

RECONSTRUCTING THE ANCIENT GREEK WARP
WEIGHTED LOOM

HONORS THESIS

Presented to the Honors Committee of

Texas State University-San Marcos

In Partial Fulfillment of

the Requirements

For Graduation in the Mitte Honors Program

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December 2006

Reconstructing the Ancient Greek Warp Weighted Loom

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INTRODUCTION

Penelope, Arachne, and Athena: all are prominent female figures in Greek mythology who are known for their magnificent weaving skills. The emphasis on weaving in mythology shows that the Greeks took pride from the skills that their daughters and wives exhibited on the loom because of the economic and social importance of weaving.¹ Modern scholars study textile production by focusing on the translation and possible implications of literary references, recorded archaeological finds, or representations of the weaving process on pottery. However, it is more practical to draw from all of these fields in order to discuss the mechanical elements of this important process. Literary resources often reveal important technical, social, and religious details concerning weaving, and some of the most well known Greek authors such as Homer reflect on the value of a woman's weaving skills. As for archaeological finds, no complete looms are found because the main construction element,

¹ Probably the most well known myth takes place within Homer's *Odyssey*. Penelope is able to put off the advances of her suitors for three years by claiming she needs to weave a shroud for her father-in-law.

wood, rarely survives the test of time. Another problem concerning archaeological finds is that possible evidence for textile production was often overlooked in the past. Still archaeology helps to increase our understanding of the mechanics of weaving through the discovery of loom weights and pottery. Pottery supplies representations of different stages of the weaving process and of the warp weighted loom. However these representations can cause a certain amount of confusion. Artists who painted the weaving scenes were most likely not weavers themselves and may not present a technically accurate representation. Many educated hypotheses concerning the construction of the ancient Greek warp-weighted loom draw from these sources, yet few have been tested in a practical manner. This lack of experimental archaeology in the field of Greek textile manufacture, and the importance placed on the role of women as weavers in ancient times are the two main reasons why this study is being undertaken. Using the different sources a model of the ancient Greek warp weighted loom was constructed. By then testing this model under

different conditions a body of data was formed which can be used as a comparison to future findings.

Before discussing in-depth the evidence and theories concerning the construction of the warp-weighted loom, a brief overview of the spread of the warp-weighted loom as shown in the archeological record is presented, along with its appearance in Greece during the Neolithic period. Next the terminology, construction, and use of a basic warp-weighted loom are discussed, followed by the problems concerning the construction and use of the Greek warp weighted loom.

Then literary evidence, archaeological evidence and modern theories concerning the construction of the loom are discussed briefly. The literary and archaeological evidence focuses on the Bronze Age (approximately 3000 BCE) until the Classical Period (ending in 323 BCE with the death of Alexander the Great). While this is a large period of time there are several reasons for this chronological constraint. First, the use of the warp-weighted loom became entrenched during the Bronze Age in Greece and it is this period that produced many of the

loom weights found in the archaeological record. The end of the Classical Period is the end of the time under study because much of the representation of pottery comes from this and slightly earlier periods. In addition, this is done to avoid changes that might have taken place during the quickly altering Hellenistic Period. Also, no marked change in the technology of the warp-weighted loom has yet to be recorded between the Bronze and the Classical period.

This evidence, especially visual representations, helps to create a basic model of the Greek warp weighted loom and to highlight certain gaps in the knowledge concerning the construction of the loom. Based on this information a methodology of testing the model loom is developed. These tests look at the ease of certain ways of using the loom while producing information which can be compared to or supplement future evidence, the results of these tests are then presented and discussed within the context of the evidence. Additional conclusions are made and possible methods of further study are suggested.

BACKGROUND AND USE

Spread of the Warp Weighted Loom

The use of the warp-weighted loom is best documented through the loom weights found at archaeological sites and the representation of the loom in works of art, particularly pottery. The earliest evidence for the warp weighted loom comes from the Near East. Loom weights found at Catal Huyuk in Anatolia date to the seventh millennium.² The warp weighted loom is thought to have come into use in Europe during the Neolithic period which is the time period from which the first loom weights are found. It is during this time period that the earliest known examples of warp weights in Europe are found in Hungary dating to the sixth or seventh millennium B.C.³ The remains of an early warp weighted loom have also been found in late Neolithic Switzerland.⁴ By the Bronze and Iron ages warp weighted looms are common over Europe and Anatolia as indicated by the increased amount of warp weights

found at sites from this period.⁵ During the Bronze Age we find the first possible representation of a warp-weighted loom in the Camonica Valley in North Italy at Naquane. This representation dates to the 14th century B.C.⁶ Some believe that warp-weighted looms may also be represented in some of the ideograms of Linear A used by the Minoans.⁷ However, only the decipherment of this script could verify these claims.

It is during the Neolithic Period (6000 – 3000 BCE) that the warp-weighted loom reached Greece.^{8 9} In Corinth truncated pyramidal warp weights have been found which date to the Early Neolithic Period. The warp weighted loom appears to continue to be used during the middle Neolithic, as indicated by possible warp weights found at Sitagroi and also those found at Tsani in central Greece. However, during the later Neolithic period, use of the warp-weighted loom seems to be non-existent in the southern part of

² Broudy 1979, 25.

³ Barber 1991, 95.

⁴ Barber 1991, 95.

⁵ Barber 1991, 101.

⁶ Barber 1991, 91.

⁷ Barber 1991, 91.

⁸ Barber 1991, 99.

⁹ For a more indepth look, see "Spinning Weaving and Textile Manufacture in Prehistoric Crete." (1975) by Jill Carington. This work serves as a survey of early Greek textile manufacturing

Greece, with the exception of Crete.¹⁰ The warp weighted loom still appears to be used in northern Greece during this period.¹¹ However, the loom resurges all over Greece during the Bronze and Iron Ages and continues to be popular until its use wanes in the first century A.D. Even after general use of the warp-weighted loom became limited, it is still used for some ceremonial garments until the 7th century A.D.¹²

Description and Use of a Warp-weighted Loom

This is a short glossary of important terms pertaining to the basic warp-weighted loom.¹³ There is also a description of the basic construction and use of a warp-weighted loom.

- Cloth beam – The cloth beam is located at the top of the warp weighted loom to which the heading band is connected. On looms with a rotating cloth beam, it is also the part on which the woven fabric is wound.
- Heading band – A small woven section which is attached to the cloth beam and which holds the warps.
- Heddle – Device used for controlling the warp during the weaving process.
- Heddle rod – This is a rod to which the heddles are connected.
- Shed Rod – Rod which is connected to the uprights of the loom and is used for creating a natural shed.

- Shed – This is the space in the warp through which the weft is passed. It is created by separating the warps with either the shed or by lifting the heddle rod.
- Loom weights – Small weights usually of stone, clay or metal which are tied to the warp strings to keep them taut.
- Warp – This is the lengthwise element in the weaving. On a vertical loom such as a warp-weighted loom, the warp hangs vertically from the heading band.
- Weft – The weft runs perpendicular to the warp and is the widthwise element in the weaving. On a vertical loom, such as the warp-weighted loom, it runs horizontally.
- Shuttle – A device around which the weft is wrapped so that it can more easily be passed through the shed.
- Beater/Shed stick – On the warp-weighted loom the beater is a long stick which is used to pack the weft in an upwards motion against gravity

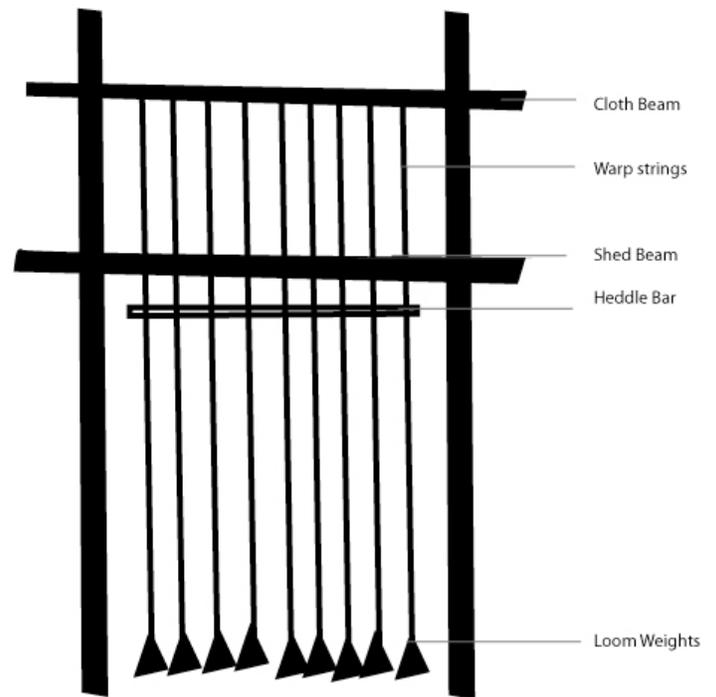


Fig. 1. Diagram of a warp weighted loom

¹⁰ Barber 1991, 100.

¹¹ Barber 1991, 100.

¹² Broudy 1979, 27.

¹³ Held 1999, 407–14.

While the process of dressing an ancient Greek loom and weaving may have differed from the following method, it is important to have a general grasp of the preparation and use of the warp-weighted loom before exploring different elements in-depth. The basic frame of a warp-weighted loom is composed of two uprights and the cloth beam and the shed rod which are connected at a perpendicular angle to the uprights and remain attached throughout the weaving process. The warp is attached to the cloth beam using the heading band. Every other warp string is released in front of the shed rod, creating a natural shed. On a warp-weighted loom with a mechanical heddle, the back warps are attached to the heddle rod using the heddles. Loom weights are then attached to the warp so that the needed length is available to weave. The mass of the weights depends on several factors, including the material of warp being used, the piece being created, and the tightness of the weave needed.

The loom is now prepared for a plain weave. While other weaves can be woven on the warp weighted loom, and the remains of twill weaves have been

found in Scandinavian countries, for the sake of simplicity the plain weave will be used during the course of this study. The weaver then starts at the top of the loom by inserting the weft into the shed and beating upwards with a beater.¹⁴ This means that each row of weft is packed against the forces of gravity. The heddle rod can then be drawn forward to open the second shed, and the process is repeated until the piece is finished.

Problems Concerning the Construction and Use of the Warp Weighted Loom in Greece

Several parts of the construction of the warp-weighted loom, as it was used in Greece, remain a mystery and discovering possible answers to these questions is the topic of this study. This is a short discussion of these issues and a more in-depth discussion of the theories and evidence will be discussed in the following chapter.

The first question is whether the loom was used horizontally or at an angle. The reason for this discussion is derived from apparent discrepancies between depictions of warp weighted

¹⁴ Broudy 1979

looms on pottery and the pattern of warp weights found archaeologically.

The second is the attachment of warp weights to the warp. There are two main categories of possible attachments: directly on to the weight or through an intermediary. The warp weight is connected directly by having the warp run through a hole in the warp weight. Intermediaries include metal rings, loops of yarn, or metal rods which are put through a hole in the warp weight.¹⁵ The warp is then connected to the intermediary.

The other problem which arises is the form of the heddles on ancient Greek warp-weighted looms. There have been arguments that no heddles were used or if they were used whether they were temporary or permanent heddles.

There is also a question of how the woven cloth was stored during the weaving process. The main theory here is the use of a rotating cloth beam to store finished cloth. However since there are no complete ancient looms which exist, we must depend on artistic representations to decide whether or not a rotating cloth beam was commonly used.

¹⁵ Carroll 1983, 96-9; McLauchlin 1981, 79-81.

Evidence

This discussion of the evidence and theories concerning the construction of the warp weighted loom is divided into four sections which depend on the problem being addressed: the position of the loom, form of the heddles, how the loom weights are attached, and the possibility of there being a rotating cloth beam. Before these topics are discussed there are several assumptions concerning the construction of the warp weighted loom which need to be made.

For the sake of this research it is assumed that the loom was designed with the ability to be mobile, so that when in use it could be assembled and when the piece being woven was complete, the loom could be taken down to conserve space. This point is important because weaving was for the most part done in a domestic setting and the ability to minimize clutter is of extreme importance. Other than the practicality, there is evidence to support this claim as well. In his famous book of practical advice, Hesiod mentions which days are best for textile production and mentions setting up a loom:

Also the eleventh and twelfth are both excellent, [775] alike for shearing sheep and for reaping the kindly fruits; but

the twelfth is much better than the eleventh, for on it the airy-swinging spider spins its web in full day, and then the Wise One, gathers her pile. On that day a woman should set up her loom and get forward with her work. [780]¹⁶

Barber hypothesizes that this could be one of the reasons why looms are rarely found in situ or evidence of them being present and complete at sites.¹⁷

As discussed in the “Background and Use” section there are several parts of the loom which are important and can be verified by scenes on pottery. The pottery in the photo section spans different periods in time but all depict the same part of the Greek warp weighted loom: the cloth beam, shed bar and uprights. It is these three main components which are assumed to exist.

Position of the loom

This section deals with how the frame of the loom set up for use. The two main theories are that the loom would either be completely vertical, so that it is set up to be approximately at a

¹⁶ Hesiod, 775 – 780.

¹⁷ For a concise list of evidence from all over the Aegean concerning the cases in which looms or loom weights may be found, see Barber 1991; 102-103.

90 degree vertical angle to the ground, so that the loom is slanted. The main reason for tilting the loom would be to create the natural shed. Without tilting, the weaver would have to manually create the shed.¹⁸

There is little or no archaeological evidence found within Greece which points to the loom being either completely vertical or slanted. However at Troy the fallen weights from a loom were found in two rows, indicating the loom was slanted, not upright.¹⁹ In these situations images of looms on pottery can be very helpful.

To begin, we will look at the depiction of Penelope and her warp weighted loom on the early Fifth century Greek vase from Chiusi, Italy (Fig. 2). The actual angle of the loom is hard to discern because it is portrayed from the front and not from the side. However there appears to be two lines of warp weights along the bottom which may indicate that the loom is slanted so that the shed rod creates a natural shed. The same arrangement can be seen on Fig. 3 and Fig. 4, both of which depict Circe's loom of Homeric fame. The loom on

Fig. 4 is shown from the front as with Fig. 2 and Fig. 3, however it does not depict the two rows of loom weights. This leans toward a completely vertical loom, but the drawing is already so abstracted that it is hard to use this alone as evidence. There is also the black-figured Greek lecythus from about 560 BC (Fig. 6) which only has one row of loom weights as well. An interesting point on this portrayal is that the loom may be standing upright to be used to make a tapestry which means a shedding device would not be necessary.²⁰ The only completely obvious representation is on another fifth century vase from Pisticci, Italy which shows a loom which is obviously slanted (Fig. 7).

Form of Heddles

The presence of mechanical heddles has served as a field for much debate and as Barber mentions, it is interesting that many classicists would insist that looms in Greece had no heddles, when they were in use all over Europe.²¹ Still there are three possible forms of heddles which are discussed here: the possibility of there being no

¹⁸ Broudy 1979, 27.

¹⁹ Broudy 1979, 26-7

²⁰ Broudy 1979, 27.

²¹ Barber 1991, 110.

heddles, temporary heddles, and permanent heddles. Without heddles the weaver would need to manually create the counter-shed each time they put a new row of weft through. Temporary heddles were usually made of string or rope which were connected to every other string (for the plain weave) and to a rod which would be used to control the heddles. With permanent heddles the warps would be passed through the heddles while the loom was being set up.²²

Because heddles were most likely composed of wood and string it is hard to detect their presence in the archaeological record, but it is even harder to find evidence of their non-existence. While looms set up for tapestry may not need heddles, other weaving also took place on a regular basis which would have benefited from this invention.

Again we turn to Troy for evidence concerning the presence of heddles as we did the position of the loom. In level II a set of weights is found in either two or three rows which

indicate that the loom was slanted and that heddles may have been in use.²³

Before looking at representations of the loom on pottery for clues as to the existence of heddles, a precautionary note must be made. Much debate surrounds pictures of looms which appear to have heddles. Often when two rods are shown, the thicker is thought to be the shed rod and the other the heddle rod.²⁴ However, there are several possible reasons for these rods: as heddle rods, shed rods, a warp spacer, or a mistake in representation.²⁵ Still these depictions are worth studying in order to shed some light on the construction of the warp weighted loom. According to Barber, the Pisticci vase (Fig. 7) has a loom with a heddle bar which deflects the warp strings to which it would be attached to.²⁶ Barber also makes an interesting comment on the form of the heddle rod. Since Greek looms do not have supports for large heddles rods as they do on Scandinavian looms, the rod would have to be small enough to remain unsupported and not

²²Barber 1991, 109.

²³Barber 1991, 110.

²⁴Broudy 1979, 27.

²⁵Broudy 1979, 28.

²⁶Barber 1979, 110.

damage the warp.²⁷ The depiction on the black figured lecythus (Fig. 6) also gives a clue to the existence of heddles. The only way for a bobbin to stay in place between the warp strings as the one in this picture would be if there was a mechanical heddle in use.

Attachment of Loom Weights

Before looking at the attachment of loom weights there is an important point which needs to be addressed concerning their identification. Often artifacts which appear to be loom weights serve a different purpose entirely. Items which appear to be loom weights could also have been used for such activities as weighting fishing nets, dresses and a number of other different activities. There is also the fact the weights may have been made from poorly fired or unbaked clay, significantly decreasing the chance of finding them during excavation. Still, there is some scant evidence which points to two major ways of attaching loom weights: warps tied directly to the weights and warps attached through an intermediary.

The evidence supporting the claim that each warp was connected to its own individual weight is usually based on the fact that most holes in loom weights are not large enough for a bundle of thread to be passed through.²⁸ This excludes the donut shaped ring weights which often show use wear caused by the rubbing of string against the weight.²⁹ However, Barber states that these marks were most likely made from a permanent loop of cord attached to the weight as an intermediary. Compiling a range and average of holes in loom weights may help to answer this problem in the future. There is also the fact that the bundling of threads may cause an uneven distribution of tension within the bundle itself.³⁰ However, McLauchlin theorizes that having one warp per weight is not a practical way of warping the loom on a regular basis for the following reasons: the warp would either have to be extremely strong or the weight very light so that proper tension could be maintained without the thread snapping. Even if the warp holds under pressure, the movement of the warp can cause the fibers to untwist. Finally,

²⁷Barber 1991, 110.

²⁸McLauchlin 1981, 80.

²⁹Barber 1991, 104.

³⁰McLauchlin 1981, 80.

there is a larger chance of an uneven distribution of tension if each warp is attached individually.

The two intermediaries thought to be used most often are metal rings or loops of cord which are permanently attached to the weight. The cord or ring would have gone through the hole of the loom weight, because the holes are usually too small for multiple strings to pass through. As mentioned above, there is evidence of use wear caused by the rubbing up of strings, most likely a permanently attached cord.³¹ Figure Fig. 6 appears to depict weights attached with metal rings, but this could also be the loops of cord. Mclauchlin also hypothesizes the use of rods put through the holes in the weights. The warps would have then been tied to the rod which acts as the intermediary.³² While much of her evidence comes after the period in question, there are four Corinthian conical loom weights from the fourth or early third century with stamps images which indicate this type of arrangement.

Ways of Increasing Cloth Size

There are many ways to increase the length of the cloth, however here we will deal only with the possibility of a rotating cloth beam. This is done because this is the technique that would most affect the actual construction of the loom. A rotating beam is perhaps the most practical solution if combined with extra height in the loom itself. This means the weaver does not have to constantly readjust the weights and let more warp out.³³ However, practicality is not enough evidence for the use of such a device. The same problem arises as with other questions regarding the construction of the loom. A rotating cloth beam would most likely have been made of wood and therefore not survived the centuries. To help alleviate this problem we turn to depictions on pottery. Both Fig. 2 and Fig. 6 seem to indicate the presence of a rotating cloth beam. However, both are from the classical period so it is difficult to project this invention onto past generations.

³¹Barber 1991, 104.

³²Mclauchlin 1981, 79-81.

³³Barber 1991, 106.

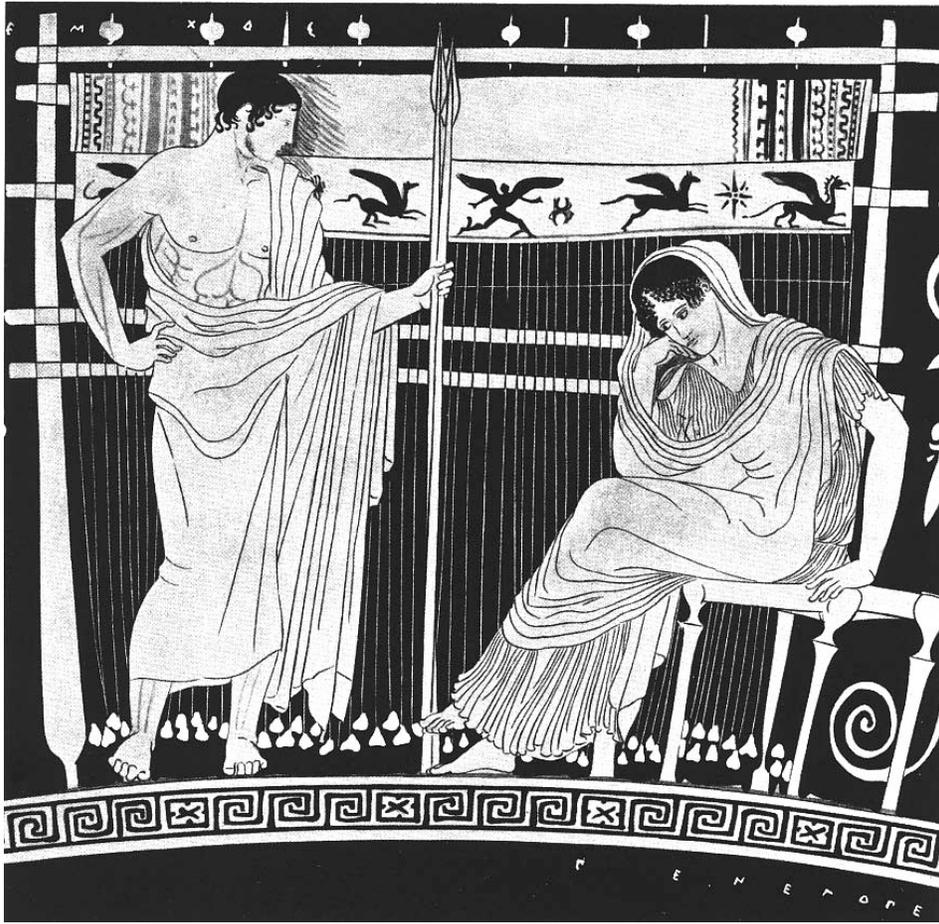


Fig. 2. Greek Vase from Chuisi, Italy; early 5th century B.C. (Kaiker 1958)



Fig. 3. Kabeiric scyphus with Circe and her loom, 4th century B.C. Broudy 1979, 23.

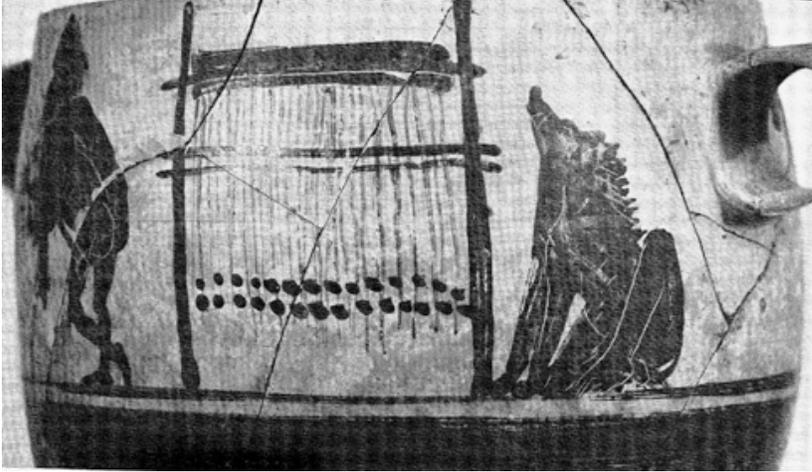


Fig. 4. Boeotian vase, c. 450-420 B.C. Broudy 1979, 24.

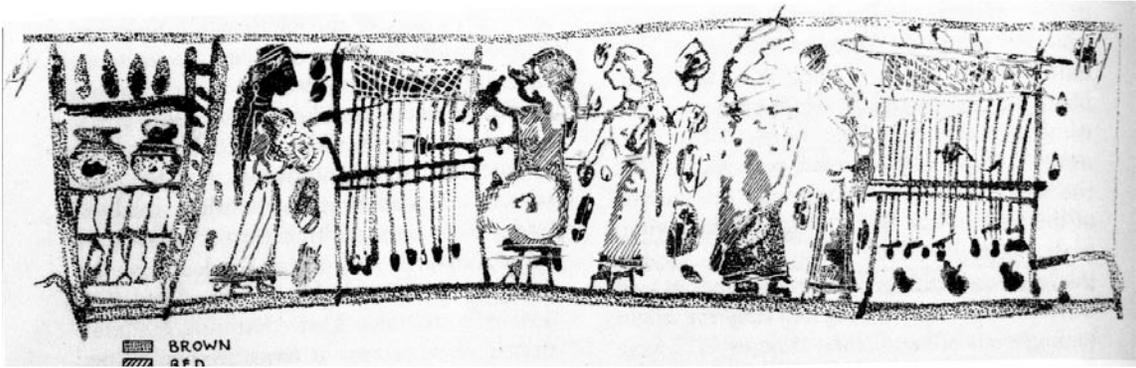


Fig. 5. Small vase (aryballos) from Corinth, Greece, ca. 600 B.C. (Drawing by M. Welker, in Weidberg and Weidberg 1956, fig. 1) From Barber 1991, 106. Fig 3.24.

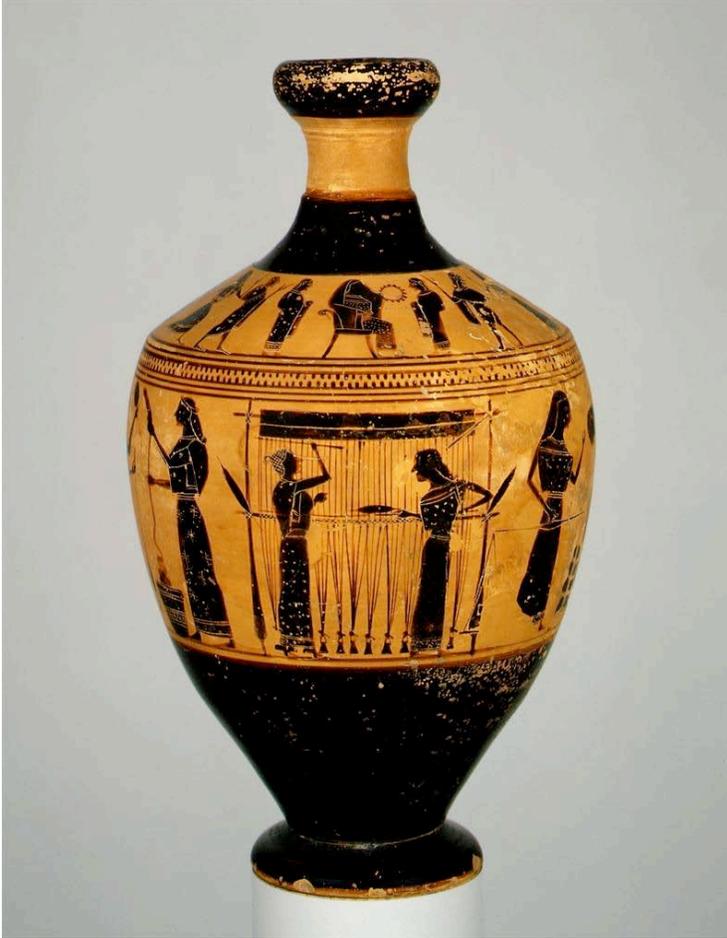


Fig. 6. Lekthos attributed to Amasis Painter, c. 550-530 B.C. Metropolitan Museum of Art, Fletcher Fund. Artstor.org.

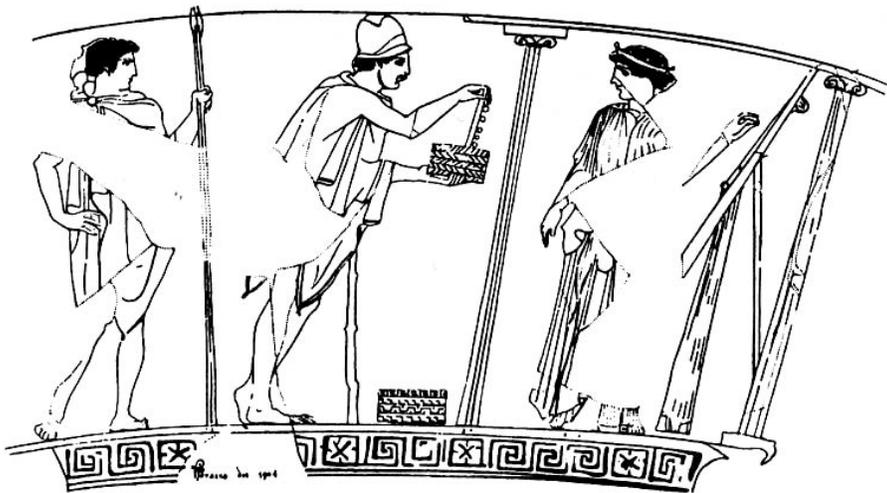


Fig. 7. Greek vase depicting the side view of loom from Pisticci, Italy, 3.28 B.C. (Quagliati 1904, 199 fig. 4) From Barber 1991, 111. Fig 3.28.

Methodology

The purpose of building this loom is to test the possible methods of construction based on evidence from archaeology and from representations on pottery. After the completion of the basic frame, each component is tested separately and photographed. Each component is tested to find any possible connection to other components, such as using heddles on a slanted loom. On selected sections a sample is woven. After the testing is completed, the warps are cut to simulate possible destruction while the loom is in use. Except in reference to the dimensions of materials used to build the loom, all dimensions are given in metric units.

The frame of the loom is created using two six foot 2x3 pieces of lumber for the uprights, one four foot rod, 1 ½ inches in diameter for the cloth beam, and another of the same dimensions for the shed beam. Twine is used to connect the cloth beam to the top of each of the uprights and to connect the shed beam approximately two and a half feet down from the cloth beam. Both are at a perpendicular angle to the uprights. This frame serves as a basis for each experiment and will not change. The

loom weights are composed of unbaked clay to make quick production possible. Ten are discoid elliptical so that their height is greater than their width and the two weights at the selvage weight 300 grams while the other eight weigh 150 grams each. Another five are also discoid elliptical, but are fluted on top for use in testing the presence of a rod as a spacer. Other parts of the loom include several different lengths of wooden dowels for use as heddle bars, a thin twine for the heddles themselves, wool yarn for the warp and weft, a shuttle for weaving and a rod to use as a beater/shed stick.

Each column represents the specific component being tested. The individual boxes in the columns are independent testing stages which have the ability to produce several different possible methods of construction. For example, when testing a slanted loom it may be slanted at varying degrees or positioned against different objects. Every possible method tested is photographed. Those stages which are indicated in the chart also produce weaving samples which are 11.5 x 10 cm. Each sample is labeled according to testing conditions, photographed, and

kept in a separate sample folder. Where it may be helpful in producing information to compare to archaeological data, the warps are cut at the end of the stage to get a loom weight fall pattern. The weights are then reattached to the warp and the process is repeated three times. When testing situations which might produce a derivative from the main tests (Tests 1-3), the weights are dropped once. The fall range is recorded as is the length of distance encompassing the fallen weights. They are also photographed and drawn.

Other than the detailed notes for each testing stage, three other forms of evidence are created through this line of

testing: photographs, weaving sample, and loom weight fall patterns. The photograph is useful both as a way of recording the testing process and in comparing photos to representations of the loom on pottery. The weaving sample and loom weight fall pattern provide physical evidence for the various types of construction which can then be compared to what is found archaeologically. While each box in the chart is independent, during the testing process other questions concerning the connection between two different conditions or elements may arise. These questions are reported in the data section of this report.



Fig. 8. Full sized model of the warp weighted loom.

Table 1. Testing Outline

Position of Loom	Form of Heddles	Attachment of Loom Weights	Ways of Increasing Cloth size
<p>Completely Vertical</p> <ul style="list-style-type: none"> • Position of warps in reference to shed beam • Fall of loom weights 	<p>No Heddles</p> <ul style="list-style-type: none"> • Weave sample on completely vertical loom • Weave sample on slanted loom • Fall of loom weights on each 	<p>One weight per warp</p> <ul style="list-style-type: none"> • Test ease of setting up loom in this manner 	<p>Rotating Cloth beam</p> <ul style="list-style-type: none"> • Possible ways of rotating cross beam • Difficulty of use
<p>Slanted</p> <ul style="list-style-type: none"> • Possible positions • Position of warps in reference to shed beam • Fall of Loom weights 	<p>Temporary heddles</p> <ul style="list-style-type: none"> • Possible modes of attachment • Weave sample on completely vertical loom • Weave sample on slanted loom • Fall of loom weights 	<p>Bundle of warps per one weight</p> <ul style="list-style-type: none"> • Possible amount for hole in weight • Test ease of setting up loom in this manner 	
	<p>Permanent Heddles</p> <ul style="list-style-type: none"> • Possible modes of attachment 	<p>Warps attached by metal ring</p> <ul style="list-style-type: none"> • Test ease of setting up loom in this manner 	
		<p>Warps attached by cord</p> <ul style="list-style-type: none"> • Test ease of setting up loom in this manner • Already done 	
		<p>Warps attached by rod</p> <ul style="list-style-type: none"> • Test ease of setting up loom in this manner 	

Data

These are results from the tests performed on the warp weighted loom. Each test is divided into section so that section 3 of test 1 is test number 1.3. The weights attached to the back warps are marked with yellow or purple markers to distinguish them from the weights attached to the front warps. A description of the test results are given followed by individual tables containing the measurements and photographs of the results of each test.

Test One

The first round of tests looks at the ease of using a completely vertical loom and a slanted loom. While setting up the vertical loom it became apparent that some sort of support system would need to be in place for the loom to remain steady during weaving. First the loom was placed directly against the wall and the fall pattern of the weights with the loom in this position was tested. The width of the warp strings at the beginning of testing was 11.5 cm. The weights were cut by their intermediary to simulate the loom being destroyed while in use.

However, this meant that each weight fell individually instead of the entire set falling at once. The proximity to the wall also affected how the weights fell. Table 1 has the fall range for each testing of the loom in this position.

Test Two

Next the loom was placed completely vertical, but away from the wall. This was done to see how the weights would fall without being closed in by the wall. Again the weights were cut individually from an intermediary. This round of testing produced a longer fall range because the weights were not inhibited by the wall. The results of test 2.3 may be affected by the fact that the loom was not as stable as during the other tests, causing the weights to swing slightly back and forth. The results can be seen in the photograph for the test.

Test Three

In test three the loom was placed against the wall at an angle. On the first test the bottom of the uprights were placed 60 cm from the wall, in

the second 65 cm, and the third 55 cm. The width of the natural shed was also measured as the distance from the back line of warps to the front warps. This was done to see whether the angle of the loom might affect the pattern of the weights. When the weights fell in two distinguishable rows, the distance between the two rows was measured as well. Table 3 contains the results of the tests.

Test Four

Test four primarily focuses on the ease of weaving on a slanted loom with no heddles. To weave a 10 cm sample took approximately 35 minutes. While it was difficult to differentiate each string from the next, the natural shed caused by the slanting of the loom helped somewhat. The fall pattern of the weights was tested only once to see whether the distance between the weights would be affected by the presence of woven cloth on the loom.

Test Five

Test five looks at weaving on a completely vertical loom with no heddles. In comparison to weaving on a slanted loom with out heddles,

weaving was much more difficult. This is primarily due to the inability to tell which warp was supposed to come next in the weaving pattern. One test for a fall pattern was done, with the weights falling into a pile below the warp.

Test Six

Test six looks at the use of temporary heddles on a slanted loom. One main variation from the other tests is the position of the two 300 gram weights. They were moved so that the last warp string on each of the selvages had more weight. The heddles were difficult to make and attach to the loom, but this may be due to inexperience. Once the heddles were set up the weaving process went much quicker than without them. In test 6.1 the warp had been rolled up causing the weights to hang higher and this may account for the high fall range. During this test an observer also mentioned that the type of surface the weights fall on might affect the pattern in which they fall. For 6.2 the heddle bar hung freely in front of the loom causing it to pull on the back warps slightly. In 6.3 the heddle rod

is propped up so that it doesn't pull at the back warps. The weights did not fall into two rows in 6.3.

Test Seven

The temporary heddles were then tested on a completely upright loom. It was slightly harder to weave with the heddles on an upright loom than on a slanted one. One problem was that the natural shed was somewhat obscured by the heddles. However, the heddles still made it possible to weave more quickly than without them. In the first test the loom was not very stable, causing the weights to swing slightly. In the second test the heddle bar was propped into position to keep the heddles from pulling on the back warps.

Test Eight

Test eight used the same string method as with the temporary heddles, but the heddles were made and tied to the heddles rod before putting warps through. The warps were passed through the heddles, the loom was set up and then the loom weights were attached. This could also be done in reverse by passing the warp through the heddles and then attaching the warp to the cloth beam.

This is difficult if there is a pre made border made to be attached to the cloth beam. No weight drop tests or weavings were done on the permanent heddles because they are essentially the same as the temporary ones except for the way they are attached to the warps.

Test Nine

Test nine looks at the process of attaching one warp per weight. It took much longer to set up the loom in this manner and it also takes more time to adjust the position of the weights. The warps are tauter than when attached in bundles. Also, when only one warp string is attached to a weight the warp begins to spin. This causes the string to begin to un-spin itself and the warps get tangled up with one another.

Test Ten

Next the weights were attached by passing a bundle of the warp through the hole in the weight. It was hard to get the thick yarn through the holes. The warps do not try to twist and un-spin themselves. Also fewer warps could be attached to a weight in this manner than by using an intermediary. It was easier to adjust

the position of the weights, especially if the warps are bundled on one side to act as an anchor.

Test Eleven

In test eleven the warp was attached to the weight through an intermediary, a metal ring. It was easy to attach the weights to a bundle of warps and to adjust the position of the weights on the warp.

Test Twelve

The next form of intermediary was a cord loop passed through the hole in the weight. It was easy to attach the warp to the cord loop and to adjust, especially by passing the bundle through the cord. In this way the weight stays in place without having to tie the warp to the intermediary.

Test Thirteen

Next the warps were attached to the weights by a rod passed through the hole of the weight. The two sides of the rod which stick out of the weight provides space to attach more than one bundle of warps. However the bundles slide off the rod easily.

Adjusting the weights on the warp is as easy as adjusting it using the metal ring as an intermediary.

Test Fourteen

The last test dealt with the possibility of having a rotating cloth beam on the loom. With the cloth beam simply lashed to the loom it was easy to roll the beam so that any finished warp gathered on the cloth beam. No additions to the loom were needed. After the warp was rolled on to the beam it didn't slip or unroll itself even with the weights attached and more weaving taking place.

Table 2. Results of Test One.

Test Number	Fall Range	Photograph
1.1	34 cm	
1.2	27 cm	
1.3	30 cm	

Table 3. Results of Test 2

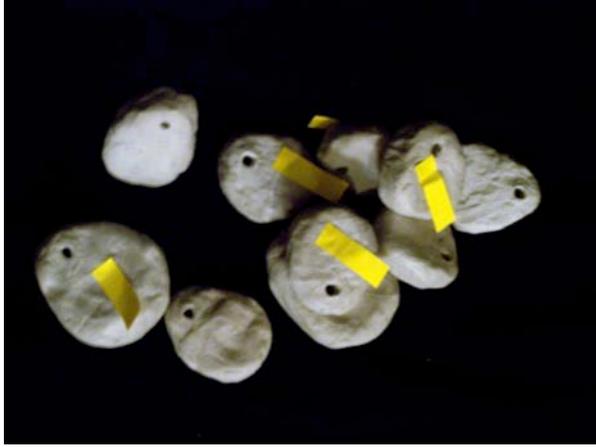
Test Number	Fall Range	Photograph
2.1	41 cm	
2.2	43 cm	
2.3	22 cm	

Table 4. Results of Test 3.

Test Number	Distance from Wall	Fall Range	Distance between Rows	Photograph
3.1	60 cm	32 cm	22 cm	
3.2	65 cm	35 cm	22cm	
3.3	55 cm	35 cm	20 cm	

Table 5. Results of Test 4

Test Number	Distance from Wall	Fall Range	Photograph
4.1	60 cm	35 cm	



Fig. 9. Weaving sample for Test 4.

Table 6. Results for Test 5.

Test Number	Fall Range	Photograph
5.1	26 cm	



Fig. 10. Weaving sample for Test 5.

Table 7. Results for Test 6.

Test Number	Fall Range	Photograph
6.1	84 cm	
6.2	24 cm	
6.3	24 cm	

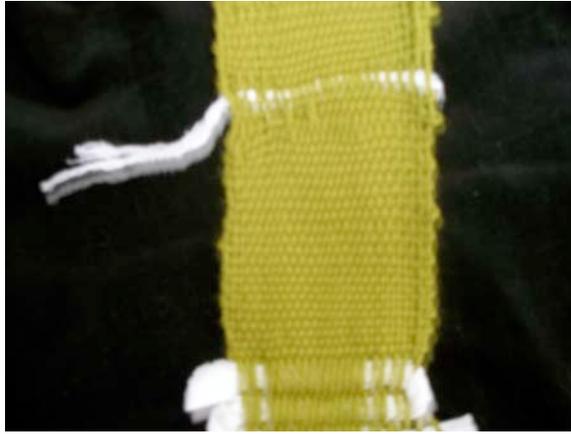


Fig. 11. Weaving sample for Test 6.

Table 8. Results of Test 7.

Test Number	Fall Range	Photograph
7.1	42 cm	A photograph showing several small, light-colored, circular objects, possibly seeds or samples, arranged on a dark background. Some objects have small yellow markings. The objects are scattered across the frame, with some appearing in pairs or small groups.

7.2	34 cm	
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Fig. 12. Weaving sample for Test 7.

Table 9. Results of Test 9.

Test Number	Photograph
9.1	 A photograph showing a white, bulbous, irregularly shaped object suspended by several thin yellow strings. The object has a rounded, somewhat flattened top and a narrower base. It is centered against a solid black background. The strings are tied together at the top and fan out slightly before attaching to the object.

Table 10. Results of Test 10.

Test Number	Photograph
10.1	 A photograph showing a white, oval-shaped object, likely a seed or fruit, suspended by a yellow string. The object is centered in the frame against a dark, possibly black, background. The string is tied around the top of the object and extends upwards. The object has a smooth, slightly glossy surface.

Table 11. Results of Test 11.

Test Number	Photograph
11.1	 A photograph showing a cluster of approximately six white, oval-shaped floats. Each float is attached to a yellow rope. The ropes are gathered at the top and hang down, with some floats positioned higher than others, creating a tiered appearance. The background is solid black.

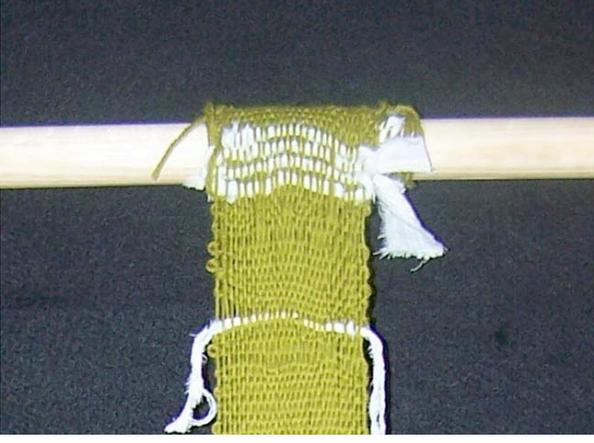
Table 12. Results of Test 12.

Test Number	Photograph
12.1	 A photograph showing a cluster of white, oval-shaped floats attached to yellow ropes. The arrangement is similar to Table 11, but the ropes are more loosely gathered at the top, and some floats are more spread out. The background is solid black.

Table 13. Results of Test 13.

Test Number	Photograph
13.1	 A photograph showing a single, white, oval-shaped object, possibly a seed or a small fruit, suspended by a yellow string. The object is positioned centrally and is held in place by a thin, horizontal metal rod or wire. The background is solid black, making the white object stand out.
13.1	 A photograph showing a cluster of several white, oval-shaped objects, similar to those in the first image, suspended by multiple yellow strings. The objects are arranged in a vertical line, with the top one being slightly larger and more prominent. The background is solid black.

Table 14. Results of Test 14.

Test Number	Photograph
14.1	 A photograph showing a yellow mesh fabric sample wrapped around a light-colored wooden rod. The fabric is frayed and damaged, particularly at the top and bottom edges, where the mesh structure is broken and white fibers are visible. The background is dark.

Conclusion

While setting up the vertical loom for the first round of tests it became apparent that some sort of support system would need to be in place for the loom to remain steady during weaving. After the first and second rounds of testing the completely vertical loom, the fall patterns showed that the weights were most likely to fall in a pile instead of rows. However, this is affected by whether or not the loom is against the wall. The presence of the wall seems to have controlled the fall of the back weights especially, causing the weights to fall into distinguishable rows.³⁴ Therefore if loom weights were to be found right near the wall either in a pile or in close rows this may indicate that the loom was completely vertical. The same sort of pattern away from the wall could also indicate a completely vertical loom. The third round of testing shows that distinct rows of loom weights indicate a slanted loom. This reflects the pattern seen at Troy.³⁵ Setting the loom up at slightly different angles did not

³⁴See picture of the fall pattern produced by Test 1.1

³⁵ See *Position of the Loom* in the evidence section of this paper and Broudy 26-7

seem to cause any major differences in the pattern or in the fall range. The two distinct rows of weights depicted as hanging from the loom on some pottery was not seen in testing the slanted loom.³⁶ This may just be an artistic device to indicate depth or layering. An important discovery was made in Test four and five: the presence of woven cloth can change the fall pattern. On both the slanted and the vertical looms the weights fell into piles instead of distinct rows. This is most likely caused by the cloth closing up the natural shed.

There are two types of evidence that can help to indicate whether or not the weaver used heddles: the weaving samples itself and the fall of the weights. Weaving with no heddles can possibly lead to random mistakes while a mistake made while weaving with heddles would be caused by connecting them to the warps in the wrong order and this would cause a repeating pattern. The sixth round of tests shows that the heddles can pull the back warp forward if it is not held in place. This causes the weights to fall into a pile instead of distinct rows. This may indicate that the heddle rod

³⁶ Fig. 2, Fig. 3, and Fig. 4.

used in the test was too large and heavy.³⁷

Testing the possible attachment of loom weights to the warp proved to be a more subjective process based on the perceived ease of one method over another. Rounds nine and ten proved the difficulty of tying the warp directly to the weights as mentioned by McLauchlin.^{38,39} The individually tied warps tended to un-spin themselves and tangle with their neighbors, which trying to pass a bundle of warp through the hole in the weight proved to be difficult. No difference in tension among the warps was noticed, however only the weights weighing 150 grams were used. No doubt using uneven weights tied to single warps would be much more difficult to adjust than tying multiple warps to each weight. One question that arose during the tests dealing with the metal rings and rods was the influence of costs of materials. The use of metal to make rings or rods for a great number of loom weights seems somewhat unpractical; however this would depend

³⁷ See *Form of Heddles* in the evidence section of this paper and Barber 1991, 110.

³⁸ McLauchlin 1981, 80.

³⁹ Also see the previous chapter discussing the evidence concerning the different problems of constructing the loom.

on the availability of such a resource. Over all, the use of an intermediary appeared to be most effective, especially the use of a loop of cord since it was easier to let out more warp.⁴⁰

Test fourteen suffers from the same subjectivity as the tests concerning the attachment of loom weights. Because the cloth beam was simply lashed to the uprights it was easy to rotate the cloth onto the beam. Neither the weight of the cloth or loom weights or the motion from weaving caused it to unravel. While this shows that the presence of a rotating cloth beam on even a most primitive vertical loom is possible, it does not prove that it was actually in use. Depiction of the loom with a rotating cloth beam can indicate that this device was used during the time the vases were painted. However most depictions are from the Classical period.

Through the course of testing the warp weighted loom, several interesting points arose. One was that the fall range of the weights does not necessarily indicate the width of the weaving or the width of the loom. The fall range in every test was wider than the width of the

⁴⁰ This conclusion falls in line with the use wear mentioned by Barber (Barber 1991, 104.)

warp. This means that it would be almost impossible to estimate the size of the loom or warp by looking at the fall range of the weights. While heddles are most often associated with slanted looms, they also make the weaving process go quicker on completely vertical looms. These last two points are important since the use of heddles is thought to go hand in hand with loom weights found in rows.⁴¹ During the weaving process it became apparent that the presence of woven cloth on the loom can cause the rows of weights to fall in closer proximity to one another. More interesting discoveries arise when the loom is compared to representations on pottery. The two rows of weights depicted in Fig. 2, Fig. 3, and Fig. 4 are thought to indicate a slanted loom. However this pattern was never observed while the loom was slanted. Another point has to deal with the depiction of intermediaries. The only picture which obviously shows an intermediary is Fig. 6. If one were to use loops of cord to connect the warps to the weights the distinction between the warp and the cord would be difficult to depict

and could possibly be left out or go unnoticed by the artist.

Future Study

The findings of this study create a solid base for future research. Some important variables should be taken into consideration if other tests of the warp weighted loom are to be performed.

First, a way should be found to drop the weights all at once to further simulate immediate destruction. While it is unlikely that the weights would fall at the exact same time at the point of destruction, it might be interesting to create a spectrum of fall patterns depending on the time constraints under which the weights fall of the loom.

Also, it might be helpful to test the fall of the weights on multiple surfaces such as packed earth, tile, And pebble floor. For practicality and to make it easier to control other variables the tests for this study took place inside on a carpet floor. Unofficial tests took place to compare the way the weights fall on other surfaces such as concrete, tile, packed earth, asphalt, and pebbled surfaces to make sure the results would not be too skewed. No difference was identified and the I am comfortable that this does not invalidate the results of this

⁴¹Barber 1991, 110.

study. However, as the fall pattern of the weights are studied more in depth and different variables are discovered it may prove useful to study the possible affects that multiple surfaces may have.

When weaving samples on the warp weighted loom it may be advantageous to purposely make mistakes in the pattern. This can make comparing samples made with no mechanical heddles to those woven with a heddle more useful.

As mentioned previously, the weight of the heddle may have been the reason it affected the fall of the loom weights. More testing should be done with different weighted heddles. It may be useful to test looms with multiple heddles as well.

Finally, a database of the different type of loom weights including their weight and diameter of their holes would be useful. This would supply a range of different shapes, sizes and forms which could be tested on the loom as well.

Addendum

After the tests were completed the loom was compared to other images on pottery which were not among the images used for the model's construction.

All of these depictions appear to show the loom as being slanted and with built in supports. This supports the findings in the Test 1 that some sort of support is needed for the loom to stay stable during weaving.

Also, all of these depictions appear to have a rotating cloth beam. This adds more support for its use, especially in later antiquity.

The most interesting affect that these depictions have on the evidence of the warp weighted loom is that it makes the even more mobile. With built in supports, a loom can be set up any where the weaver needs it to be.

Comparing other images of the loom to the findings of this study show the advantages of having a basic body of data concerning the construction of the warp weighted loom. Hopefully future archaeological evidence and depictions of the loom can be better understood using the results of this study.



Fig. 12. Red-figure Hydria: Seated Woman at a Loom Handing a Male Child to Another Woman, Draped Male Figure Standing to the Left. Classical period, High, c. 450-404 BC. Courtesy of the Arthur M. Sackler Museum, Harvard University Art Museums, Bequest of David M. Robinson, 1960.342



Fig. 13. Black-figure Skyphos with Depiction of Penelope. Courtesy of the Arthur M. Sackler Museum, Harvard University Art Museums, Bequest of Joseph C. Hoppin, 1925.30.127



Fig. 14. Attic red figure hydria, ca. 430. Robinson Collection.

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