, but it has also illuminated how complicated this comparison really is. While one may weave cloth significantly faster on the horizontal treadle loom than the warp-weighted loom, not every stage of the process is more efficient; the setup times were nearly equal, but the threading stage took longer on the purportedly more efficient loom. In comparing the total times, the horizontal treadle loom was only approximately twice as fast as the warp-weighted loom. This highlights the need to consider the entire weaving process when discussing the horizontal treadle loom as a medieval technological innovation.

Technology, skill and gender

This experiment has demonstrated that weaving consistent cloth on the warp-weighted loom requires more skill than weaving equivalent cloth on the horizontal treadle loom. The issue of skill is significant, as the skill of the weaver can be overlooked when discussing technological innovation. This omission is compounded by the fact that there has been an unfortunate trend in writing on late medieval weaving to describe the roles which women continued to occupy in textile production as unskilled, without any means of accurately quantifying the skill involved in such tasks.

The horizontal treadle loom's incorporation of a reed and built-in beater allowed for functional cloth to be woven with considerably less skill than the warp-weighted loom. This does not mean that the operation of the horizontal treadle loom is unskilled work, but the level of automation provided by this new type of loom meant that the male weaver in late medieval England would have been able to produce cloth more quickly, with less care than was previously the case. This mild de-skilling of weaving associated with the introduction of the horizontal treadle loom is another important factor in the growth of the English textile industry during the high to late Middle Ages. It should not be considered a coincidence that this de-skilling of labour preceded male clothiers/drapers/weavers seizing control of textile production.

It is interesting that the introduction of a machine which allowed for a reduction in the necessary skill to produce serviceable cloth is so strongly connected to increased craft specialisation. One might expect a higher level of skill to have been involved in a specialised trade. However, the fact that a weaver could specialise in weaving as a trade, and focus his time on a single task under the overall organisation

of clothiers and/or drapers (Karras 2004, 97), rather than working on multiple stages of textile production ,would also have a significant impact on the quantity of cloth produced. In contrast, Anglo-Saxon textile production did not involve this same division of labour in terms of textile production, meaning it would have been common for an Anglo-Saxon weaver to develop skills beyond weaving alone.

One factor which likely contributes to the connection of the horizontal treadle loom with the specialisation of labour is the complication of acquiring the equipment itself. Specialist knowledge would be required to construct such a machine, making it more likely that a weaver would need to import or commission the construction of a loom. The horizontal loom would also take up more space, which not every household would be willing or able to accommodate. This was certainly the case in Early Modern Iceland when the horizontal treadle loom was introduced, and alterations to both loom and house needed to be made to accommodate this new weaving equipment (Hoffmann 1974, 225-226). It is likely that the same space considerations would have impacted the medieval weaver. The expenses of owning a horizontal treadle loom would have stretched beyond simply acquiring one: there are recorded fees for owning and operating a loom in late medieval England, such as the payment of five shillings per year per loom to the town authorities required in 13th century Winchester (Salzman 1923, 218-219). Therefore, it is not just the efficiency or the de-skilling effects of this loom which encouraged specialisation, but the nature of the machine, as both a spatial and financial investment, which may have made specialisation a necessity.

In order to interrogate why this specialisation is connected primarily with men, one must focus on who controlled textile production over time. The varied ways in which women made vital contributions to cloth production in England and in Europe in the late Middle Ages has been discussed. It is clear however, that despite these contributions, female textile workers were frequently overlooked or treated as subordinate by the English guild system, and it is clear that while women still participated and played arguably crucial roles in textile production, they no longer controlled cloth production as they had during the early Middle Ages. This is reflected by restrictions such as one at Norwich, which alleged women did not have the strength to weave proper worsted cloth (Salzman 1923, 217). The experimental loom comparison demonstrates, however, that this assertion is false. The weaver in this experiment can say from experience that beating the weft vertically with a weaving sword while working at the warp-weighted loom takes at least as much strength as does beating the weft horizontally with a beater bar on the horizontal treadle loom, and a good deal more endurance due to the constant upward arm movements. Such written evidence indicates a bias against female labour in some primary medieval sources, which is likely indicative of broader attitudes during this time.

Exactly why this gender switch in weaving came to be is complicated and merits further research. The supremacy of male weavers in guilds contrasts strongly with the role of women as key organisers of textile production during the Anglo-Saxon period. However, this displacement of women as organisers of textile production appears to be congruent with an overall reduction of female autonomy during the Middle Ages. The status of women in medieval British society appears to have been negatively impacted by the Norman conquest of 1066, as an obsession with land-tenure influenced attitudes towards marriage and rights of inheritance, further infringing women's freedoms (Clark & Williams 1984, 149). From this point on, a woman was unlikely to own land, had little freedom of choice in marriage, and, upon marriage, her finances were under her husband's control (Clark & Williams 1984, 149). Additionally, in contrast to the relative equality experienced by both male and female converts to Christianity during the Anglo-Saxon period (Fell 1989, 109), a complicated relationship developed between the Christian church and women post-1066. Despite a belief in the equality of all souls, anti-female attitudes seem to have increased, spurred on by late 11th century Gregorian reforms (Clark & Williams 1984, 152). However, this is not a clear-cut issue. Canon law, for example, emphasised the idea of spiritual love, leading to a requirement by canon lawyers of full consent from both parties in the event of marriage, while simultaneously alleging the inferiority of women (Clark & Williams 1984, 153-54). Based on this, one cannot attribute this reduction in women's status solely to Christianity, but an increasing adherence to canon law after the Norman Conquest may have played a significant role.

The observations from this experiment highlight that, for centuries, the type of weaving that has been typically defined as "women's work" was a highly skilled and time-consuming task. The adoption of new specialised technology led to an increase in weaving speed and a reduction in the skill required to produce cloth. At the same time weaving as a trade became associated with male craftsmen.

Ultimately, the adoption of new technology and reduced weaving time appear to be key factors in

the process of weaving becoming a male-dominated trade, but these factors should not be taken for granted as a complete explanation of why men came to inhabit the role of weaver. The fact that male weavers are so strongly connected to the growth of the English cloth industry despite the continued involvement of women, highlights a key issue in the discussion of weaving and gender in the medieval period. Boulding (1976, 96) writes, "Woman's production is normally noticed by statisticians only when it leaves the home. Man's production is more apt to be noticed whether it leaves the home or not." This illustrates how our understanding of the status of female weavers throughout history is at least partially coloured by scholarly biases.

The academic diminishment of the role of medieval women as administrators and organisers during the later Middle Ages is a recognised problem in the field of archaeology (Gilchrist 1997, 44). This has been particularly demonstrated in the way that the role of women in late medieval production has been discussed in the past. Øye has called attention to a tendency amongst historians to dismiss the likely crucial role that wives and daughters would have played in household-based production during the birth of the guild systems (Øye 2016, 12), which underscores Boulding's argument. Therefore, the study of gender and weaving in medieval England not only involves the examination of shifting attitudes towards women during the Middle Ages, but also requires the acknowledgement of a foundational academic bias that, despite being challenged by many contemporary scholars, can still influence the study of medieval female labour. Technology-driven production organised by a male workforce has previously taken precedence over time (and skill) intensive female-organised labour in the study of the medieval English cloth industry. If we are truly to understand the changing role of time and skill in connection to medieval weaving, this topic must be examined through a feminist lens.

Conclusion

Examining time in relation to the processes of textile production is significant to the study of medieval craft practices, as it allows for a better understanding of how labour may have been organised, the impact of new technology on craft production, and, in a broader sense, how different types of labour were regarded at various points during the Middle Ages.

This experiment has focused on loom type as a factor affecting weaving time. A controlled methodology was achieved by using the same weaver, cloth width, and thread density on two different looms, but the results cannot accurately reflect specific early and late medieval cloth production times. This experiment has instead allowed for the isolation of technology as a factor in weaving speed, which has clearly emphasised that other variables such as skill and access to tools, would have had an equally important impact on production time and the organisation of textile manufacture during the Middle Ages. The issue of skill in particular highlights problems with the way in which gendered labour has historically been regarded. Further experimentation can address differences in modes of production, factoring in other variables and testing variations in equipment. It would be worthwhile, for example, to build a horizontal treadle loom of the style depicted in medieval sources, keeping in mind what archaeological evidence is available. It is likely that advances in the design of this type of loom will have been made over time. Therefore, while the basic mechanics are close enough to the loom which was used for this experiment that the results are still relevant, it would be worthwhile to work with a custom-built loom in order to understand any differences in operation which may have been overlooked here. Regardless of these variables, however, it is arguable that the general impression of faster weaving on the horizontal treadle loom, and the key observations of difference in required skill level will likely remain unchanged.

The results of this experiment, when viewed in relation to historical context demonstrate some of the biases inherent in discussing gendered labour. The emergence of the role of "weaver" as a profession is the result of a number of factors, but this evolution of weaving as a male-organised trade appears to be strongly linked to the introduction of the horizontal treadle loom. The key observation from this experiment is that the skill necessary to produce cloth on the warp-weighted loom is far greater than that required by the newer horizontal treadle loom. Reframing the discussion of this technological transition as not just an increase in efficiency, but a moderate de-skilling and increased division of labour, will allow for a more nuanced discussion of gender roles and the medieval textile economy. Furthermore, this experiment has demonstrated the value of experimental archaeology as a tool for conducting a feminist analysis of medieval labour practices.

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Author: gretpepper@gmail.com