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KEYWORDS: Craft, craft research, instructions, knowledge transmission, learning resources, mortice and tenon, skill, stolpverk, teaching, timber framing, video.

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Making Instructions: Developing Learning Resources in the Craft of Timber Framing

By Ulrik Hjort Lassen

INTRODUCTION

How is it possible to transmit the craft skills involved in timber framing when there is no longer a living tradition of building timber-framed constructions[1] in Sweden? The Swedish master-apprentice system was dissolved in the middle of the nineteenth century (Hantverksföreningen, n.d.), but timber frames were still built on a large scale, mainly for outhouses, until the Second World War. Because of the industrial development of materials and methods in the 1950s and 1960s, the role of the carpenter has moved more and more towards montage and prefabrication. The Swedish term for carpenter, *timmerman*, is now only used to refer to carpenters working with log buildings or restoration of historical buildings.

Today there is a growing sustainable movement, and this can be evidenced from the developing interest in small-scale building projects using unprocessed and locally produced materials with small environmental footprints. Historical building methods using wood require very little technology and when using locally produced materials these methods have very little environmental impact. The most energy is used by the carpenters themselves. Today most carpenters think to use machines first, although they are not always more efficient. In some situations, hand tools will be almost as efficient but they use less energy when considering the total environmental impact, including the manufacture of tools, the production of materials, transport, and the energy used in the building process (Craftlab, n.d.). The environmental consideration is also a reason why it can be important to transmit basic craft skills, basic craft knowledge, and use of low-technological methods, tools, and material.

I am a Danish carpenter and throughout the last fifteen years I have been studying historical

working methods in timber-framed constructions. I took my Bachelor's degree in conservation, which was the reason for coming to Sweden, as this kind of educational programme was very unique and did not exist in Denmark at that time. After that, I worked as a PhD student at the Department of Conservation where I had the opportunity to learn different traditions within the field of timber framing, to build many types of constructions, and to use different types of tools and approaches (Lassen 2014). I have mostly learned by working alongside experienced carpenters and through practical 'learning-by-doing' situations. The field of craft research was new at the Department of Conservation and alongside fellow PhD students studying other crafts, I experienced the difficulties involved in describing or explaining working procedures. Often, this involved different kinds of gestures and sound effects in the dialogues and discussions between carpenters. To be able to analyse and describe working procedures at the executional level is an important part of craft research, and this is what I call procedural analysis (Lassen 2014, 37). What happens in the practical situation? As part of my PhD, I have also taught practical courses at the Department of Conservation at the University of Gothenburg, teaching students how to build timber frames. In this context, I have experienced the challenges involved when describing working procedures and have found that the most efficient way of teaching has often been to perform demonstrations. However, sometimes it is not possible to teach using demonstrations, and over many years I have produced a number of descriptions of working procedures in timber framing, both as an instructor and as a craft researcher (Lassen and Wood 2013). For the last five years I have had my own company, where I carry out restoration work and new constructions in timber framing. Alongside this, I have continued to teach two courses lasting several weeks at the University of Gothenburg and I also teach short courses lasting from 2–5 days in timber framing for both novices and experienced carpenters.

1. Introduction – what is timber framing, layout, tools, literature, exercises and presentation of the practical project.
2. Practical introduction in the workshop, hand tools, timber and exercises
3. Marking and sawing exercises. Cutting 5 pieces off a timber in square and exact measures (+/- 1 mm)
4. Wooden joints – mortice and tenon
5. Wooden joints – pegs and drawboring
6. Working methods and procedures
7. Working environment - ergonomi, how to lift and move heavy timbers.
8. Lining not perfect timbers - reference lines.
9. Wooden joints – scarf joint (blixtskarv)
10. Wooden joints - producing symmetrical wedges
11. Wooden joints – corner joint (snett blad)
12. Practical work in groups – building a timber framed trestle
13. Theory in groups – types of timber frames, terminology, literature search.
14. Sorting and grading timber
15. Measuring and cutting timber
16. Production of a timber framed structure
17. Introduction to machines – kettenstämmer, circular saw, band saw among others.
18. Statics in timber framing
19. Visiting historic timber frames
20. Developed drawing - basic
21. Timber framing repairs
22. Seminar – types of timber frames
23. Practical and theoretical examination

Figure 1: The structure of the course *Stolpverk 1* from 2016.

The two courses, *Stolpverk (Timber Framing) 1 and 2*, of four to five weeks have been developed at the Department of Conservation over the last 20 years, and according to the internal course evaluation conducted by the department, the courses are highly appreciated by the students. Across the two courses, we[2] have developed a structure which includes most of the important aspects of timber framing for a beginner within the craft. This involves an introduction to the field, the development of complications in exercises, and the balance between practice and theory (see Figure 1).

However, there was no updated Swedish learning resource within the craft of timber framing and the resource we have used until now, Byggnadskonstruktionslära (för timmermän) (Hermods-Korrespondensinstitut 1922), is now 100 years old. We have also used a book from the Danish carpentry school, Træsamlinger og lette konstruktioner (2003), and books on timber framing from the United States[3] (Sobon 1994; Benson 1995; Chappell 1998; Beemer 2016). The learning resource dated to 1922 contains most aspects of the world of carpentry from that time, such as practical geometry, wood species, and joint types, but the resource was created for carpenters and not for novice learners. There is no explanation of tools or procedures for marking or cutting, perhaps because this was all common knowledge among carpenters in 1922.

In the Danish and American learning resources, the use of hand tools is well described and illustrated (see Figure 2), but there is a general lack of explanation as to why these particular methods are used and often there are no references to other possibilities. Here, neither the described type of construction or the tools used correspond to the Swedish tradition of timber framing, and so there is a need for developing a Swedish learning resource which can be adjusted to suit education in practical situations and to the world of today, where students generally search for knowledge using digital media.

Recently, I have been working on turning *Stolpverk 1* into learning resources for novice learners in timber framing, which should be applicable in practical teaching situations at vocational schools when the practical hands-on situations are not a possibility. It is now published in an instructional book *Bygga i stolpverk* which was recently published by the author of this article (Lassen 2021). For the purpose of this present chapter, it has not been possible to include mention of all of the different parts of the course used in the learning resource, so I have chosen one specific exercise for demonstrative purposes. One of the first practical exercises is to make a mortice and tenon joint, which is one of the most common joints in timber framing (see Figure 3). This exercise involves layout and marking, exact cuts with a hand saw, a chisel, and a mallet, and drawboring for the peg. The method in this case study has been used when developing the learning resources for the above mentioned book.

Figure 2: Illustrations from the Danish learning resource, *Træsamlinger og lette konstruktioner* (2003, 52).

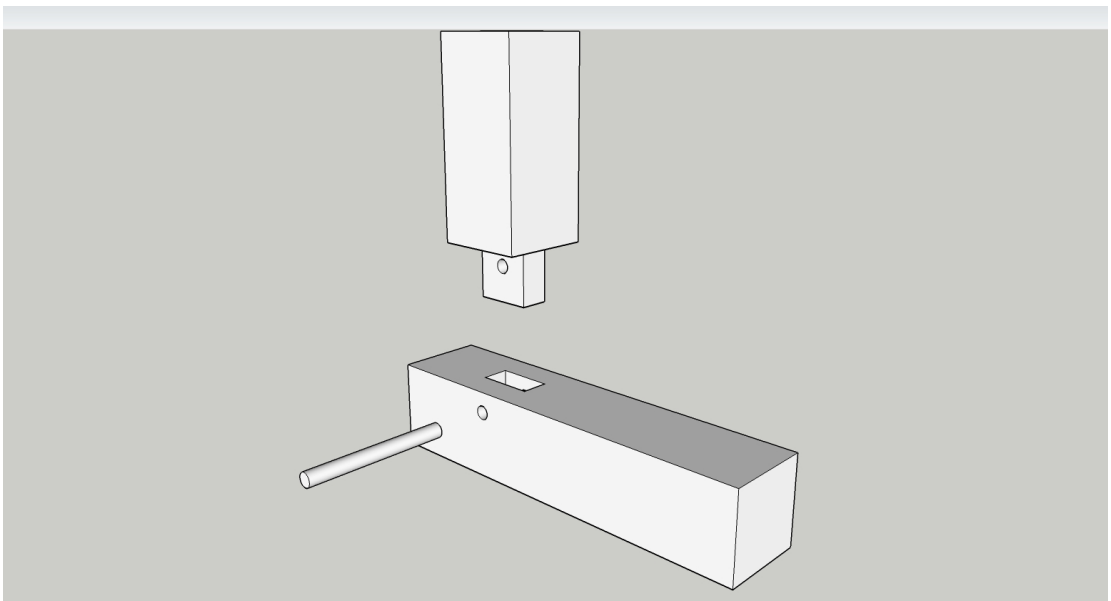


Figure 3: Animation of the mortice and tenon exercise. Click the image to see the video if reading a pdf version, scan the code to the right or go to: https://youtu.be/Tgk1s3zaxrU. Animation by Ulrik Hjort Lassen.

The aim of this study is therefore to develop a video-based learning resource of the cutting procedures involved in this specific exercise. Both practical and theoretical levels of knowledge should be included, balanced, and combined. Questions to consider are: *How to get into my own practical knowledge? How should the working procedures be described? How are illustrations, text, and video to be combined to create appropriate learning for novice learners?*

DIFFERENT METHODS AND APPROACHES

I am a Danish carpenter, so, unsurprisingly, my way of cutting the mortice is very similar to the procedure described in the Danish learning resource using only a framing chisel and a mallet (see Figure 1). This is illustrated by five illustrations, a simple but very efficient two-dimensional line drawing, a photograph of how to sit on the timber, two 3D drawings, and one drawing of an arm and a mallet (Træsamlinger og lette konstruktioner 2003, 52–53). Other descriptions of cutting a mortice are found in American literature, where the mortices are often bored with an antique boring machine first, before the chisel is used (see Figure 4) (Sobon 1994, 85; Beemer 2016, 64). This is indeed a very efficient approach, but this boring machine was developed in the USA in the nineteenth century and has, as far as I know, not been used historically in Sweden.[4]

In many historic constructions it is possible to find traces from an auger in the bottom of mortice holes (in some situations the round cut from the drill has been left in the mortice and the ends of the

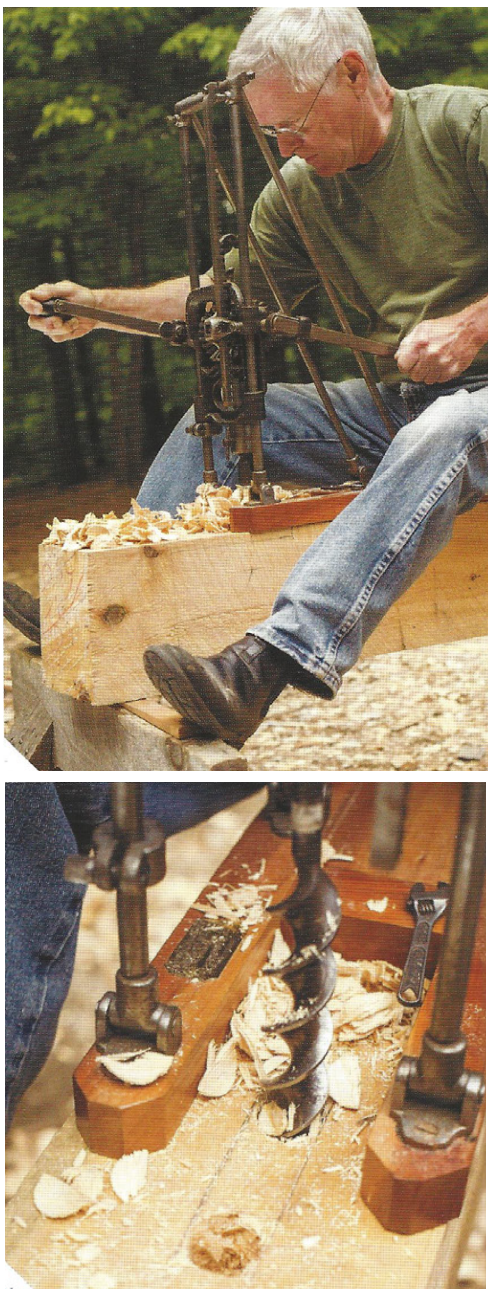


Figure 4: Illustrations from Will Beemer's book, Learn to Timber Frame (2016), where he demonstrates the boring machine when making a mortice.

tenon have been rounded instead). This is also an efficient and attractive approach, especially when cutting a mortice in a knot or in dry wood. There are other historical tools, such as the mortice axe (German: *kreutzaxt*), the French *bisaigüe*, and the Norwegian *hålyxa*, which are all suitable for making mortices, but which all take more experience to use, with the mortice axe being fairly dangerous.[5] Furthermore, special tools such as the corner chisel or the swan neck chisel can ease the procedure a little by cutting the corners or cleaning the bottom of the mortice, but I have never seen these used historically in Sweden (see Figure 5).

On YouTube, there are many descriptions of how to cut mortices for furniture or doors/windows, which are smaller than the mortices in timber framing. But the way of demonstrating the procedure on video is what is of interest for this study. An interesting method used by Paul Sellers is to use a plexiglass as one side of the mortice, which allows the viewer to see what is going on inside the mortice when cutting (YouTube, Paul Sellers 2012). This is an interesting way of developing the learning resource, but it was considered more important in this study to demonstrate the actual situation of the exercise in the instructional video on the cutting procedure.

MAKING LEARNING RESOURCES

To make learning resources is a field of research in itself, and there is a great variety in the approach irrespective of whether the subject is mathematics, psychology, or cooking. The way of describing a procedure also depends on the level of experience of the learner. In practical, personal, or procedural knowledge, important parts are often tacit and, as such, are hard to describe in words (Polanyi 1966; Rolf 2017, 51). Furthermore, it is a challenge to generalise this kind of knowledge because in most

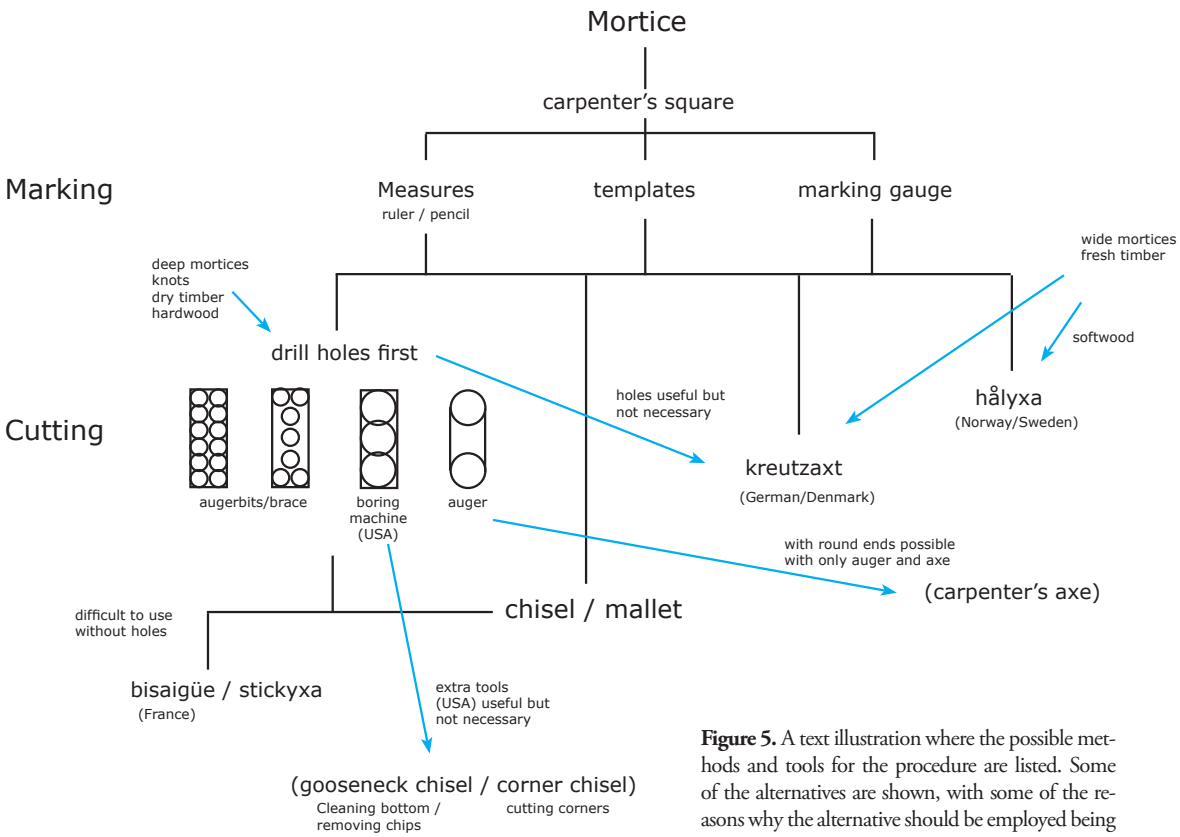


Figure 5. A text illustration where the possible methods and tools for the procedure are listed. Some of the alternatives are shown, with some of the reasons why the alternative should be employed being presented. It is, however, difficult to generalise this knowledge. Text illustration by Ulrik Hjort Lassen.

cases it is very situation-specific (Archer 1995, 12; Lassen 2014, 39). A result of this is a general lack of detailed descriptions of working procedures within crafts. In an earlier study, I made a multimedia learning resource of a layout and marking method, *plumb line scribe*, which is a complex system for marking the timbers for timber framing (Lassen and Wood 2013). This study showed that the transmission of craft knowledge is eased by making multimedia learning resources with paper-based procedural descriptions using simple line drawings combined with video material, which corresponds to the procedural description (Lassen and Wood 2013, 38). In that study the actual cutting of the joint details in the timber were not included in the learning resource. This part of the process is more active and the way of describing the procedure is therefore different: the practical knowledge is even more bound by the physical actions when cutting than it is when marking.

To cut a mortice and a tenon is a rather simple exercise for an experienced carpenter, but to make a procedural description of how to do so is not necessarily a simple task. To describe working procedures without being able to demonstrate them through physical action requires many words. Of course, this depends on the exactness in the description, and it is almost impossible to include all aspects of a situation in such a description. In the 1922 Swedish learning resource, such a description would have been

Figure 6: Video sequence of me teaching, demonstrating how I cut a mortice. Click the image to see the video if reading a pdf version, scan the code to the right or go to: https://youtu.be/cBSERnzhn2Y. Video by Ulrik Hjort Lassen.

that the mortice is preferably cut with a framing chisel and a mallet and that the tenon is cut with a cross cut saw and a rip saw or an axe/chisel. But, of course, not even this information can be found here (Hermods-Korrespondensinstitut 1922).

Throughout the last 10 years I have experienced students struggling with making a mortice with hand tools, and they spend more than an hour on this task, even after I have demonstrated my way of working (which takes a maximum of 10–15 minutes). This has made me realise the importance of demonstrations and even more so the continuous guidance needed in the learning situation. I have myself experienced describing the same procedure in three different ways to different students, depending on the level of skill of the students. As it is not always possible to be present for the students, to make a video-based procedural description of the procedure is considered an interesting way to enable the students to study the working procedure several times.

The procedural description in this study is mainly based on my own practice as a carpenter and on my experience as a teacher. The first step in making the video-based procedural description has therefore been to find out how I 'do' myself. The second step has been to study other methods and the different possibilities within the method (for example, the types of tools used and alternative methods). The last step has been to produce an instructional video of the procedure, which is followed by a procedural description, where both of these are to be used in the final learning resource.

HOW DO I 'DO' MYSELF?

Of course, I have a good idea of how I cut a mortice and a tenon myself. However, to be able to describe each part of the procedure—when I do something, how I do it, and all the small decisions that I make during the process—it has been necessary to make a procedural analysis. Video has been successfully

Nu tänkte jag att visa lite hur jag huggar ett tapphål, för det här kan ni ju. (Haha). Orkar ni? –menar då tappdelen också. (Jatack! Man skulle ha haft en kopp kaffe.) 2.17: Gör biten fast i motsatt ända med tving. 2.45: Börjar att såga bröstsnittet. Pratar om att en grovtandad såg är lite svårare att starta, men annars är det ingen stor skillnad. Jag såger från ena sidan och ned och när jag är nästan nede håller jag koll på båda sidorna, kollar 2-3 gångar på motsatt sida. 3.15: Borstar bort sågspån, och tänker vända på virket. Kommer på att jag i stället vill visa hur man huggar bort materialet med stämjärn och klubba. 3.29: Tar kantarna först och huggar sedan bor nästan till linjen. 3.47: När jag sedan skall ta inne vid bröstet på tvärs av fibrarna, ligger inte timret fast, och jag behöver ta en tving till.

4.05: Jag tar linjen med stämjärnet och startar inne vid bröstet och vinklar stämjärnet lite utåt och tryckar det längs linjen, medan jag håller vänstre handen på virket. 4.09: bytar ställning och trycker stämjärnet ind längs hela bröstet. Vinklar lite i början (kanske) och jobbar sedan utåt. Kollar linjen i ändan att det blir bra. 4.25 klart.

Säger att det kan ju verka lättare att göra såhär än att såga det. Vad tycker ni? (ja, jo, men?) Vänder på virket. (det beror väl på strukturen i träet?) Ja absolut, är det en kvist är det inte så roligt att hugga det. Och går fibrarna nedåt är det inte häller så lätt.

Man kan använda en yxa i stället. Men jag hade glömt att såga bröstsnittet först. Man skall akta sig för att det inte går för snabbt. Tar en annan och mer grovtandad såg till nästa snitt. 5,27: igen lite svårt att starta. Såger på samma sätt som för. Kollar 3 gångar. 6.07: huggar bort med yxa och klubba. Här är det lite mer vridigt. Slår i ändträet först, ligger på knä framför, och sedan resar jag på mig och vinklar yxan lite uppår. Sedan huggar jag inne vid bröstet för att få bort material. Tar yxan och tryckar på tvärs av fibrarna. 7.06 funderar lite på nästa steg. Tar fram fintandad såg, men måste vända på tvingen först (någon hade ställd den åt fel håll (!). 7.25: Sågar kortsidorna av tappen. Först med en hand och sedan byter till två händer när jag sågar vertikalt. Vänder på mig. Hur noga är det egentligen? Huggar bort md yxa och klubba. Fibrarna går lite åt fel håll. Putsar med yxan. 9.00 Nu kan man kolla lite grann om den bular ut härinne vid bröstet. Gör den det är det bra att ta det nu, och huggar bort med yxa och stämjärn. Sedan kan det betala sig att fasa tappen ganska rejäl fasning och det är lite jobbigt att ta undersidan nu, så det brukar jag att göra med en gång. Jag kollar tappen 80,5 mm lite väl stor… jag tar sidorna lite med stämjärnet då går den lite lättare in. Sedan mäter jag bredden på tappen.

I stället för att göra det här är det någon som har kommit på att göra en tappmall, och den går inte på, därför tar jag lite mer på tappen och tappmallen går på. Tappen klar. Tar bort tvingerna och bytar till tapphålsdelen.

Judgment of the timber, best corner.
- *Avoiding nots/cracks and rounded surfaces.*
- *Choosing best corner and reference sides.*

Measuring.
- *Putting on the exact lines in 90 degrees to the best corner*
  - *Length measures and marking on the best corner.*
  - *Squaring off from the best corner.*
- *Placing the mortice in the center of the joint.*
  - *10/100 mm from the one face of the post*
  - *40/40 mm from the other face*
- *Marking the tenon*
  - *10/100 mm from the one face of the post*
  - *40/40 mm from the other face*
  - *80 mm in length (ca 4/6 of 125)*
- *Marking the chisel with 85mm*

Cutting
- *Marking with the chisel round the mortice*
  - *Small hits of the mallet starting with the ends ca 5 mm from the line (2-5 mm deep) and along the lines at the sides.*
- *Cutting the mortice*
  - *Starting in one end and working down. Chipping off 5-10 mm each time. Working all the way down till the marking on the chisel.*
  - *Turning the chisel and working off material till the other end (5-10 mm)*
  - *Slicking the sides of the tenon with the chisel and control ling the direction of the sides of the mortice (combination square?)*
  - *Cleaning the bottom - Cutting off the chips in the bottom by twisting the chisel, checking that the depth is ok all the way (combination square).*

Figure 7–8: A small part of the text that I wrote to articulate the actions in the video, and to document my comments. This part is about cutting the tenon (in Swedish). Figure 8, the step-by-step description written out in text. There are quite a few steps involved and the whole procedure with mortice, tenon, and peg will last for about 25 minutes.

used by other craft researchers as an important tool to analyse working procedures (Jarefjäll 2016; Groth 2017) because the video catches procedures as no other media does, and "allows for a more detailed investigation of the events and the analysis can be conducted on many levels" (Groth, 51, in this anthology). To be able to analyse my own working procedure, I have recorded video sequences of myself in action in two similar but different situations.

The first is in the educational situation where I make demonstrations to the students. In this situation I demonstrate my way of working while I talk aloud to the students about what is going to happen and why I perform specific movements (see Figure 6). Here, I even chose to show two different ways of cutting a tenon on the same tenon, to demonstrate that there are different possibilities (maybe this was not the best pedagogical approach for novice learners, but I believe that more experienced students will understand both possibilities). In this video I have been able to record some comments from the students during the demonstration, as the camera was placed among the students. This provides an insight into the reactions of the receivers of the demonstration.

In the second situation, I have recorded video sequences of my own practice, where I just try to work efficiently, without stopping and explaining. This gives me an idea of how long the different steps take in relation to each other. I have also used the concept of "thinking aloud accounts," which is a method originally used in design cognition tasks, but which has also been applied in autoethnographic research (see the respective chapters by Groth and Seiler in this anthology). Here, I was talking to myself as if explaining what I was doing to somebody else, but without slowing down in the process (as I normally do when I demonstrate for students).

I have watched the videos and tried to write down what I do and what I say (see Figure 7). When forcing myself to write about what I do, I have been able to point out specific movements and approaches that I had not realised were things that I was doing. An example of this is that I loosen the grip on the handle of the chisel just before I hit it with the mallet. On reflection, I do this to avoid the force of the stroke hitting my hand, as it can hurt, but this comes very naturally after you have hurt yourself a few times, and I have never really thought about it before watching the video. To put into words what you see and do is an important tool in procedural analysis (Lassen 2014, 38), and together with the thinking aloud accounts it has helped me to delve deeper into the procedure. From this I have started to separate the procedure into different steps. These steps can be considered as the first version of the paper-based procedural description (see Figure 8). Once I know how I 'do', I am able to define how I want the video to be, which steps are most important, and what to show when and how. I have then prepared my procedure and tried to make an instructional video of the working procedures separated into different steps.

SITUATION-SPECIFIC KNOWLEDGE

As mentioned above, the approach used to solve this specific situation, to cut a mortice, is based on my way of working. Other approaches will work just as well, or maybe even better, but this depends on the specific circumstances of the situation. To describe these circumstances, it will be necessary to answer the following questions. *What is the experience of the craftsperson? How many mortices are to be cut? What are the conditions of the tools? What are the dimensions of the mortice and tenon? What are the conditions of the wood?*

One example of situation-specific knowledge in action can be seen in the complications of knots in the timber. If there is a knot in the mortice it is more difficult to cut, and it might be better to first drill holes to remove material before using the chisel and mallet. Furthermore, when the timber is dry, drilling holes can be preferable, as the timber is harder to work and it can almost feel like the chisel is chewing when cutting the wood fibres. But how many holes to drill and how to place them also depends on the dimensions of the mortice. Sometimes there will also be a knot on the side of the mortice timber, and this could cause the joint to become weaker because the wood fibres are diagonally crossing the edge of the timber and will split from too much tension. This is not even to mention the situation with cracks or knots in the tenon. The last two described situations are examples of structural failures in the joint, which should be avoided when building timber frames (Newman 2005, 115), and this is important to know about and to possibly avoid when creating the layout of the joinery on the timbers.

There are a number of different situations which might occur when working with wood. An experienced timber framer would be able to make

a quick diagnosis of the situation and choose an appropriate approach for solving the issue (Sjömar 2017, 114). In some cases, it might be desirable to change to another approach such as drilling holes, but in my experience it is possible to solve almost all of these situations (cutting mortices) with a sharp framing chisel and a mallet.

When making learning resources for beginners, it is not possible or even desirable to consider all situations and potential complications when describing a procedure, as this might confuse the learner and lead the attention away from the specific action (Wood 2006; Westerlund 2017, 196). In this case, the choice of tools and methods used also aims to allow the students to become acquainted with specific tools and how they are used. It is possible to include more examples in the same instruction (Westerlund in this anthology), but the extent to which the level of difficulty should be increased depends on the experience of the receiver. The more experienced the learners, the more complex situations can be considered and other kinds of tools introduced (Lassen and Wood 2013, 45).

DESCRIBING THE SITUATION

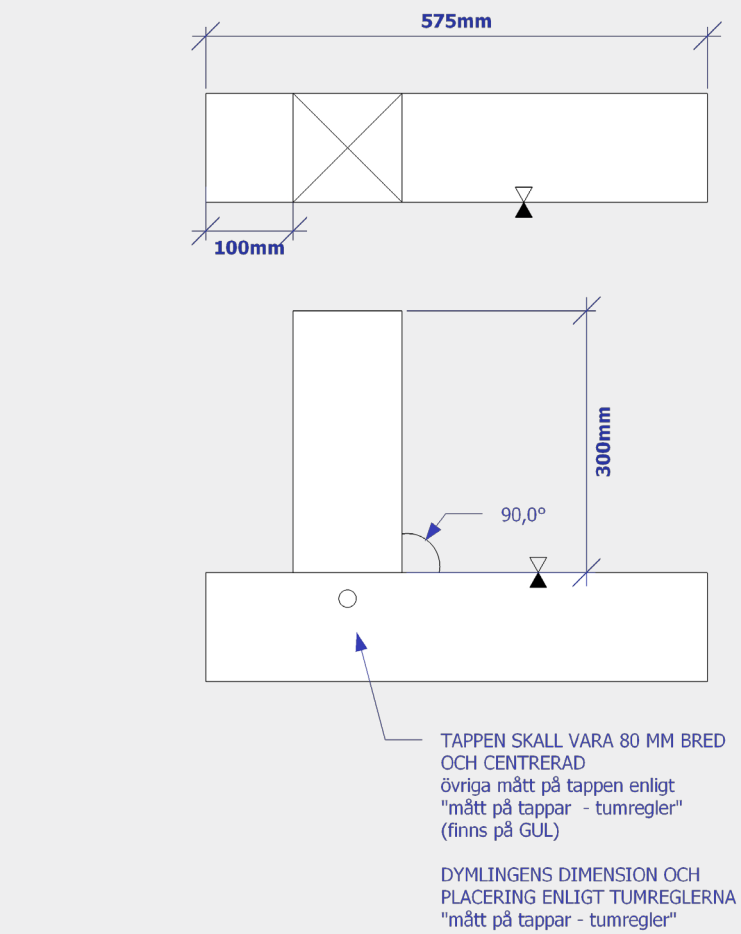
In an academic context it is important to describe the circumstances of the situation in order to be able to evaluate and discuss the result, although much of this will be rather technical to non-carpenters. For the practical understanding of the situation, it is also important to define and describe the tools and the conditions of the wood—to describe the situation that has to be resolved.

The timber used when recording the video is mill-sawn Swedish pine, *Pinus sylvestris*, which is not too dry.[6] It is not too dense (1–3mm between the year-rings), it has rather straight wood fibres, and there is both heartwood and sap wood in the timber. The dimensions are five by five inches (ca. 127x127mm). The parts of the timber were purposely chosen without obvious flaws, such as knots or cracks. The layout method is square rule without reductions—also known as mill rule (Lassen 2014, 111).

The joint design is based on the exercise we have used for the students for more than 15 years. The dimensions of the tenon are 40x100x80 mm[7] and the mortice is made 5 mm deeper (see Figure 9). The peg is 19 mm (3/4") and the peghole is drawbored at 2–3 mm to make the joint as tight as possible. The peg is made of pine heartwood and is planed to fit octagonally into the round peghole. In this case, it should fit tightly but not too tight, which means that there is enough resistance that it doesn't slip in and so that you do not have to hit the peg too hard so it ends up cracking. The sound of the peg going in is also very specific and changes the further in the peg gets, as the tone gets higher. When you have pegged a number of joints, you will know the good sound from the bad. This kind of sensory experience will be addressed in the next part.

The trestles are heavy and very robust, specifically made in timber framing for timber framing (building a trestle is a task taught later on in the course) and two heavy work clamps are used to keep the timber still when working. The tools used in the exercise are: a carpenter's square, a ruler, and a carpenter's pencil for marking (see Figure 10); a German 28 mm heavy duty framing chisel and a well-used round Danish beech wood mallet (1150 g) for the mortice; a new Bacho cross cut saw (277 7T/8P - 550mm) and an old Orsa rip saw (progressive teeth - 650mm) for the tenon, both of which can be re-sharpened; and an antique drill with C.I. Fall auger bits, a wooden bench plane, a wooden template for planing the peg, and a heavy hammer for the pegging.

Projekt: Övningsuppgift
Titel: Tapp och tapphål (material 5"x5")
Ritad av: Ulrik Hjort Lassen
Datum: 29-03-2016



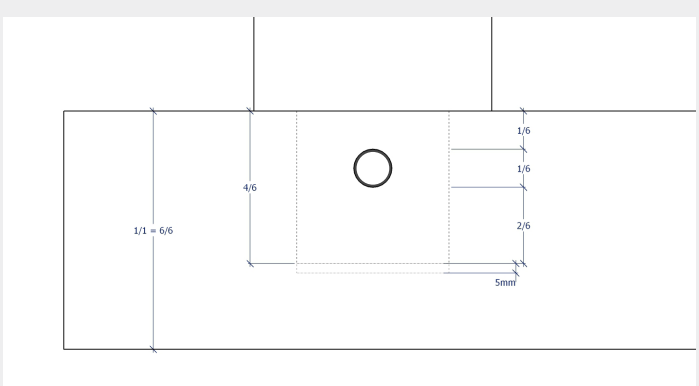


Figure 9: A) The exercise used for the students. B) Rules of thumb with measures for the tenon and peg. Text Illustrations: Ulrik Hjort Lassen.

Figure 10: The tools used for the video-based learning resource with the finished exercise in front. Photograph by Ulrik Hjort Lassen.

REPETITION AND SENSORY EXPERIENCE

To perform a specific task many times is an important part of learning craft skills, and in the master-apprentice system repetition has always been very important. Historically, carpenters usually started their careers as apprentices, where they were put on the most simple tasks in the beginning, such as carrying timber, sweeping the floors, or running errands. Slowly they would be given more complex tasks until the master was content with the result. This often meant that they repeated the same procedures over and over again, until they did them well (Molander 2015).

When talking about procedural knowledge, to do a thing well often means that the action is incorporated or internalised (Polanyi 1966). You do not have to focus on all of the details in the procedure when working. You know how to do it and when doing it you can react if something is not working as you want it to. To reach this point, to incorporate a procedure, it is necessary to repeat the procedure a number of times (Dreyfus and Dreyfus 1980; Rolf 2017, 51).

As an experienced craftsperson, the tools used turn into a prolongation of the fingertips when working, and you can somehow feel the condition of the wood through the tool when cutting. This can be defined as a kind of sensory experience of the practitioner, which can be compared to the way a painter recognises the properties of linseed oil paint by using their different senses (Källbom in this anthology).

This kind of sensory experience in timber framing is developed by repetitive actions. It is clearly possible to hear when a rip saw is sharp and cuts well, and when it does not, and to hear when the peg you are inserting into the peg hole is fitting properly or not. Nobody ever told me about this.[8] To develop this ability, you have to make many cuts with both sharp and blunt saws to get to know how it feels and how it sounds, and, furthermore, to be able to judge the result. Another example is when you cut a mortice with a chisel and a mallet and you feel that the chisel 'bounces' and doesn't really cut, which can be caused by a lack of support directly under the timber. A third example is when, finishing a tenon with a chisel, you can feel that the fibres of the wood are not cooperating and that you will have to turn around and cut from the other side. How do you explain this? It is very difficult to describe these sensory experiences in words. But, as a teacher, it is possible to demonstrate and to show these things in the practical situation, and for the student to actually see and hear how an action is performed is a very useful and educational tool for transmitting craft skills (Lassen and Wood 2013).

In the vocational schools, for logistical reasons, it is often not possible to get enough repetition in educational situations, and therefore it will be valuable to use video-based instructions so that the students will be able to watch the same actions over and over again using tablet computers or smart phones while they are on the work site. However, it is important to notice that the haptic dimensions are often overruled by vision, as eyesight is our dominant mode of perception (Groth in this anthology). The best way of learning must still be through repetitive actions. This is one of the challenges of the system for the vocational school and in using video-based learning resources, rather than using demonstrations and active guidance.

VIDEOING

Video has been used as an analytical tool with a focus on how to obtain good documentation of the working process. To make a video intended for publication, however, is something different. It is a craft in itself, where writing the manuscript or making the storyboard is only one part. How to capture a good sound, establish the right light conditions, and catch the right movements are difficult tasks for a novice (like me), as is the filming and editing necessary to produce a watchable video.

Of course, the amount of work put into filming and editing depends on the quality of the final result. In this case, the video quality when recording how I make the joint has not been of great importance. But the final result, the video-based procedural description, should preferably be of reasonable quality. In order to catch both the situation and the details, it was necessary to use two cameras at the same time, and this makes both filming and editing even more complex. The advantages of video in the documentation of working procedures now becomes a challenge, as the audio-visual media catches much more information than you might necessarily want to show (e.g., background noises), and this extra information might confuse the viewer of the video.

When the focus is on making learning resources, the most important aspect of this process is to capture the actions and to demonstrate how to 'do', how to hold the tools, with how much power to hit the chisel with the mallet, or which angles to hold the chisel at. The aim is that inexperienced viewers will get enough information to learn the procedure properly while keeping the attention on what they have to learn. Furthermore, the idea is also that more experienced viewers of the film will be able to notice other aspects of the working

Figure 11: Part of the final video-based learning resource, with one camera directly above me and the other camera in front of me. The rest of the video will be published together with the finished learning resource of the whole course *Stolpverk 1*. Click the image to see the video if reading a pdf version, scan the code to the right or go to: https://youtu.be/DbgFTBF__iE. Video by Ulrik Hjort Lassen.

process, especially when things are done differently from their own practice.

I set up two video cameras at the same time and filmed myself in action. One camera was placed in front of me capturing the whole situation, how I move, and how I hold the tools. The other camera was placed directly above me which enables the viewer to see what I see when I work, which is something that the students often cannot see during practical demonstrations, where maybe one person sees well and 15 others do not. I chose to speak on the video, rather than adding my voice to the video at a later stage which I had done in the earlier study (YouTube, Hantverkslaboratoriet 2014).

Editing the video is challenging. You do not want the video to be boring, but you also do not want to leave out important information. I chose to make short video sequences of the different steps so that it would be easier to find specific methods or parts. With the help of a professional film editor, it was possible to cut some of the more repetitive parts and some of the irrelevant parts so that the video was not too long for watching. An example of this can be noticed in the video, where both clamps are removed one by one without seeing me do that. The final result works rather well in the sense that it shows more or less what I intended (see Figure 11).

Naturally, it would have been a better product if a professional team had filmed me and edited the video. However, it is of great importance that the person filming knows what is important and how to catch this on film, and also that the person edi-

ting the film knows about the procedure. A good solution might be that there is a close cooperation between the camera operator, the editor, and the craftsperson. The present video must be considered as the first version. In the future, film makers would be able to watch this video and use it to see roughly what I intended the final result to be like.

Another challenge with video-based procedural descriptions is that moving images are very dominant. It is possible that the learner will consider the demonstrated procedure as 'the true method' or as 'the only right way' when this is not the case. But this way of thinking is often found in the trade of today (Lassen 2014, 29). Combining the video-based procedural description with a paper-based one can be one way to show or discuss alternative methods and approaches. The focus in this specific study has been to investigate how to make a video-based learning resource within the trade of timber framing. An important result is therefore the video. But another result has been to show the complexity involved when describing a simple working procedure.

PAPER-BASED PROCEDURAL DESCRIPTION

In the earlier study, the paper-based procedural description was created using simple instructions and static drawings. As such, this could work as an instruction by itself, even without the video (Lassen 2014, 201). It also included supplementary notes in an information panel alongside the more simplified instructions to allow a deeper understanding without disrupting the attention of the learner. It was practical for the student to take the instructions into the workshop and to communicate the basic practical instructions as bridges into the knowledge (Lassen and Wood 2013, 45). This was more several years ago, and today there are even more possibilities to bring moving images and animations into the workshop using tablet computers or smart phones, and to include the videos in the digital version of the learning resource.

Images are very important when communicating craft skills as they reveal information about something's shape, size, proportion, and volume, as well as orientation, which can be difficult to describe in words (Linscott 2017, 28). But when the aim is also discussion and reflection, text-based descriptions can add another dimension, as "writing […] allows the communication to be ambiguous and uncertain" (Linscott 2017, 28). This is again a concern, depending on the level of skill the learners have. The learning resource in this study is mainly meant for novice learners, and compared to the earlier study, the paper-based part of this learning resource should be simpler and contain less hands-on information (Lassen 2014, 175). It is to be a complement to the video or the practical demonstrations, and it should explain in short terms what happens in action in the video.

However, layout is still important, and it is preferable that text and images appear together so each adds meaning to the other. This corresponds to the cognitive design principles for learning resources, which require "adding pictures to words, eliminating extraneous words and pictures, placing words near corresponding pictures, and using conversational style for words" (Mayer 2003, 137). Furthermore, the illustrations should only show what is necessary, avoiding unnecessary details, and it is often better to use two-dimensional images when explaining working methods for learners (Wood 2006, 53).

CONCLUSION

This study shows some of the considerations involved when developing learning resources in a practical field, and it is a case study which was used for developing the entire learning resources for the course *Stolpverk 1* and for developing the manuscript and videos for the book *Bygga i stolpverk* (Lassen 2021). It highlights some of the complexity involved when a carpenter is to solve a simple problem within the trade of timber framing. To make a mortice and tenon joint is not complicated, and when timbers framer have done this a number of times, they can stop thinking about how they do it, and so it can be difficult to explain to others what they actually do, and how they do it.

In this study my own carpentry experience of making the joint has been used as the main body for the learning resource and video has been used as a tool to delve deeper into my own practice. As I have experience from both practicing the craft and from teaching, I have been able to notice and describe most of the little movements in the video. Needless to say, I have not been able to notice or describe everything, but with my experience from teaching I have been able to decide which movements are of importance for the novice learner and which are not. In this way I have been able to make a procedural analysis of my own approach, which would have been difficult for a researcher without practical knowledge of how to cut a mortice.

It is important to notice that there are different ways of cutting the joint. The focus has not been to find the best way of cutting the mortice and tenon joint, but to develop a learning resource appropriate for novice learners. A similar learning resource could be made of other approaches as well, and there is the potential to demonstrate some of the different situations in future studies on video-based learning resources when the learners are more experienced (see Westerlund in this anthology). Hopefully, this learning resource will help future learners within the trade to get a basic understanding for the use of hand tools when working with timber frames. In contact with other actors within the field of timber framing, such as architects, engineers and building conservators, it might be of importance to describe the complexity of (what appear to be) the more simple carpentry tasks in order to demonstrate the complexity involved in practical problem solving, in choosing the right tools, and in using the tools correctly.

To do the same task many times is important in order to develop craft skills and practical knowledge related to working with timber framing. Repetition has therefore been an important issue within the trade of historical carpentry, and even today it must be considered when working with learning resources in a practical field. The practical knowledge of the carpenter will enable him or her to make a diagnosis of the situation and to choose an appropriate approach to solve the situation. To a large extent, the practical knowledge is developed by repetitive actions which help to incorporate the procedures into the body and also to develop the sensory experience of the carpenter. In the research group at the Department of Conservation in Mariestad, an important focus has been placed on how to analyse and describe working procedures, both when studying masters of the crafts and when developing learning resources for novices. Depending on the activity, there are different methods for this, from only text-based step-by-step descriptions to video-based descriptions but also the use of more theoretical tools such as traceology or time geography (Jarefjäll 2016).

Video has proven to be a good tool for recording the actions involved in the procedure and for

the procedural analysis. It enables the practitioner (me) to focus on the working situation while actually performing it, to watch the video afterwards, and to analyse the procedure. The procedural analysis involved watching the recorded videos and writing down the procedure in text, and also separating the whole procedure into different steps. This has shown that there are many small steps and decisions that have to be made when cutting.

To make an instructional video is challenging. The advantage with video when recording working procedures for analysis is that a large amount of information is included in the video, but this also proved to be a challenge when recording for the instructional video, as too much information risks confusing the novice learner. However, a professional video editor will be able to cut out some of the irrelevant information. The video produced in this study must be considered as the first version, which could be improved by a more professional team. But even if the video-based learning resource is not perfect, it still demonstrates the working procedure, and combined with text and images in the paper-based learning resource it should be considered as an appropriate tool for transmitting craft skills when it is not possible to make workshops with hands-on demonstrations by experienced timber framers. Or, rather, it can be used as a complement to these demonstrations, enabling the learners to see what I see when working and to watch the same video sequences many times.

It would have added more credibility to the study if the result had been tested on groups of students to see how they respond to the learning resource, as was done in previous studies (Lassen and Wood 2013, 41–44). Hopefully, these learning resources will be tested many times by students and other learners, and therefore the evaluation of the learning resources will be a project for further studies.

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ENDNOTES

1. Timber framing is a type of construction where the load-bearing skeleton consists of square, two-side converted or round timber of dimensions four by four inches or larger, and where the internal and external loads are transferred to the ground by a cooperation between vertical, horizontal, and/or diagonally positioned timbers (Lassen 2014, 14).
2. The person who has mainly developed the structure of the courses, my former teacher and colleague Nils-Eric Andersson, sadly passed away in June 2017. Today the courses are changing for mainly economic reasons, and therefore the course structure from 2016 seems to be the best point of departure for the learning resource.
3. In the 1980s, a revival of building timber frames started in the USA and in 1985 the Timber Framers Guild was founded. They have published several books and, since 1985, a journal with much information on methods, structures, and tools, both relating to historical times and to the present day.
4. When used efficiently, the boring machine can take around half the time for cutting a mortice compared to a chisel and mallet (CRAFTLAB), but it is quite unusual in Europe and expensive to buy from the USA.
5. In Germany the mortice axe was forbidden by law at the end of the nineteenth century, as too many people died from cutting themselves in the face when trying to look at their work.
6. The video was recorded in the beginning of October 2018 and the timber was sawn in spring of the same year.
7. In the exercise (see Figure 10) the tenon is defined to 40x80x80 mm, but I have found that it is better for the students to have a mortice which is a little longer, as it is easier to clean out the chips in the bottom.
8. When I started my carpentry career in the Danish vocational school, we used a cross cut saw when cutting timber lengthways. There, I experienced that cutting in this way with a handsaw is not an attractive approach. The first time I tried a rip saw, at the Department of Conservation in Mariestad, I realised that this approach works rather well. Most Danish carpenters believe that a hand saw is not an attractive choice of tool for cutting lengthways.