The Acquisition of Skill in Early Flaked Stone Technologies:
An Experimental Study

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I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

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Abstract

This thesis describes the experimental work carried out as part of the Learning to be Human Project, investigating skill and learning in early flaked stone technologies. A group of 16 volunteers were studied as they learnt skills in Oldowan style flaking, Acheulean handaxe technology and Levallois preferential flake technologies. Aptitude, practice hours and hours spent in taught sessions were recorded and skill in each of these technologies was assessed at regular intervals. This information was used to answer questions concerning the acquisition of high level skill in these technologies, the role of practice, teaching and aptitude in determining skill in terms of connaissance and savoir-faire and the archaeological visibility of skill. At a more in depth level the significance of these findings for cognitive capacities of early hominins and the evolution of modern human brains and intelligence was assessed.

The results of these experiments allowed the identification of the greater impact of teaching on Acheulean handaxe and Levallois technology compared to Oldowan style flaking. Technologically focussed teaching was shown to be essential for achieving high level skill in handaxe technology while all knapping contributed to the skill achieved in Oldowan style flaking and Levallois technology. In terms of aptitude, previous craft experience and contact with flaked stone assemblages most affected skill achieved in handaxe and Oldowan technologies while spatial ability best determined skill in Levallois. The findings of the connaissance and savoir-faire analysis have indicated that the differences seen between Oldowan and Acheulean technology are predominantly physical in nature, while the differences between Levallois and the earlier technologies are cognitive. This suggests a greater cognitive capacity for the Neanderthal Levallois manufacturers in contrast with the earlier hominin species. The results have, however, highlighted problems with a strict dichotomy between physical and cognitive skills. A number of material markers that could be related to skill were identified. Future work has been identified that could provide a fuller understanding of these findings.

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1. Introduction

Flintknapper skill plays a very important role in the formation of flaked stone assemblages. Skill limits the types and shapes that can be made by a knapper and, as such, is a concept that must be confronted to gain a full understanding of the factors that determine the character of archaeological lithic assemblages. Beyond this, an understanding of skill and its identification in assemblages can give information on the social structures that surround learning in stone tool making communities. Building on the theories of Lave & Wenger (1996) apprenticeships can be seen as means of gaining entrance into communities of practice and moving from peripheral to full participation in society. Information such as this can be applied to archaeological examples of low skilled tool making performance and used to give information on social interaction between learners and experts.

Information on social factors is particularly important in time periods as remote as the Palaeolithic where next to nothing is known about social structure. In the Lower to Middle Palaeolithic, during the time hominin brains were in the process of evolving to modern human capacity, an understanding of the social structures that underpinned lithic learning can give information on the necessary cognitive capacities that such social interaction would require. To understand the role of the stone tool technology in the evolution of modern human brains and intelligence, an understanding of the ways in which high levels of skill can be acquired is essential. For instance, if teaching is the most important factor in allowing an individual to become highly skilled this suggests that social learning would have been a significant area of development in early periods. If, in contrast, natural ability in certain cognitive or physical areas determines skill level achieved these areas should be investigated as likely significant for human cognitive evolution. These points illustrate the importance of gaining an understanding of the skill level that is represented by archaeological remains. Despite a large number of experimental studies previously focusing on this area (e.g. Apel 2008; Bril et al. 2000; M. Eren I. et al. 2011; Ferguson 2008; Finlay 2008; Shelley 1990; Stout & Chaminade 2007; Stout et al. 2008; Winton 2005), a comprehensive understanding of skill acquisition and the learning process in flaked stone technologies has yet to be achieved.

Building on the work of previous experiments, this study uses experimental knapping to gain an understanding of skill acquisition in Lower and Middle Palaeolithic flaked stone technologies. In order to achieve a more complete picture of the learning process the majority of volunteers studied had no previous knapping experience. This enabled the mapping of all the hours of practice and learning that contributed to their knapping skill. Due to practical constraints many previous experimental studies have taken place over short time periods and involved few participants. Skill acquisition and learning are necessarily long term processes, with psychological literature stating that it typically takes 10 years to become expert at any pursuit (Wynn & Coolidge 2011, 85). For this reason participants in this experiment were studied for a longer than usual time period of nearly two years. This represented an attempt to map their learning from no knapping experience to competent stone tool makers. Previous studies have often taken place over a single knapping episode and usually last no longer than a couple of weeks (Bril et al. 2000; Finlay 2008; Geribàs et al. 2010; Stout & Chaminade 2007).

At a more in depth level this study attempted to gain a greater understanding of the reasons that some individuals gain high levels of skill while others do not. Very few previous studies have looked at aptitude as a factor in determining skill level and those that have focus on modern knappers who are already experienced in the field (Olausson 1998; 2008). By giving aptitude tests to participants before any knapping was carried out it was possible to map the influence initial aptitude had on skill level achieved in the project, giving unprecedented information on this area of flintknapping skill acquisition. Practice and teaching hours have also been tracked so that the different levels of influence these areas had on skill achieved could be compared to that of aptitude across the technologies that the project focused on. These differing influence levels have been used to give information on the different requirements for teaching or practice in different technologies and the different areas of aptitude that may precondition someone to achieve a high level of skill. This information is vital if a comprehensive understanding of the ways people learn in these technologies is to be gained.

These factors can also give information on the cognitive capabilities that would be required for stone tool manufacture in early technologies. By investigating these areas a greater understanding of possible cognitive abilities of early stone tool making hominins and the importance of specific areas of development for the evolution of modern human brains and intelligence can be achieved. For instance, in cases where high levels of spatial ability are crucial for allowing a high level of skill to be achieved in a particular technology, it can be stated that the development of spatial abilities was an important cognitive development that allowed the innovation of that type of technology. This is another area that this thesis seeks to shed light on through experimentally derived data and analysis of the chaîne opératoire of early flaked stone tool technologies. There are, necessarily, issues in inferring hominin cognitive capacities from data produced through experiments involving individuals with modern human brains. Stone tools are, however, one of the few areas of evidence with which we can address hominin capabilities (Stringer & Andrews 2011, 208) and only through experimentation can we gain a full understanding of the different requirements for learning and practice of individual flaked stone technologies.

Beyond these areas this study also critically assesses the means by which we currently identify skill in archaeological lithic assemblages. Skill is a complicated concept, which can have limited artefactual visibility but has been the focus of many, particularly experimental, studies (e.g. Apel 2008; Bril et al. 2000; M. Eren I. et al. 2011; Ferguson 2008; Finlay 2008; Shelley 1990; Stout & Chaminade 2007; Stout et al. 2008; Winton 2005). Different areas of ability that make up a person's skill in a technology have been identified and usually given the terms connaissance and savoir-faire, or knowledge and know-how (Pelegrin 1990, 118). Our ability to identify these different areas of skill in archaeological lithic remains has been assessed in this study as well as the utility of such a division. Studies have also focused on the embodied nature of skill, knowledge and cognition (Ingold 2000, 291–2). Here the links between the adaption of the body to learning new skills and the cognitive abilities that this involves are highlighted, moving away from a strict dichotomy of physical ability and cognitive understanding. For this reason the links between areas of ability that have been labelled as connaissance and those that have been labelled as savoir-faire have been a focus in this study as well as the identification of these different areas of skill. In addition to this, markers of high and low skill identified in previous experimental studies, have been considered together with their accuracy for distinguishing skill levels that have been assigned based on actual knapping performance. Through these means it is hoped that it will be possible, building on the work of previous researchers in this area, to create more secure means of identifying knapper skill from archaeological remains. The experiments described in this thesis took place as part of a research project funded by the Leverhulme Trust. The Learning to be Human Project was a collaborative study that aimed to use experimental archaeology to answer questions about flintknapping skill acquisition and early hominin cognitive processes. The project had three main strands, one, led by Dietrich Stout, focused on the analysis of fMRI scans of knappers in the project before any knapping had taken place, in the middle of the project and at the end after two years of knapping teaching and practice had taken place. These scans were used to observe changes in brain activations influenced by knapping practice and skill level. Another strand led by James Steele and Stuart Page used the knappers in the project in transmission chain experiments to investigate changes in blade and handaxe form through time. The final strand was the study of flintknapping skill acquisition that this thesis focuses on which was led by Professor Bruce Bradley at the University of Exeter. All these strands were linked by the use of the same group of experimental flintknappers and a focus on Oldowan style flaking, Acheulean handaxe and Levallois preferential flake technologies.

The work described in this thesis was designed largely to support the potential neurological findings that would stem from the fMRI analysis of the experimental knappers. This put a number of constraints on the research programme that had to be incorporated into the methodology. For a successful series of brain scans it was necessary that a group of individuals with no prior experience of flintknapping be recruited. This group were required to be either all right or left handed and could not have any qualities that would exclude them from research scanning (e.g. tattoos or metal implants). The scans were intended to highlight differences in activations in the different early technologies on which the project focussed. For this reason all knappers in the group had to be taught all technologies so direct comparisons could be made between the activations in individuals. The timing of skill evaluations in these technologies was also dictated by the requirements of the brain scanning schedule as these were designed to coincide in order to relate brain activity to skill level. While these constraints necessarily affected the results of the skill study presented in this thesis they allowed the project as a whole to produce a strong dataset that could combine evidence of skill with neurological factors to expand our understanding of three early flaked stone technologies and how these relate to hominin cognitive evolution.

The three technologies that the project focuses on are some of the earliest practiced by our hominin ancestors and each have distinct features that may require different levels of teaching, practice or natural aptitude to master (Mithen 1996, 132–5). Oldowan is a basic flake production technology often referred to as mode 1, Acheulean handaxes are more complex bifacial tools requiring greater planning and strategy, referred to as mode 2, and Levallois is a prepared core technology that involves the understanding of a number of defined steps and complex platform preparation, referred to as mode 3 (Stringer & Andrews 2011, 208-9). For this reason these technologies had the potential to produce interesting results both in terms of answering questions about the cognitive capabilities of hominin tool makers and the social structures that are necessary for learning. Using three different technologies also allowed assessment of the utility of different measures of skill to different technologies, as it was deemed unlikely that high levels of skill would manifest themselves in the same way in each technology. All the data analysed in this thesis are derived from experiment, based on replication of Palaeolithic tool types by a group of volunteer flintknappers. By assessing knapping performance as well as the materials produced, a fuller picture of what is represented by assigned knapping skill level has been achieved which can be applied to archaeological assemblages more successfully than previous approaches.

A long term experimental study of flintknapping skill acquisition and learning is an important innovation in the field of skill studies. Building on previous work in this area, it has provided an unprecedented amount of data on the ways skill is learnt in specific technologies. As mentioned above this study took place over a much longer time period than most similar experiments, which has undoubtedly been of benefit in providing a fuller picture of the learning process. Additionally this study has involved a far larger number of participants than most previous experiments in skill and learning. These studies often involve only two or three learners (although there are some exceptions: e.g. Geribàs et al. 2010; Nonaka et al. 2010; Roux & David 2005). A larger sample size of knappers can be of value in producing more reliable results and in providing a wider range of different initial aptitudes and abilities in the study group. This has helped to identify whether patterns seen in learning apply only to individual cases or appear across a number of individuals. It is only through longer term projects with wider participation such as this that the field of flintknapping skill acquisition experiments will move forward.

In summary, the work carried out for this thesis had two major aims the first was to investigate how skill may be acquired in Early to Middle Palaeolithic technologies and the second to assess the means by which we currently identify skill level in the archaeological record. The first of these areas has the potential to more widely provide information on early hominin cognitive capacities and the necessary social structures that surround learning in stone tool making communities. The second area is one in great need of investigation, if we are to move beyond identifications of what constitutes skilled and unskilled work in the archaeological record based on simple assumptions or the findings of short term experiments with few participants. The long term nature of this study has not only allowed a large amount of data to be gathered on the learning process, it has also necessitated the introduction of new methods due to the practical constraints of such a study. For instance, the use of moulded porcelain as a raw material for use in skill evaluations in the study is an innovative technique that enabled the same size, shape and quality of raw material to be given to each individual (Khreisheh et al. 2013). New methods such as these have the potential to advance the field of experimental lithic studies even further.

A review of previous work relating to skill acquisition and early flaked stone technologies in Chapter Two is followed by a detailed methodology, in Chapter Three. The results of the skill evaluations, related to levels of practice, teaching and materials produced for each of the technologies (Oldowan style flaking, Acheulean handaxe and Levallois preferential flake core technologies) on which the project focusses are presented in Chapters Four, Five and Six respectively. Chapter Seven introduces the concept of aptitude as a contributing factor to the level of skill achieved in each of these technologies, with results based on aptitude tests performed at the beginning of the project. This information is built on in Chapter Eight that comprises a detailed reflection on the role of connaissance (knowledge) and savoir-faire (know-how) on skill in specific flaked stone technologies and the wider archaeological implications this has. Finally, in Chapter Nine, the findings of the project are summarised, used to make comment on the cognitive development of early hominins, and related to the initial research aims.

2. Skill Acquisition and Hominin Life in the Early and Middle Palaeolithic

2.1 Introduction

The identification of skill in archaeological assemblages and the methods by which it is acquired are currently issues at the forefront of research into flaked stone technologies, with a recent edition of the Journal of Archaeological Method and Theory (2008) dedicated to this field. The cause of this attention can be partly attributed to an increasing focus on identifying the individual in archaeological remains. Identifying different skill levels in the same types of artefacts in an assemblage should allow for the identification of different individuals carrying out the same tasks (Finlay 2008). Identification of skill level is often coupled with attempts to identify idiosyncratic knapping style in order to locate the work of individual flintknappers based on their unique methods of production (Bamforth 1991). Another reason for this increase in interest is a new focus on identifying groups that have been previously ignored in archaeological research, in this instance children (i.e. Baxter 2005). Ethnographic studies of modern human knapping groups have suggested that children as young as 10 could begin craft apprenticeships (Roux & David 2005, 93). Prehistoric craft novices, displaying less skilled behaviour, have often been equated with children and those trying to create an archaeology of childhood (Shea 2006) have looked to the identification of novices to further their interpretations.

This study focused on the issues of the acquisition of high level skill in flaked stone technologies, with particular reference to Oldowan, Acheulean handaxe and Levallois preferential flake technologies. It involved the experimental study of a core group of knappers who were intensively taught these technologies, as well as a wider cohort of knappers with a range of experience levels. The methods of analysis of materials produced during skill evaluations made use of previous works that have focused on tool and debitage analysis (e.g. Andrefsky 1998; Hardaker & Dunn 2005; Odell 2003; Whittaker 1994). Previous literature most relevant to this study falls into four main areas: cognitive development, skill, learning and aptitude. Within each of these areas studies that have gained their data from one or more of three approaches –

experimental studies, ethnographic studies and archaeological assemblages have been highlighted for review. The major previous publications in the four main areas of research are assessed below, with a particular focus on those that directly relate to the three technologies that this study takes as its core.

2.2 Cognitive Development

Studies of the cognitive development of human species is relevant to this study as the cognitive complexity of the three technologies on which it focuses has a bearing on the assessment of skill of the knappers' attempts at replication during skill evaluations. Hominin cognition was likely affected by the requirements of stone tool manufacture; however, investigating what form this influence took is a complicated matter (Moore 2010, 34). A good overview of previous literature on the subject of deriving evidence for cognitive abilities from stone tools can be found in Davidson and Nowell (2011), an introduction to an edited volume of papers on the evolution on human cognition. The cognitive development of hominin species is a topic that is of particular interest in the field of human evolution. Roth and Dicke (2005) have looked at the aspects of intelligence that set humans apart from non-human primates. They concluded that it is having a theory of mind, the ability to imitate and language in combination and enhanced from that of non-human primates that distinguishes us. This is useful in that it sets out distinct areas of cognitive advancement that may have allowed for the development of stone tool technologies in hominin as opposed to other species. Following on from this, comparisons of the tool making of chimpanzees and early hominins can give information about the different cognitive demands of each tool making task (Davidson 2011). This information can be used to identify areas of cognitive ability that set us apart from other tool using primates and thus are significant areas for investigation in this study.

Much of what has been written about the increasing levels of cognitive ability in the evolution of *Homo sapiens sapiens* has been based on their stone technologies, as stone artefacts are the primary source of durable evidence for their behaviour (Pelegrin 2005, 23). A number of studies that look at this evidence have tried to draw conclusions about the learning or teaching implied by the types of technologies employed by these early hominins (e.g. Pelegrin 1990; Stout 2005; Winton 2005). In addition to comparison of the cognitive requirements for tool manufacture, studies have also compared the inferred learning and teaching necessary to achieve success in early stone tool technology with that seen among monkeys and primates. These studies look at degrees of imitation, trial and error and independent invention seen in the transference of knowledge of tool use in different species. For instance Byrne and Russon (1998) investigate the role of imitation in social learning in modern apes suggesting that some behaviours that have been previously dismissed from consideration may in fact be imitation but at the program rather than action level. The introduction of the idea of program level imitation may be a way to understand how lithic skills in Oldowan technologies were transferred. While this study did not attempt to replicate prehistoric learning and teaching styles, considerations of the necessary levels of teaching implied by the technologies that the research focuses on is relevant as a greater requirement for teaching implies a greater social and cognitive complexity in the hominin species that made and passed on knowledge of these technologies.

Another focus has been on identifying the differential levels of prior planning involved in Oldowan core reduction compared with handaxe technologies for instance and using this to give information on the different cognitive competencies of the makers of each. Studies have demonstrated that even from the earliest periods Oldowan tool manufacture showed a high level of technical competence in terms of knowledge of conchoidal fracture properties (de la Torre 2011, 58). Handaxe technology, however, has been stated to show evidence of superior cognitive abilities in that it appears to represent an imposed form on raw material (Stringer & Andrews 2011, 209). Pelegrin (1990), for instance, discusses how symmetry can be seen as an indicator of imposed form, which seems to appear in the Acheulean for the first time. He sees this as signs of an ability that goes beyond simple memorisation of actions and gestures and allows for the achievement of a fixed intended outcome within the constraints of the raw material (Pelegrin 1990, 122). To achieve this imposition a level of planning is necessary. The necessity for planning and its importance in distinguishing between the cognitive abilities of different human ancestors has been an area of some disagreement. While many authors (e.g. Mithen 1996; Pelegrin 2005) agree that Acheulean handaxes and Levallois prepared core technologies show a level of planning and goal directed behaviour not seen in the Oldowan tool types, others (Noble & Davidson 1996) do not see planning or imposed form in handaxes or Levallois cores. The differing requirements for planning between the technologies has been investigated in this study, in part by investigating levels of symmetry present in handaxes, as well as evaluating the technological strategy of knappers. In addition to planning abilities, Pelegrin (2005) has stressed the importance of the ability to form mental templates as a factor that determines ability to carry out flaked stone technologies and the cognitive implications this has for the evolution of modern human brains and intelligence. This is another aspect that is addressed in this study, which has examined how aptitude in different areas, including spatial visualisation, preconditions someone to success in each of the technologies on which the study focuses.

The degree of planning and goal directed behaviours required for certain technologies and the necessity for a mental template has led to discussions of the capacity for language for the species' involved in their creation. Some work has identified similarities in the requirements of, for instance, making a handaxe and forming a sentence (Holloway 1969). As mentioned above, some have also seen the imposition of a specific form in the manufacture of handaxes, as implying that early hominins held a mental template of what a handaxe should look like (Mithen 1996, 132–3). This is cognitively significant for the origins of language as it can be seen as a form of symbol (Wynn 1995). Words hold the same position as symbols for things or actions and this implies that similar cognitive developments are required to allow both for language and elaborate knapping activities such as handaxe and Levallois technology. Works such as Vygotsky's (1976) that look at child development for what it can tell us about the evolution of higher psychological processes such as language in human evolution, also have some use here, although there are issues with this model (Mithen 1996, 66). Aspects of this work deal with the links between tool use and language in small children which have implications for the importance of the development of language in allowing tool use for early hominins. Arbib (2005) has looked at the possible evolutionary development of language in detail, seeing it as a progression from hand gestures to single word units to syntax and highlights the fact that Broca's area (the area in the brain that has been shown to control language) is also activated by grasping motions. This is important as it implies that the greater control of hand movements required by more complex knapping activities may have also allowed for greater complexity of language.

There have been attempts to move beyond theoretical models to scientifically test the different cognitive competencies required for different knapping technologies. Positron emission tomography (PET) studies of functional brain activation after experimental replication of Oldowan and Acheulean handaxe technology has been used to assess which parts of the brain are involved in these activities (Stout & Chaminade 2007; Stout et al. 2008). Scans of people who had performed Oldowan style flaking revealed activations in areas associated with fine finger movements and the manipulation of objects, whereas those who had performed more complex Acheulean style knapping sequences showed activations in areas associated with visuospatial representations and hierarchical action organisation (Stout et al. 2008, 1944, 1946). This information is useful in determining what kind of intelligence is implicated as necessary for success in stone toolmaking. It implies motor skills and spatial representations are key areas responsible for flintknapping ability and these areas have been the focus of aptitude assessments of the participants in this study.

The majority of authors, regardless of their approach to the evidence, are in agreement that Acheulean handaxe and Levallois core technologies show a degree of planning and imposed form not seen in Oldowan tool technologies (with some notable exceptions – Noble and Davidson 1996). For most this also implies a greater degree of cognitive development in the species involved in Acheulean and Levallois technologies, which may imply the presence of language in these communities. Approaches that look directly at the cognitive requirements of Levallois technology have highlighted the importance of long term working memory in allowing successful manufacture (Eren & Lycett 2012; Wynn & Coolidge 2004; 2011). These studies have helped indicate the cognitive abilities of Neanderthal knappers and made comparison with modern human abilities to form conclusions that while different they were equally intelligent (Kuhn & Stiner 1998, 157). The experimental skill acquisition that took place for this study involved replication of Oldowan style flaking, Acheulean handaxe and Levallois preferential flake core technologies. The differences that have been seen in the ways the technologies are learnt over a longer time period than is usually allowed for in an experiment and with an expert teacher have provided information that adds to our understanding of how these skills can be learnt and what it takes to become proficient at them. These results are discussed in detail in the following chapters.

This study has approached the field of cognitive development by examining a group of volunteers as they experimentally acquired skill in three of the earliest technologies practised by our hominin ancestors. The differences that have been seen in the way these technologies were learned by the individuals in the study has given information on the amount of teaching as opposed to independent learning required for each. An understanding of the natural aptitudes of the study group was also sought with the hope that it would help elucidate the particular skills and abilities that precondition someone to achieve high-level performance in a flaked stone technology. These areas build on the work of the researchers discussed above to provide further information that can be used to infer cognitive abilities from the stone tool remains produced by our hominin ancestors.

2.3 Skill

The main aim of this study is to achieve a comprehensive understanding of the ways in which high skill level may be achieved in flaked stone technologies. This has involved analysing the products of the volunteer knappers in the project and the processes by which these products were achieved. Bamforth and Finlay's (2008) introduction to a volume of the Journal of Archaeological Method and Theory dedicated to lithic production skill and craft learning provides a good overview of archaeological work in this area and includes two tables that summarise characteristics of stone tools that have been used to indicate high and low levels of skill in previous literature (Figs 2.1 and 2.2). These characteristics can be used as a good starting point for recognising skill levels in archaeological assemblages.

Characteristic	Some Examples
Unusually large size	Clovis ceremonial points: Frison and Bradley 1999 Bamforth and Hicks, this volume Scandinavian daggers: Callahan 2006; Nunn, Apel, this volume
Extreme thinness relative to width	Folsom "ultrathin" bifaces: Root 2000 Ferguson, this volume
Extreme length relative to width or thickness	Adzes in Irian Jaya; Stout 2002, 2005; Scandinavian daggers, Callahan 2006
Extremely complex outline form	Mayan eccentrics; Fash 1991:100, pp. 103–104, 147–8; Titmus and Woods 2003
Regularity of form	Whittaker 1987; Finlay; Sinclair, this volume
Volume	Bamforth and Hicks, this volume
Plan-view symmetry	
Smooth/symmetric cross-section	Bamforth and Hicks, this volume
Precise and regular finishing flaking	Post-Folsom Paleoindian points: Bradley and Frison 1987
Intentional "overshot" flaking	Clovis bifaces: Frison and Bradley 1999
Minimal platform preparation	Mesoamerican blades: Andrews 2003
Very low metric variation in artifact size	
Reliance on complex, patterned multistage reduction strategies	Folsom points: Winfrey 1990 Bleed, this volume Apel 2001; Apel and Knutsson 2006, this volume
Consistency in production	Finlay, this volume

Figure 2.1. Markers of high-level skill in flaked stone technologies (Bamforth and Finlay 2008, 5).

Characteristic	Some Examples
Irregularity in form	Ferguson, this volume
Predictable errors	Experiemental: Ahler 1989; Shelley 1990; Upper Palaeolithic: Pigeot 1990
Stacked steps & hinge terminations	Nichols and Allstadt 1978; Ahler 1989; Shelley 1990; Andrews 2003; Clark 2003; Milne 2005
Mis-hits and hammermarks	Shelley 1990; Pigeot 1990; Clark 2003; Finlay, this volume
Inconsistency in production	Finlay, this volume.
Wasteful and ineffectual use of raw material	Shelley 1990; Ferguson, this volume; Högberg this volume
Failure to rejuvenate	Pigeot 1990.
Low length/breath flake ratio	Fischer 1989, 1990; Stout 2002, 2005
Deviation from expected chaîne opératoire	Grimm 2000; Fischer 1990; Högberg 1999, this volume
Peripheral spatial knapping location	Bodu *et al.* 1990, 1996; Pigeot 1990; Grimm 2000; Högberg 1999, this volume

Figure 2.2. Markers of low-level skill in flaked stone technologies (Bamforth and Finlay 2008, 6).

The information from the above figures (2.1 and 2.2) can be used in addition to studies such as those of Andrews (2003), Callahan (1979), Clark (1997; 2003) and Sheets (1978) that have identified differing error levels in prehistoric artefacts to give an indication of the features that are significant in determining skill level in flaked assemblages.

Most previous experimental work that has looked at skill level has focussed on the recognition of high and low levels of skill in the archaeological record in various different technologies. A review of previous knapping experiments into skill acquisition and teaching illustrates the number and variety of experiments that have taken place in this area (Table 2.1). For instance Finlay's (2008) experimental study into late Mesolithic blade core knapping aimed to establish what assemblage attributes best determine skill in this technology (Finlay 2008, 74). This experiment involved six knappers of mixed abilities (from 25 years to no experience) replicating blade core technology using beach pebbles. The small sample size and short period of time for the knapping episodes (1-3 hours) limit the usefulness and applicability of the results of this experiment but it did give some indications of where skill lay – the main difference between the knappers was that those more experienced were better able to read the raw material and overcome flaws. It also indicated that those of medium skill level could display features of both experienced and novice knappers (Finlay 2008, 84–5). This highlights the difficulty of recognising middle skill levels in the archaeological record.

Shelley (1990) similarly used the products of novice and expert knappers produced experimentally to give information on the markers of high and low level skill in the archaeological record. This study looked at errors produced, error corrections and the morphology of materials produced, finding that beginners committed more fatal errors, produced more stacked steps and hinges and did not prepare platforms (Shelley 1990, 188–91). Eren (2008) and Eren et al. (2011) have also looked at ways to identify skill but in this case with a focus on Levallois tortoise core technology. Eren concluded that by looking at termination type, core mass, surface area of flake to core and symmetry, that it was not possible to identify individual skill level because there was too great an overlap between expert and learner performance (Eren 2008, 85). Eren et al. have a more encouraging conclusion, although still stressing that the overlap makes secure skill level identification difficult, they set out some evidence for areas of preferential Levallois flake removal that can be used as skill markers

Table 2.1 – Previous skill and learning experiments

Author	Aim	Technology	Participants	Period	Method	Result
Apel 2008	To reproduce the chaîne opératoire involved in Late Neolithic flint daggers	Late Neolithic Scandinavian daggers	Errett Callahan (an expert knapper), and the author	2 summers and a 3 week knapping course.	Production stages were identified in replication of daggers out of Senonian flint by Errett Callahan. The author attempted to reproduce them and from these built up an idea of the amount of skill involved in each stage broken down into connaissance and savoir-faire.	The stages of dagger production involve different levels of required connaissance and savoir-faire that would require different skill levels of individuals from apprentices to experts to carry out.
Bril et al. 2000	To measure knapping skills "universally" in terms of apprenticeship duration and assess to what extent observable performances reflect the real abilities of the craftsmen	Harappan stone bead preforms.	12 craftsmen, 6 who produced high quality beads daily and 6 who produced low quality.	1-1.5 days.	Each craftsman knapped 80 roughouts of different shapes, dimensions and materials. Activity and acceleration of the hammer was recorded. Analysis was carried out on the finished product, the knappers plan of action and the structure of elementary movement.	Results confirmed hypothesis that the best craftsmen would adapt to the new material the best. Plan of action did not distinguish between the two groups. Elementary actions, appear to be determinant as a high level of expertise is characterised by acceleration, while minimising energy.
Eren 2008	To see if it is possible to identify skill levels in Levallois preferential core technology.	Levallois preferential core.	Metin Eren (beginner skill level at Levallois, some experience of other technologies).	3 months.	100 Levallois cores were knapped over a period of 3 months with the aim to take as large a preferential Levallois flake off the surface without overshooting. Various material attributes were analysed.	Concluded that it was not possible to identify individual skill level because there is too much overlap in performance.

Author	Aim	Technology	Participants	Period	Method	Result
Eren et al. 2011	To identify the markers of skill level in Levallois tortoise core technology.	Levallois tortoise core.	Metin Eren (intermediate skill level) and Bruce Bradley (expert).	c. 3 months.	Eren knapped 100 cores over 3 months aiming to take as large a preferential Levallois flake off the surface without overshooting as possible and being as conservative as possible with material. Bradley's cores were from a knapping session 30 years previously but also knapped 5 cores as a more recent comparison.	Identified 4 measures that are potential markers of skill level: total stone consumption during initial core preparation, consumption from upper and lower core surface, symmetry of the first detached levallois flake and failure rate of flake detachment by overshooting.
Ferguson 2008	To examine the efficiency of raw material use for 2 different models of teaching the pressure flaking of small projectile points.	Pressure flaking projectile points.	Author and 4 men and 4 women aged between 21 and 36 years of age, only author had prior knapping experience.	Completion of 30 projectile point attempts each.	Subjects were divided into 2 groups of equal men and women. Group 1 were shown a point production attempt and then only received verbal instruction. Group 2 were also given a demonstration but then were taught using scaffolding method. Every 5th arrowhead and the final 5 were completed without scaffolding comparison.	Group 1 only yielded 2 marginally competent knappers, 3/4 subjects in group 2 produced near identical arrowheads to author's. Scaffolding process is conservative of raw materials.
Finlay 2008	To explore what features characterise Late Mesolithic blade cores and debitage produced by different knappers. To address consistency in knapping and to examine what assemblage attributes best determine skill.	Late Mesolithic blade core microlith blank making using direct percussion	6 knappers of mixed ability from 25 years to no experience. 5 men 1 woman.	1-3 hours.	Each subject knapped a number of flint beach pebbles with aiming to create suitable blanks for microlith manufacture using direct percussion. 3 of the knappers worked separately and 3 as a group.	Cores of beginners showed clear signs of novice work. One of mediocre group produced cores that showed experience and that showed inexperience. Most experienced produced longest and most complete blanks. Knappers differed in the consistency of production. There were few idiosyncratic elements.

Author	Aim	Technology	Participants	Period	Method	Result
Geribàs et al. 2010	To determine what technical gestures must be learned in order to produce stone tools	Crude handaxe	18 volunteer participants - 9 experts (7 men, 2 women, average age 41) and 9 novices (7 women, 2 men, average age 32).	Information not provided.	Participants were asked to knap a crude handaxe out of a house brick based on a model knapped by an expert knapper. They performed as many attempts as they wished until they were satisfied with the results. The knapping process was filmed.	3 main technical gestures distinguish experts from novices - type of percussion support, the position of the blank and the angle of percussion. These are therefore the technical gestures that have to be learnt to successfully knap stone.
Nonaka et al. 2010	To provide data on skill at controlling conchoidal fracture that can be used to help infer processes responsible for technological diversity in the Early Stone Age.	Oldowan style flaking.	22 participants, five women and seventeen men - 5 were experts, 6 intermediates and 11 novices.	One 2 hour training session for novices plus 3 flake removals.	Each participant drew three flake predictions onto a flint core using a paint marker, followed by three removals. Movements of the striking arm were recorded using a magnetic tracking system.	Only experts were able to predict the flakes. Experts predicted and removed longer flakes and selected a flat or convex face for removals. The kinetic energy used only reflected the dimensions in the expert group and their strikes tended to accompany relatively lower kinetic energy.
Roux and David 2005	To investigate the relationships between motor and cognitive abilities and between the mastery of functional movements and courses of action.	Knapping of stone bead rough-outs	22 artisans of 4 different levels of expertise - high level experts (average 48 years old), low level experts (33), high level learners (20), low level learners (18).	Information not provided	Each artisan was asked to knap 16 bead roughouts from a selection of pebbles, 8 with a parallelepipedal cross-section and 8 with a triangular cross-section. The manufacturing process was recorded with a video camera.	3 main methods of making roughouts were identified. Learners of both groups appeared to know methods even though they had never carried out the task before. There was a correlation between level of expertise and method. Most often it is impossible to infer level of expertise from the course of action followed. Knowledge of methods is not enough to produce high quality beads.

Author	Aim	Technology	Participants	Period	Method	Result
Shelley 1990	To assess how variation in lithic assemblages can be accounted for by the skill of the knapper.	Various	31 novice knappers and 11 experienced knappers	Study of materials produced over a period of 11 years.	Samples from various reduction strategies were collected from students at the beginning and end of 15 week courses in flintworking. Samples were also collected from experienced flintworkers. Various material and technological attributes were recorded.	Beginners made more fatal errors leading to core discard, more stacked step and hinge fractures, did not prepare platforms and could not correct errors. Bifaces of beginners resulted in exaggerated triangular cross-sections.
Stout and Chaminade 2007	To assess the neural correlates of the demands of Oldowan tool making.	Oldowan core flaking.	6 previously inexperienced right handed humans, 3 male, 3 female, 20-30 years old.	4 weekly 1 hour practice sessions.	Each subject performed 3 tasks; 1: they struck cobbles together without attempting to create flakes; 2: they struck cobbles together with the intention of creating sharp flakes; after 4 weekly 1 hour practice sessions they again tried to strike flakes. Their brains were scanned after each task.	Practice altered performance. Activations were seen in areas homologous to those responsible for prehension and simple tool use in monkeys. Activation was also seen in areas indicating novel task demands and substrates, which provide additional central visual field representations and sensitivity to the extraction of 3D form from motion.
Stout et al. 2008	To assess the neural correlates of the demands of expert performance in Oldowan and Acheulean flaked stone technologies.	Oldowan core flaking and Late Acheulean technology.	3 right handed subjects, 1 woman, 30-55 years old. Professional archaeologists with more than 10 years knapping experience, familiar with Oldowan and Late Acheulean technologies.	Information not provided.	Each subject performed 3 tasks; 1: they struck cobbles together without attempting to create flakes; 2: they produced Oldowan style flakes from cobbles; 3: they were instructed to make 1 or more typical Late Acheulean handaxes out of obsidian flake blanks. All subjects were scanned after each task.	Experts produced more cores, more, longer flakes and fragments, more similar to assemblages. Oldowan technology showed activation in areas associated with tasks involving manipulable objects and fine finger movements. Acheulean showed increased importance of visuospatial representations and increased planning and complex action regulation.

Author	Aim	Technology	Participants	Period	Method	Result
Winton 2005	To test the validity of Newcomer 1971 and Schick 1994 with regard to knapping skills required to make handaxes and to attempt further qualification on the effects of poor knapping skill on handaxe variability	Palaeolithic handaxe	Phil Harding and Nick Barton (skilled knappers) R.J McRae, Martin Green and Geoff Halliwell (less-skilled knappers)	49 handaxes were knapped in total.	Less practised knappers were not given a particular design of handaxe to replicate, skilled knappers knapped a ficron, several ovates, a large limande, a small ovate and a number of pointed plano-convex forms.	More practised knappers made regular and evenly shaped tools due to control of hard hammer knapping. The novices produced short thick handaxes, with asymmetical profiles and cross-sections, cortex retention, obtuse sections on the bifacial edge of the middle and upper parts and did not stick to a 3 stage knapping sequence. The relationship of handaxe length and thickness was stated to be the most easily measured and significant skill related feature.

(Eren et al. 2011, 244–5). These studies are particularly useful as they directly relate to one of the technologies that was taught to knappers in this study. The issues identified in Eren and colleagues' study were used as a starting point when choosing areas to analyse of the materials produced in skill evaluations.

In addition to studies that derive their evidence for skill from experimental sources, some studies have combined ethnographic with experimental research to use behaviour seen in modern human individuals who still regularly practice knapping to test hypotheses about skill in lithic technologies. Torrence (1986) provides a useful overview of ethnographic studies of flintknapping in her work on the production and exchange of stone tools. Studies that use ethnographies to give information on skill include those by Stout, Roux and David, and Bril, Roux and Dietrich (Bril et al. 2000; Roux & David 2005; Stout 2002). Stout's research focussed on determining the differences seen in the products and procedures of skilled and unskilled adze makers from the village of Langda in Indonesian Irian Jaya. By filming the entire knapping technological process, and examining the finished adze form and the debitage produced, Stout was able to see differences between those produced by skilled and unskilled craftsmen and produce general guidelines for the evaluation of knapping skill (Stout 2002, 713–4). Bril et al. and Roux and David take a similar approach to carrying out experiments using traditional craftsmen, but in their cases use stone bead knappers of Khambat in India. Their studies also sought to answer different questions – both asked what kind of understanding or know-how distinguishes between those with greater or lesser skill. Their conclusion was that the development of perceptual-motor skills and a mastery of the required elemental movements more clearly separates the skilled from unskilled groups of knappers than an understanding of the required sequences of action and a good grasp of necessary planning (Bril et al. 2000, 209; Roux & David 2005, 104–5). Roux has also used studies of the same group of bead knappers to collect information on the likelihood and degree of craft specialisation in individual technologies, highlighting the duration of apprenticeship as a significant factor in determining whether a craft is specialised (Roux 1990, 146). The ethnographic approach contributes invaluable information to archaeological studies of skill as it can provide supporting evidence for conclusions indicated by archaeological experiments and suggest new areas and avenues that should be investigated when assessing artefactual evidence.

Using data from experimental and ethnographic studies, attempts to study skill in archaeological assemblages have focussed either on determining different skill stages seen in the same technology or site or on determining different skill levels seen between technologies and sites. Researchers have assigned anything from two to four different skill levels to the assemblages they have assessed. Table 2.2 displays the different skill levels researchers have defined and the reasons given for their distinction. Larger numbers of skill levels are more relevant for the study reported here, that has investigated skill acquisition in detail over long periods, however, it can be hard to provide secure evidence for more than a simple split between skilled and unskilled products. An example of a study that has successfully identified multiple skill levels based on archaeological assemblages at an intrasite level is provided by Lohse's study of the Clovis blade cores at the Gault site, Texas (Lohse 2010). Lohse sees four separate skill levels in the assemblage he analyses and bases his conclusions on an assessment of the amounts of savoir-faire and connaissance possessed by the knapper as interpreted from their products (Lohse 2010, 157). This is an excellent example of the application of an understanding of the process of learning to knap to an archaeological assemblage and the assignment of skill level based on the results of the skill evaluations in the study presented in this thesis has focused on the skill levels identified by Lohse and used the same evidence of differing amounts of connaissance and savoir-faire.

A contrasting study that has attempted to assign skill levels to archaeological remains is Pigeot's study of refitted blade cores for the Magadalenian site of Etiolles (Pigeot 1990). Skill levels are simply identified as either expert or novice in contrast to Lohse's more complex 4 level scheme but Pigeot does provide useful information on skill by focussing on how technical knowledge and know-how were learnt and concluding that these types of knowledge were not separated but taught or learnt at the same time (Pigeot 1990, 136–7). Similar studies of refitted flaked assemblages of Upper Palaeolithic age can be seen in the work of Bodu (1996), Bodu et al. (1990), Fischer (1989; 1990) and Karlin and Julien (1994). These studies have used

Table 2.2 – Definitions of stages used to describe knapper skill level

Author	Technology	Stages	Attributes	Evidence Used
Apel 2008	Late Neolithic flint daggers	Apprentice/ youth	Able to carry out 1st 3 stages of dagger manufacture: acquisition of suitable raw material blank, creation of a rough-out, creation of primary pre-form.	Difficulty of different stages in biface manufacture as assessed by experimental replica manufacture.
		Journeyman/ young adult	Able to carry out 1st 4 stages of dagger manufacture: as above plus creation of a secondary pre-form.	
		Master/old adult	Able to carry out all stages of dagger manufacture.	
Bodu 1996	Upper Palaeolithic blade	Mediocre	Mediocre blades and flakes produced. Generalised knowledge of flintknapping rules, modest know-how.	Refitting analysis, including spatial analysis and recreation of chaîne opératoire.
		Good/ competent	Perfect preparation of cores, productive debitage with great regularity	
Bodu et al 1987	Upper Palaeolithic blade	Debutant/ Child	Core discarded prematurely, no production of blades.	Refitting analysis, including spatial analysis and technological characteristics indicating skill.
		Competant	Simplest conceptual scheme used, apparent gap between aims and realisation. Core discarded early. Variable production of mediocre blades.	
		Expert	Produced complicated sequences of debitage as well as sequences of blades 'en eperon', economic used of raw materials, normal development towards core discard. Consistent production of good quality blades.	

Author	Technology	Stages	Attributes	Evidence Used
Finlay 2008	Scottish Later Mesolithic blades	Inexperienced	Stacked steps, visible hammermarks on core face, persevered beyond what was useful.	Number of blades produced, regularity, blank completeness and cortical frequencies, consistency of production.
		Mediocre	Displays features of both inexperienced and experienced	
		Experienced	Able to produce largest blanks, use of platform rejuvenation or creation of a second platform to deal with flaws, knowing when to abandon reduction and use of freehand percussion to open pebbles.	
Fischer 1990	Upper Palaeolithic retouched tools	Skilled	More platform edge preparation and blows delivered with care.	Examination of refitted assemblage based on spatial considerations and experience of the author as a flintknapper.
		Untrained	Irregular flakes and blades, platform edge preparation and blows delivered with less care	
Grimm 2000	Upper Palaeolithic	Apprentice	Limited access to good quality material, most work occurring in a marginal precinct, largely unproductive knapping, asking expert assistance.	Spatial distribution of refitted remains as well as observations of errors made and technical strategy.
		Expert	Platform preparation, assists apprentice knapper, attempts to rejuvenate piece, productive blade making.	
Karlin and Julien 1994	Upper Palaeolithic blade	Bad	Minimum or absent conceptual scheme. Can not achieve aims. No production.	Perceived difference in levels of technical skill - degree of proficiency in acquiring knowledge and know-how.
		Average	Simple homogenous conceptual scheme chosen. Difficulties achieving aims. Varied production.	
		Good	Complexity of conceptual scheme, showing personal preferences. Able to achieve aims. Stable quality production.	

Author	Technology	Stages	Attributes	Evidence Used
Lohse 2010	Clovis blade core	Beginners/ relatively unskilled	Highly erratic ridges, poorly defined face-to platform angles, abrupt and numerous blade terminations, repeated attempts at removals from the same platform.	Observed errors, compared against well-made cores and position of workers on a continuum from increasing to decreasing physical and/or cognitive skills.
		Adepts/ moderately skilled	Cores that show sophistication of design but mistakes in mechanical execution, e.g. serious mistakes made and core reversed, and cores that are simply designed and adequately executed. E.g. shorter than average core face.	
		crafters /moderately skilled	See above.	
		experts/highly skilled	Parallel/near parallel ridges to either side of blade scars, relatively smooth faces, feather terminations. Reversal of core when mistakes made, following elaborate reduction sequences and applying complex techniques for controlling/guiding blade removals.	
Stout 2002	Langda adze manufacture	Unskilled	Smaller mean size of adze heads, inability to maintain relationships between dimensions.	Social status of knapper (established craftsman vs apprentice).
		Skilled	Greater mean size of adze heads, access to larger rough -outs, ability to maintain a constant relationship between length and width	

detailed technological reconstruction made possible by refitting studies to identify two or three skill levels in their material based on conceptual schemes, consistency, quality and productivity evident in the work of individual knappers. This illustrates the benefits of refitting for gaining a more significant understanding of individual technologies and the skill of individual knappers (see also: Cziesla et al. 1990).

Another approach to the assigning of skill levels to archaeological assemblages can be seen in the work of Apel (2008). In this case skill levels are assigned based on the assumed position in the apprenticeship system of the individual who was responsible for the production of a particular artefact. This is an interesting approach, combining a consideration of the social aspects of skill acquisition with a simple recognition of skill level, however, there are some difficulties with the assumptions it involves. A comparison with Stout's ethnographic work has shown that individuals operating and acknowledged as masters in the apprentice system may sometimes have an inferior level of skill to what would be considered "journeymen" in Apel's scheme (Stout 2002, 705).

Assignment of skill level is an important part of considerations of skill acquisition both in experimental studies and in analysis of archaeological assemblages. While in many cases this can seem to be an arbitrary distinction it is through clear-cut definitions of high and low skill levels that we can seek to identify learners in the archaeological record. In this research Lohse's (2010) more extensive four category skill level scheme has been followed. While it may be more difficult to find evidence for multiple skill levels than for a simple split between novice and expert, it is only through a more thorough and detailed division of skill stages that our knowledge of skill acquisition and learning in early stone tool technologies will progress. This relies on a thorough understanding of the concepts of savoir-faire and connaissance and how they relate to flaked stone technologies. Pelegrin (1990), when introducing these concepts of connaissance and savoir-faire, states what different types of knowledge and abilities fall into each of these areas. Although there has been some debate surrounding these definitions (See Chapter 8 for further details), it is on these terms that I base my own assignments of skill levels (see also, Hodder 1990 - for commentary on the issues of connaissance and savoir-faire and their utility to archaeological understanding of technology). As well as differences in areas of understanding that fall under connaissance and those that fall under savoir-faire, the links between these two types of skill must also be stressed. The notions of embodied knowledge can provide a starting point for understanding the ways in which explicitly taught knowledge affects physical as well as cognitive abilities (Ingold 2000, 375). Ingold discusses skill as a property of a dynamic system of enskilment rather than the product of a strict dicohotomy between aptitude and acquired abilities (Ingold 2001). It is through this process that he sees communities progressing in terms of cultural and material expressions. Other authors who have taken this approach to the understanding of skill and learning include Coward and Gamble (Coward & Gamble 2008; Gamble 1998). Studies of this variety reject a body/mind dichotomy and see cognitive and social advances strongly linked to physical advances (Coward & Gamble 2008, 1970). These theories provide a good model on which to base attempts to identify links between connaissance and savoir-faire ability and move beyond a clear distinction between knowledge and know-how.

As well as studies that attempt to identify different skill levels within certain technologies on particular sites there have also been intersite studies of skill that seek to look at a particular technology practised at a number of sites and compare skill levels between these sites. Studies that take this approach include those by Bleed into Japanese Late Palaeolithic blade and microblade manufacture and Bamforth and Hicks's study into Paleoindian projectile points in the Medicine Creek drainage in South-western Nebraska (Bleed 2008; Bamforth & Hicks 2008). These studies rely on assessments of skill across different groups creating the same types of artefacts but with varying levels of success. While they are useful as an example of another way that an understanding of skill can increase our knowledge and the amount of information we can take from archaeological assemblages, they do not directly relate to the areas that my study has explored.

Another important area of consideration is the role that children play in considerations of lithic skill and learning. Ethnographic studies have shown children as young as 10 years old taking part in knapping activities (Roux & David 2005, 93). If children were engaged in knapping activities from a young age, it is undoubtedly the case that they would have contributed in some way to archaeological flaked stone assemblages, particularly those attributed to learners. Many studies simply equate lithic learners with children (e.g. Stapert & Krist 1990, 399–401; Grimm 2000, 54) but others have pointed out that this may be a misleading assumption. Finlay (1997) talks about the strengths and weakness of this approach while calling for a greater focus on the role women and children play in creating lithic assemblages, while Ferguson (2008, 61) argues that children likely did not have the strength to take part in knapping and would not have been involved in flintknapping learning activities at all. While this would seem to be in opposition to the ethnographic evidence discussed above it does highlight the fact that we need evidence before we can state that less skilled items are the products of children. Shea (2006) suggests ways to identify the products of children in the Palaeolithic record, as distinct from those of adults. He suggests that those made by children would be small, expediently made and of low value material (Shea 2006, 213). This is a useful starting point, however, it does not address how to distinguish child from adult learners. Högeberg (2008), in contrast, directly addresses this issue and looks at how children's play, based on an archaeological example that appears to show a child imitating an adults work, can contribute to the archaeological record and is distinct from but linked to lithic learning. This is useful as it suggests a way to approach the archaeological record that separates children from lithic learners. The work of ceramicists such as Bagwell (2002) and Crown (2007; 2001; 1999) has useful implications here. These authors have looked at the way cognitive and motor skills develop with age and relate this with ability to form pots. This has allowed them to identify the work of children and approximate the ages at which they began to form pots. The participants studied in my research are all adult, with the youngest aged 18 at the start of the project. It is, however, important to address the issue of the role children played in forming assemblages of lithic learning debris as the use of adult learners may in fact cause anomalous results if, prehistorically, unskilled flintknappers were always children.

Skill in technology is a complicated concept and can be hard to address, particularly in periods as remote as the Palaeolithic. The studies discussed above have illustrated some ways in which it is possible for us to begin to approach questions of skill and which have been useful in structuring my research in this area. Markers of high and low skill in knapping technologies have been discussed in some detail in previous literature (see Figs 2.1 and 2.2 above) as well as attempts to assign a number of skill levels to artefacts in archaeological and experimental assemblages (see Table 2.2). This prior work represented the main resource used when decisions were made about which material attributes to analyse in the tools and debitage produced during the skill evaluations that took place for the experiments described in this thesis. This review of work has also indicated areas relating to knapping skill that would benefit from a greater focus. There is a particular lack of long term studies of skill acquisition and studies with multiple participants. The work described in this thesis provides focus on these areas, which has been used to expand our knowledge of skill in Lower-Middle Palaeolithic technologies.

2.4 Learning

Linked to research into skill in lithic technologies is research into learning. While the experimental program involved in this study did not attempt to recreate the social learning and teaching techniques that were used to pass on skill in prehistoric societies, an overview of previous research in this area helps to put the study into its appropriate context.

Much research that investigates skill focuses strongly on the teaching methods that may have been used to pass this skill from one generation to the next. This has most often been studied using an apprenticeship model suggesting that experts or “masters” would teach skills to novices or “apprentices” (usually envisioned as children). Studies that have taken this approach to the subject include those by Apel (2008) into Scandinavian Late Neolithic daggers. Here the author tries to identify different levels of difficulty in production stages of an elaborate dagger reduction sequence and sees different stages as being carried out by different individuals with varying skill levels as part of an institutionalised apprentice system. This approach, while it has very little direct archaeological evidence to back it up, especially from periods as remote as the Palaeolithic, has some support from ethnographic studies of modern flintknappers. The work of Roux and David has shown that workers in the knapped bead industry of Khambat in India work on different production stages based on their skill and experience and the difficulty of the task (Roux & David 2005, 93). This is administered in an apprentice system in which master craftsmen pass on knowledge to less experienced knappers. Stout's work with the Langda adze makers has also shown an apprenticeship system as the mechanism for the transmission of knowledge from one generation to the next (Stout 2005, 333–4). These ethnographic studies highlight the fact that, in modern crafts, an apprenticeship system is often used as the structure for learning and teaching. It is, however, difficult to see how we can securely state that this was also the system used in prehistoric times, especially in the case of the earliest technologies created by early hominin species. Other methods for the transmission of knowledge may have equal validity for explaining learning in prehistoric times.

A possible candidate for another learning method is scaffolding. Scaffolding is an approach to the transmission of craft skill that involves the amalgamation of the work of novices and the work of experts so that novices can create adequate and useable items before they have developed the necessary skill to complete all aspects of the chaîne opèratoire. Through these means novices only carry out the areas of a task that they are physically able while experts carry out all other areas. Work done by Ferguson (2008) has experimentally investigated the effectiveness of this technique for conserving raw material and aiding craft skill acquisition. The scaffolding approach was shown to be more effective at producing competent knappers and conserving raw material in the production of small pressure flaked projectile points. This suggests that the consideration of scaffolding as a learning/teaching method might be particularly significant in cases where raw material was scarce.

Another approach that has been taken to the study of learning and teaching is a consideration of the social significance of these acts (e.g. Dobres 1995; Gero 1991; Minar & Crown 2001). Learning and technology are inherently social actions (Lemmonier 1989; 1993). The work of Lave and Wenger has highlighted the changing social position of a learner in society and highlighted the social reasons that govern the desire of a novice to become master of a certain technology (Lave & Wenger 1996). This work describes the concepts of communities of practice – a group of individuals working at a particular craft or profession in which practicing and learning skills can allow change from peripheral to full participation. Other studies focus on the gendered nature of craft activities in prehistoric periods and use this to make comment on the social aspects of manufacture and learning in prehistoric societies (e.g. Dobres 1995; Gero 1991). While this information can be difficult to obtain based only on archaeological remains, if properly applied it has the potential to provide an unprecedented level of detail about social life in the past.

Ethnoarchaeological work has also highlighted the social aspects of stone tool making (e.g. Stout 2002). The work of Stout highlighted the complex social aspects of adze making apprenticeships. Attempts have been made to use these considerations to make comment on the social lives of the earliest toolmakers. For instance, using the implied amount of time it takes to master a technology as complex as Acheulean handaxe to suggest that these societies must have had a structure that was supportive to long term skill acquisition (Stout 2005, 336–7). This is significant as it suggests another way in which a study of skill, learning and cognitive ability can contribute to our understanding of human and hominin behaviour in prehistory. Sinclair (2000) has also looked at technology in terms of a social process, in this case using it as a way to address human agency in the lithic record. Similarly Hayden and Cannon have related the stratification of societies to the ways in which crafts are learnt, for instance finding that in most unstratified societies learning is by observation rather than active teaching (Hayden & Cannon 1984, 359). The social aspects of skill acquisition in prehistoric technologies can be very hard to address through a simple analysis of the lithic remains of prehistoric peoples. The cognitive developments that allowed the introduction of more complex stone tool technologies, however, seem also to have allowed for increasing social complexity and vice versa. To get a fuller picture of skill acquisition in the earliest hominin technologies it is necessary that we also consider the social aspects of this behaviour (Holloway 1969, 406).

Even more than in skill it can seem that learning can be a near impossible phenomenon to address by observation of the archaeological record or experimentally derived materials. The above studies have shown some ways in which researchers have begun to deal with these difficulties, however, an understanding of the ways in which skill was transmitted in early flaked stone technologies is very poorly understood. For these reasons no attempt has been made to reproduce prehistoric teaching or learning styles in my experiments. It is hoped that the results will, however, contribute to the field of study and may at the least indicate new areas in which questions can be asked about mechanisms for learning among early hominins.

2.5 Palaeolithic Social Context

Research connected to the understanding of learning in archaeological contexts has, in some instances, sought to establish the nature of social life among Palaeolithic groups. This work falls into two main strands – studies focussed on gaining an understanding of life history at this time period and those that seek to reconstruct social learning methods. Social learning is a subject that has been much studied among both modern human and chimpanzee groups (Hewlett & Cavalli-Sforza 1986). With these studies the focus has often been on the modes of cultural transmission (referring to the person from whom skills are learnt) and processes of social learning apparent among individual groups (Hewlett et al. 2011, 1169). Modes of cultural transmission have been described as vertical, horizontal and oblique. These terms are defined in Table 2.3.

Mode of Transmission	Definition
Vertical	Transmission from parent to child
Horizontal	Transmission between members of the same generation
Oblique	Transmission from non-parental member of the parental generation

Table 2.3. Definitions of modes of cultural transmission (information from Cavalli-Sforza et al. 1982).

Processes of social learning, on the other hand, have been described as teaching, emulation, imitation or collaborative learning; terms that relate to the degree of direct intervention in the learning process by another. Information about these types of social learning is primarily gained through ethnographic studies of particular groups. These studies can provide a wide range of data that can be related to prehistoric social life. For instance, studies of hunter gatherer groups have indicated that although observation and imitation are the primary means of social learning, teaching is also a part of social life (Hewlett et al. 2011, 1176). This has implications for the social learning processes of similar small scale hunter gatherer groups prehistorically, information that is particularly pertinent to the study reported in this thesis if teaching is seen as having a key part to play in human evolution, as has been hypothesised by Csibra and Gergery (2011).

As well as identifying social learning contexts, the consideration of social life in the Palaeolithic has also encompassed considerations of life history of Palaeolithic hominins. This has involved investigations into the duration of childhood and relation to body size (e.g. Key 2000), life expectancy (e.g. Kennedy 2003) and the duration of different life stages based on bone and tooth evidence (e.g. Pettitt 2000; Ramirez Rozzi & Bermudez de Castro 2004). Investigating areas such as these can provide invaluable information on how learning would fit into the social context of life in the Palaeolithic and thus increase the significance of the findings of a project such as the one reported in this thesis for interpreting prehistoric activities. For instance, the analysis of skeletal remains from early hominin species suggests that survivorship beyond the age of 40 was very rare (Kennedy 2003, 553–4). This has implications for the abilities of individuals to reach levels of expertise if these are shown to require a significant input of time in practice.

2.6 Aptitude

Apart from skill and learning techniques this study has also focussed on the role of innate personal aptitude in the development of high skill level in lithic technology. This is an area that has not received a lot of attention previously with only one primary study that focuses directly on aptitude in this area (Olausson 1998; 2008). An understanding of the cognitive and physical requirements of knapping skill was necessary to establish a test for these abilities prior to the learning experiments. The previous study that focussed on flaked stone aptitude, attempted to assess which natural abilities are most pertinent to the acquisition of knapping skill by surveying modern flintknappers with questionnaires about their backgrounds and other craft experiences (Olausson 2008). Olausson's study made a strong case for the need for a combination of practice and ability, rather than practice alone to achieve world class performance in activities, illustrating this with examples from the field of sport (Olausson 2008, 44–5). Clearly this area is one that requires more research and greater attention. The experiments described in this thesis add to our understanding of this area and provide more data on the particular areas of aptitude that precondition an individual to succeed in particular prehistoric lithic technologies.

2.7 Technologies

The focus of the results chapters (Chapters Four, Five and Six) is the assessment of the effect of skill on three Lower-Middle Palaeolithic technologies. Obtaining the data for this analysis involved the experimental group of volunteers replicating Oldowan, Acheulean handaxe and Levallois core technologies. For this reason a comprehensive understanding of the chaîne opératoire for each of these technologies was essential in allowing judgements to be made on the skill of the knappers. Previous studies that have looked into skill in these technologies were also of use in establishing my experimental methodology for this project (M. Eren I. et al. 2011; Geribàs et al. 2010; Stout & Chaminade 2007; Stout et al. 2008; Winton 2005).

Butler (2005) provides a good overview of the nature of the different technologies in terms of types and form, and the variation in form of individual tool types such as handaxes has been much studied (e.g. Emery 2010; Hosfield & Chambers 2009; Machin et al. 2007; Petraglia 2003; de la Torre & Mora 2013). To achieve a comprehensive understanding of the skill involved in each technology, however, works that look in more detail at the chaîne opératoire of each technology were of more use. The utility of the chaîne opératoire concept can be seen in work by Edmonds (1990) that applies these concepts to Neolithic polished axe technology to see differences in the processes in manufacture in different phases. Taking a similar approach to Oldowan style flaking, Semaw has reported on the oldest finds of flaked stone tools, describing how they appear to have been manufactured and arguing that they display a high level of motor skills and cognitive ability (Semaw 2000, 1209). This argument has been tested in this study, which in part sought to assess the requirements of highly skilled performance in Oldowan technology as well as Acheulean handaxe and Levallois technology.

Oldowan style flaking is a relatively straightforward technology in which to understand high-level skill, simply requiring flakes to be removed in a way that allows for further successful flake removals (Stringer & Andrews 2011, 208). For this technology flakes are removed from one or more faces of a core, creating a sharp cutting edge. Acheulean handaxe and Levallois tortoise core technology, on the other hand, involved more complicated assessments of skill. The move from the creation of Oldowan style choppers through Acheulean tool types to Levallois technologies and beyond involved particular mental advances (Bordes 1971). Assessing these advances forms a key part of this study as well as their relation to the different aptitudes of the volunteer knappers. This required a detailed understanding of the sequence of removals that allow for success in replication and of both high and low skilled examples of these technologies found in archaeological assemblages if possible. Newcomer (1971) describes in detail the manufacturing process necessary in replicating a handaxe. Schlanger (1996) uses the refitting of an original Levallois core sequence to give similar information on Levallois technologies. Studies such as these were an essential comparison with the performance of the volunteers in the project in allowing evaluation of their understanding of, and skill in the technological stages necessary for recreating prehistoric tool types

2.7.1 Oldowan Technology

Oldowan style flaking is the earliest flaked stone technology known to have been practised by our hominin ancestors. This is a simple flaking technology in which flakes are removed from one or more faces of a core. The oldest examples of this technology date to 2.6 million years ago and originate in Gona, Ethiopia (Semaw 2000). Functions that have been hypothesised for these tool types include use for cutting or battering tasks, based on examinations of their edge damage and cut marks on bones associated with Oldowan artefacts (Potts 1991, 162). While examples of this technology may seem crude and random to modern human eyes (Fig. 2.3), they represent a massive leap forward in terms of application of motor skill and forward planning. Indeed, no modern species of ape has been successfully trained to reproduce this level of control over the fracture properties of flakeable materials (de la Torre 2011, 52–3), suggesting that the ability to do so represented one of the distinct cognitive advancements that paved the way for the development of modern human technology and culture. It is currently unclear which species were first responsible for Oldowan style flaking – those that have been suggested include *Homo habilis*, *Homo rudolfensis* or even australopithecine candidates (Stringer & Andrews 2011, 208). Little is known about the physical and mental capacities of these species as relates to technological ability and what evidence we do have stems from analysis of the complexities of their assumed stone tool production and analysis of their physical structure based on fossil remains (Mithen 1996, 105).

Figure 2.3. Oldowan flaked stone materials from Gona, Ethiopia (source: Stout et al. 2010, 486)

In addition to these lines of evidence, as mentioned above, brain scans have been carried out on people who have performed simple Oldowan style flaking, revealing that carrying out this task is associated with representations of the central visual field and perception of 3D form from motion (Stout &

Chaminade 2007, 1096–7). In Stout and Chaminade's study the group were not highly skilled knappers, having had very limited experience of this activity. Studying a group of individuals over the long period of time allowed by the project described in this thesis, has built on the results of this previous study to identify whether individuals with differing backgrounds and cognitive aptitudes develop skill in this task at different rates. In addition to this, the simple nature of the technology – merely requiring the knapper to knock flakes off a core, has allowed the majority of volunteers involved in the project to become proficient at this task through the course of the experiment. This has allowed these individuals' paths from no experience to expert to be mapped in at least one of the technologies covered during the experiment.

2.7.2 Acheulean Handaxe Technology

Acheulean style handaxe making is the second type of technology that the project focussed on teaching the novice knappers. Handaxe manufacture requires the bifacial knapping of a core, in order to produce a tool of a specific shape. Handaxes are normally interpreted as butchery tools, but other functions have been suggested (Pettitt and White 2012, 191-2). This type of technology first appeared around 1.76-1.4 million years ago (mya) (de la Torre & Mora 2013) and continued to be used into the middle Palaeolithic spreading across much of Africa, Europe and Western Asia (Mithen 1996, 24). Handaxes appear in a variety of forms (Fig. 2.4). While much has been written on this variety (e.g. Emery 2010; Hopkinson & White 2005, 22–3; Pettitt & White 2012, 147–9), there is not current consensus on a functional, temporal or cultural explanation for the different types that appear.

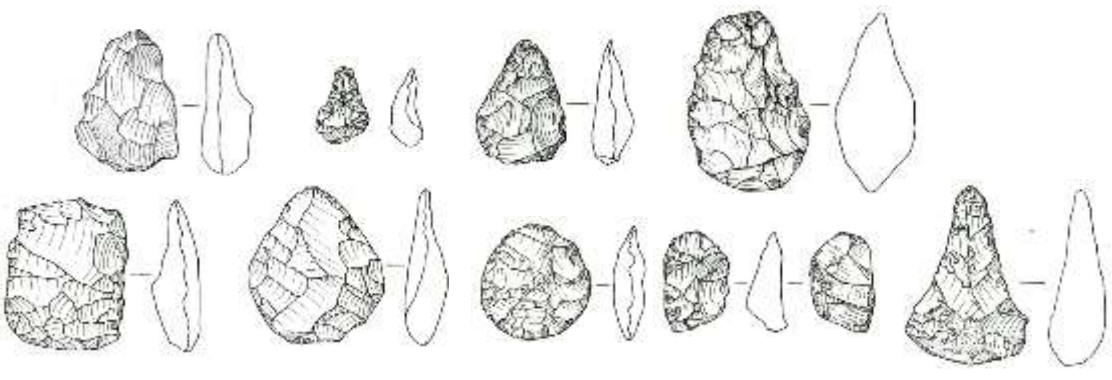


Figure 2.4. Handaxe variants; top, left to right: crude stone struck; small; pointed; sub-cordate. Bottom: cleaver; cordate; ovate; segmental 'chopping' tool; ficron (after Butler 2005, Fig. 22)

Figure 2.5. Acheulean style handaxes (Source: Stout et al. in press, Fig. 4)

This technology is of interest as it is a bifacial technology of a more complex nature to the simple Oldowan flaking and arguably shows the first evidence of imposed tool form on materials for flaked stone technologies (Stringer & Andrews 2011, 209; Fig. 2.5). This means it is likely to be the result of an enhanced cognitive ability in the species that created it compared to those responsible for the Oldowan core and flake tools.

Acheulean handaxe making has been studied in some detail previously as an important marker in hominin cognitive development, with some researchers believing that it reflects the emergence of more advanced planning abilities in the hominin species who practised it, perhaps linking in with language abilities (Holloway 1969, 401–2). This view is not, however, universal with some researchers stating that there is no evidence for forward planning or mental templates apparent in handaxe form (Noble & Davidson 1996). In addition to the scans of knappers of Oldowan style technology, brain scans have also been carried out on knappers after the creation of handaxes. This was carried out in an attempt to map the parts of the brain that are activated during this technological process (Stout et al. 2008). The results of this indicated that handaxe manufacture involves increasing activations in areas associated with visuospatial representations of the tool and body and also in areas involved in the coordination of hierarchically organised action sequences (Stout et al. 2008, 1946). For this reason it seems clear that Acheulean handaxe making represents a more advanced technology than the Oldowan style flaking that provided a greater challenge to the volunteers who were taught the technology. It may also have required different types of intelligence and physical ability to be utilised for examples of high level skill to be produced.

2.7.3 Levallois Preferential Flake Technology

Preferential flake Levallois technology is the third technique that was taught to the participants in the project. This technology was a primarily Neanderthal technique and is the most modern technology that the volunteers were evaluated in through the project. Levallois technology is first known to have been practiced from the beginning of the Middle Palaeolithic at around 300,000 years BP and continued to be the predominant technology until around 45,000 years ago (Stringer & Andrews 2011, 210–2). It is known to have been used in many parts of the world and is found across Africa, western Asia and Europe (Eren & Lycett 2012, 1). While there are multiple variants of Levallois technology (Pettitt & White 2012, 248–9), only one specific variety was the focus of experiments in the study reported here, lineal preferential flake technology. In this technology there is one preferential removal of a flake from a prepared surface.

Figure 2.6. Outline of a Levallois preferential flake removal on a core.

As well as being the most modern technology in the study Levallois is, conceptually, the most complex as it requires the careful shaping of a core to allow a single flake to be removed that retains as much of the core's surface area as possible while having a sharp edge around almost its entire circumference (Fig. 2.6; Butler 2005, 68). The complex nature of this technique has been used, in recent years, to argue for a more cognitively advanced view of Neanderthals than has previously been acknowledged (Wynn & Coolidge 2004). The different requirements for connaissance and savoir-faire ability of this technology compared with the Acheulean and Oldowan mentioned above have given indications of the different areas of aptitude that might allow an individual to achieve high-level skill in this technology. This has provided information on the different cognitive and physical requirements of this technology, compared with the older technologies also evaluated.

2.8 Experimental Archaeology

In designing an experimental project it is also important to consider the literature that relates to experimental theory and look at previous experiments to ensure that all factors possible are considered. For an overview of early knapping experiments, Johnson (1978) gives a thorough outline of experiments that took place from 1838-1976. The skill, learning and teaching experiments table shown above (Table 2.1) gives a good overview of the previous experiments that have taken place in this field and can be used to highlight some of the problems with them. The main issue that can be identified is the short term nature of the experiments. Skill acquisition is a long-term process and an experiment that takes place over a period of a couple of hours such as Finlay's study into Mesolithic blade production skill cannot deal adequately with the complex issues involved in learning a skill (Finlay 2008). Another issue is the number of participants in the experiments, some of which involve only one or two people learning a skill (e.g. Apel 2008; Eren et al. 2011). This significantly reduces the amount of data that can be obtained from the experiment and hinders the analysis of the statistical significance of the results. Aubry et al. (2008) highlight the importance of using prehistoric methods and materials in an archaeological experiment and provide useful information on identifying some of the dangers of experimental archaeology, such as variability between individual knapping styles caused by different knapping backgrounds (Aubry et al. 2008, 63). The importance of choosing adequate knapping materials for use in an experiment is highlighted by the work of Geribàs et al. who were looking to identify what technical gestures people need to learn to produce to become good at making stone tools (Geribàs et al. 2010). The experiment involved the replication of handaxes, however, the material chosen for the experiment was brick. This choice was due to a desire to eliminate raw material variability (Geribàs et al. 2010, 2858–9). This is a significant consideration in an experiment as differences in raw material shape, size and quality can affect the results produced by knappers, however, brick does not adequately replicate the materials that would have been used by prehistoric knappers and therefore does not allow a correct identification of the necessary technical gestures for the creation of handaxes. My study sought new ways to reduce the effect of raw material variability on the experiment, utilising porcelain pre-cores in skill experiments, this is discussed in greater detail in the following chapter.

To create a useful experiment into flaked stone technologies that has the potential to expand our understanding of the field, it is first necessary to have a good understanding of the processes that lie behind the creation of the types studied. A review of the literature discussed above gives a good background to current understanding of the technologies that the experiments will focus on and can act as a starting point for understanding skill levels in the experimental participants. In planning an experiment it is also important to learn from the experiences of previous experimenters in the same field and a careful consideration of the methods used and results achieved throughout the long history of flintknapping experimentation allow a more reliable and defendable experimental program to be created.

2.9 Summary

In summary, the literature that is most relevant to my research falls into three main categories – cognitive development in human evolution, skill and learning in knapped stone assemblages and the role of aptitude in high-level performance. While these areas have been looked at before, there are still many areas within each that need further study. Aptitude, in particular, is an area to which not much attention has been paid, especially in the field of flintknapping experiments. This work provides some much needed empirical data for considerations of the importance of aptitude in learning prehistoric technologies. In addition to this, there has been a lack of long term studies with large numbers of participants that deal with skill acquisition. This is likely due to practical time and funding constraints. This research begins to deal with this deficiency as it took place over a period of two years studying 16 participants through this time. The data derived from this research are applicable to archaeological assemblages and can be used to give information on prehistoric skill, learning and cognitive ability among our hominin ancestors.

3. Methodology

3.1 Introduction

Research involving identifying skill level and learning in archaeological assemblages has relied not only on analysis of the tools and debitage of prehistoric peoples, but also on the “sophisticated and detailed body of knowledge” that has been the result of a century of experimental flintknapping (Bamforth & Finlay 2008, 3). Without experimental research, hypotheses about the ways in which our hominin ancestors learnt the skills necessary for early technologies remain conjecture. This is particularly the case in flaked stone technology as there are very few modern human groups that continue to use traditional knapping practices. This limits the opportunities we have to use ethnographic studies to further our understanding in this area. While a number of experiments have already been carried out that investigate skill acquisition in flaked stone technologies (see Table 2.1) these have generally taken place over short periods of time (Bamforth & Finlay 2008, 18) and often rely on detailed assessments of a very small number of participants. Learning is necessarily a long term process with some studies indicating that it takes as long as 10 years to become expert in any activity (Wynn & Coolidge 2004, 471). This study sought to address these issues by taking a longer term approach to the study of skill acquisition and focussing on a larger group of participants than is usual in studies of this type. In this way it was hoped that the information gathered on skill acquisition was more secure and our understanding of the cognitive requirements of the earliest stone technologies practiced by hominins would be advanced. As some of the underlying research questions that this project hoped to address involved the study of the cognitive development of early hominins, the experiments focussed on the replication of early technologies, namely Oldowan style flaking, Acheulean handaxe and Levallois tortoise core (also known as preferential Levallois) technologies. Through a detailed study of skill acquisition in these early technologies it was hoped that a greater understanding of prehistoric learning would be achieved.

3.2 Objectives:

The experiments that form the core of this study aimed to answer four main questions:

- How is high level skill obtained in flintknapping?
- What role do practice, natural aptitude and teaching play?
- How is this reflected in connaissance and savoir-faire?
- Can we recognise this archaeologically?

The first objective sought to identify the ways in which individuals can achieve a high-level of skill in flintknapping. By looking at this it was also possible to address the inferred cognitive requirements of early technologies due to the focus on Oldowan style flaking, Acheulean handaxe and Levallois preferential core flaking. The ultimate goal for all knappers in the project and the focus of the teaching in the project was that they be able to produce examples of flaking, handaxe and Levallois technologies that would be recognised as highly skilled objects. In this way all participants had the same goal, allowing assessments to be made of individual skill and comparisons to be made between individuals, as each was intending to produce a high level of skill in the evaluations. The nearly two year period of knapping learning in the project, as well as aiming for the participants to achieve high-level skill allowed a number of skill levels to be identified throughout the course of the experiment. In many previous experiments and analyses of archaeological assemblages skill levels have simply been divided into two levels - expert and beginners (e.g. Bodu et al. 1990; Grimm 2000; Stout 2002; Fischer 1990). In reality skill development covers a far greater range than can be expressed by a simple two-way divide and an assessment of the path from beginner to expert tool-maker allowed for several different skill level stages to be identified as learning progressed in the project. These levels could be applied to archaeological flaked stone assemblages, increasing the range of information on skill we can deduce and adding to our understanding of this aspect of the archaeological record. Evidence for high-level skill can also give information on the cognitive capacities of early hominin species. It has been stated and demonstrated in numerous experiments that most modern humans have the ability to pick up basic knapping skills without much time investment (Bamforth & Finlay 2008, 8; Stout

& Chaminade 2007, 1094). High-level skill, however, requires a much greater level of time investment and in fact may not be achievable by all individuals (Olausson 2008, 47). The reasons why some knappers succeeded while others failed to achieve high level skill during the time period of the experiment has implications for the necessary cognitive developments that first allowed hominin species to develop knapped stone technologies and then to develop them beyond what could be simply and expediently achieved. This was investigated by looking at the levels of teaching, practice and areas of natural ability that contributed to the skill knapper's achieved in the project.

The second major objective of the project focussed on this area, looking at what role practice, natural aptitude and teaching play in the acquisition of high-level skill. This objective moved on from the first, which simply involved analysis of how high skill level as opposed to expedient tool making was achieved. Looking in detail at the factors that play a part in the acquisition of skill gives a more complete picture of the cognitive abilities that allow a person to become a skilled toolmaker. Many researchers have simply seen skill acquisition as a result of practice – the more practice an individual does the better able they will be to create stone tools (Clark 2003, 221). Recording and comparing the amount of practice carried out between participants and within different technologies allowed this to be looked at in more detail and more secure conclusions to be drawn about the role of practice in determining skill level. While amount of practice may be the most important factor for achieving skill in replicating tools and technologies that only require the mastery of some basic concepts and physical actions (Oldowan style flaking for example), some researchers have argued that examples of technology that require a high level of knapping ability to master (Danish daggers for example) require a certain degree of natural aptitude to be achievable (e.g. Olausson 2008, 47). The role of aptitude in determining the skill levels that can be achieved in flintknapping is not an area that has been much investigated previously. Looking at the natural aptitude in participants allowed these theories to be tested. In addition to this, investigating which aspects of aptitude were most significant for preconditioning someone to succeed in particular knapping activities allowed some hypotheses to be formed about areas of cognitive ability which were most significant for allowing the development of particular stone tool technologies. The effect of amounts of practice in determining the skill level achieved by an individual is another area that has not been much investigated in the past beyond a simple statement that skill in motor ability can only be acquired by practice (Apel 2008, 99; Pelegrin 1990, 118). Detailed records of practice sessions carried out by the participants allowed this factor to be analysed and its impact on skill level assessed.

Teaching was also investigated as a factor with the potential for determining the level of skill acquired by the experimental participants. There was no attempt to recreate prehistoric teaching styles due to a lack of direct evidence for these and the fact that multiple technologies used by different species were taught during the experiment. Teaching style, however, undoubtedly had an effect on the way skills are learnt by the group and for this reason the amount and style of teaching experienced by the participants was logged and considered in comparison to personal practice and natural aptitude as a factor that affected the way skill was achieved. These three factors were highlighted as likely the most significant for determining how and why skill is achieved in knapping activities. These are not the only factors to affect the development of skill, others such as knapper personality, social encouragement or physical factors such as strength, height or weight may also have an effect.

The third objective of the study focusses on identifying the relation of skill to connaissance and savoir-faire, two areas of ability and understanding that have been linked to flaked stone technologies. These terms were first brought to prominence in the field of flaked stone assemblages by Pelegrin (1990) and have since been used in studies as a starting point for understanding the acquisition of skill in knapping technologies (e.g. Apel 2008; Lohse 2010; Roux & David 2005). Pelegrin (1990, 18) defined connaissance or knowledge as an individual's understanding of the concepts and necessary actions required to successfully complete a technology whereas, savoir-faire or know-how refers to the individual's physical ability to carry out that task. These two types of intelligence are utilised whenever a knapper carries out a task within a technology. Understanding how these areas interact and how different levels of each can be identified in particular technologies is essential to gaining a fuller understanding of how flintknapping skills can be and may have been learnt. Definitions of connaissance and savoir-faire used in the study described in this thesis are presented and discussed in Chapter Eight. Previous studies that have been able to assign the highest number of different skill levels to the material they are analysing have been able to do so based on assessments of the different amounts of knowledge and know-how implied by their form (Lohse 2010). For this reason during the experiments all evaluations of skill considered both connaissance and savoir-faire ability. In this way it was hoped that it would be possible to identify a greater number of skill levels than a simple split between beginner and expert knappers and thus have a more detailed picture of how skill in lithic technologies develops.

An understanding of the stages of skill acquisition at which progress is made in increasing connaissance or savoir-faire ability can also increase our understanding of the learning process. In this study skill scores for connaissance and savoir-faire in comparison with the aptitude assessment data helped to show the effect of this factor (See Chapters Seven and Eight). Gaining a greater understanding of the roles of connaissance and savoir-faire in determining an individual's skill is of great benefit to our understanding of flaked stone technology. This is particularly relevant in early periods of stone tool manufacture when hominin brains were still evolving to modern human capacity. Identifying different levels of connaissance and savoir-faire required for different technologies may be used to give information on the cognitive capacities of early hominins in these two areas and thus progress our understanding of the role of flaked stone tool manufacture in human cognitive evolution.

The final objective focuses on gaining an understanding of how skill, as identified in the experiment, would manifest itself in the archaeological record. It is undoubtedly the case that the work of inexperienced, low-skilled knappers exists in the archaeological record (Bamforth & Finlay 2008, 3). The skills necessary to achieve expert performance in flaked stone technologies are not innate, they need to be learnt and our current understanding is that the most effective way to do this is to practice (Shelley 1990, 187). As a subtractive technology the remains of this practice should exist in the archaeological lithic record and indeed a proportion of the remains from a number of sites have been interpreted as being the products of learners or individuals of differing personal skill levels (e.g. Bodu et al. 1990; Högberg 2008; Lohse 2010; Pigeot 1990; Stapert & Krist 1990). There have also been sites where researchers have been able to infer the possible mechanism by which skill was passed from on individual to another. For example the work of Högberg (2008) identified child's play as a possible means by which lithic skills were first introduced to a novice. In many cases differences in skill that have been recognised in archaeological remains have simply been seen as the result of either beginners or experts working with no mention of the levels of ability in between these two stages that an individual falls into in the process of gaining a high-level of skill in particular technologies (e.g. Bodu 1996; Fischer 1990; Grimm 2000; Stout 2002). This is in part due to the lack of long-term studies that map skill development in flaked stone technologies over time as well as the complex problems of determining skill level from material remains alone. To gain a better understanding of the complexity of skill acquisition in prehistoric times, however, it is necessary that we look beyond a simple split between high and low skill levels and find ways to interpret different stages of learning from the tools and debitage we find in the archaeological record. In an attempt to accomplish this, a thorough analysis was carried out of all the materials produced by the knapping volunteers during the course of skill assessments in the project. These provided information that linked the performances of knappers to visible markers of skill that could be applied to archaeological assemblages to increase what it is possible for researchers to say about lithic learning and skill acquisition in prehistoric times.

While these four objectives formed the core of the experimental study's aims, focus was also given to the information that could be gained from the data gathered during the project that could be used to make inferences about the differing cognitive capacities of the hominin species who first practised early technologies. The objectives, however, covered the areas that hold the most potential for advancement as a result of the experimental study and are the areas that may benefit most from the in-depth long-term approach allowed by the project.

3.3 Participants:

The recruitment of participants for this experimental study took place prior to the start of the project in October 2010 (see Appendix 1 for full recruitment information). The study required a significant level of commitment, as it took place over a period of nearly two years, but the format also offered a number of benefits to the volunteers who took part. Initially it was hoped that the study would involve around 20 participants arranged between two different groups – the core group subjects and the wider group. The core group initially consisted of five people (later expanded to eight) who would be involved in intensive learning and be required to give a greater level of commitment, whereas the wider group would be made up of around 15 participants with less intensive learning and less required commitment. It was decided to split the group this way as it was thought that the most academic benefits would be achieved with a large sample size, however, the practicalities of the project did not allow for a large number of people to receive the high level of training that would be received by the core group, due to the costs and time investment that would be involved. The split also allowed for a comparison between learning through more intensive and less intensive methods.

A high number of volunteers was initially sought for the project to ensure that, in the case of people leaving the project, a high enough number would continue to knap throughout the two year period. The core group were recruited first. This group was to be involved in brain scans that were to take place before knapping sessions started. Initial recruitment took place in October 2010. Volunteers were preferred among second year students at the University of Exeter as many of the knapping sessions were planned to take place in the experimental facilities in the archaeology department there. Second year students were chosen because of the long term nature of the study – these students were likely to be available at the University of Exeter for the period of the project. The initial recruitment emails are attached in Appendix 1. After the core group had been established the wider group was sought. This recruitment also primarily took place among the student body of Exeter University, however, in this case it was also possible to include volunteers from other institutes and individuals interested in bush craft and survival skills due to the less intensive nature of learning involved in this part of the project. The recruitment emails for this part of the project can also be seen in Appendix 1. Due to the varied previous experience of the wider group it was decided to divide this group into two sections, one comprised of those who had some previous experience of knapping and one of those who had never knapped before. The latter group was mainly made up of first year archaeology students based at the University of Exeter while the former had a number of different backgrounds. Further information about these groups of knappers is provided below.

3.3.1 Core Group

The core group was originally intended to consist of five members made up of second year students based at the University of Exeter. All members were right handed due to the requirements of the brain scanning. This was expanded to six members to include a PhD student also based at Exeter who was working on assemblages of knapped materials and was hoping to expand this into experimental areas. Eventually this group had to be expanded to eight members due to the unsuitability of some of the members for brain scanning. Only six of this group received brain scans for this reason. The age and sex of the core group members are shown in Table 3.1. In all other aspects all members of the core group received the same treatment throughout the project.

Knapper	Age	Sex
A	20	Male
B	19	Male
C	20	Male
D	20	Male
E	20	Female
F	24	Male
G	25	Male
H	18	Female

Table 3.1. Core group knapper information.

None of the core group had previously received any training in flintknapping so their experience in the project comprised the sum total of their knapping. All participants were, however, archaeology students and had some understanding and awareness of flaked stone tools and assemblages. The majority were second year students who as part of their studies had received training in archaeological artefacts that covered a basic introduction to stone tools and involved a flintknapping demonstration. No previous practical experience of flintknapping was a requirement for members of the core group as a result of the demands of the brain scanning part of the project. For this the initial brain scan was to take place before any flintknapping had been carried out. The brain scans were designed to look at which areas of the brain are activated by flintknapping and how this is affected by practice and were conducted by Dietrich Stout from Emory University in Atlanta and Thierry Chaminade, from the Institut de Neurosciences de la Timone, Aix Marseille Université.

The core group received focussed intensive learning, with multiple taught knapping sessions taking place and frequent skill assessments. The aim of this was to get the participants as skilled as possible in the three main technologies that the experiment focused on in as short a time as possible. Each member agreed to a least two hours knapping practice a week throughout the course of the experiment in order to ensure that practice continued when no taught sessions were held. While the majority of the structured taught sessions were based at the University of Exeter, the core group was also required to be available for learning sessions in the US, Denmark and France. These sessions lasted from two to four weeks and involved intensive flintknapping both in terms of number of taught sessions and in time spent practicing. During these intensive sessions volunteers received training from expert flintknappers in these areas. This, in part, was intended to reduce the biases that could be introduced into knapper learning as a result of influence and teaching only from a single expert with a particular knapping style.

In addition to the practical knapping sessions, the core group was also exposed to archaeological collections of flaked stone tools and debitage. It was thought that this would aid the learning process and help the volunteers to create replicas that were closer to the original artefacts than might otherwise be the case. This was based on the experience of Professor Bruce Bradley who contends that it was through contact with artefacts that his own knapping progressed to expert level (Bradley pers. comm., 2010). This consideration is supported by the theories of the importance of a mental template for allowing successful technological production in complex technologies (Pelegrin 1990, 118). Viewing and handling objects allows greater familiarity with their forms and thus was thought to have potential to aid formation of mental templates in the technological types. The varied collections that were available for study in Texas, Denmark and France were of great benefit to the core group members in learning to knap and were part of the reason for taking the participants for sessions in these areas.

The program of training for the core group was, therefore, intensive and varied. The methods used, while not recreating likely prehistoric teaching methods, were thought likely to best produce high levels of skill in the knapping group. Through these methods individuals in this group performed many knapping hours during the project and were thus well prepared for skill evaluation in the three technologies on which the study focussed.

3.3.2 Wider Beginners Group:

The wider beginners group were initially made up of nine members although five participants dropped out over the course of the experiment due to other commitments. The requirements of the wider group members were less intensive than for the core group. The wider beginners had had no previous practical experience of flintknapping and were exclusively made up of first year archaeology students based at Exeter University. The beginners group needed more initial training than the experienced group and this took place in the archaeology department at Exeter. The age, sex and handedness of knappers in the wider beginners is given in Table 3.2.

Knapper	Age	Sex	Handedness
I	19	Female	Right
J	32	Female	Right
K	18	Female	Right
L	19	Male	Right
M	29	Female	Left
N	19	Male	Right
O	18	Male	Right
P	18	Female	Right
Q	38	Female	Right

Table 3.2. Wider beginners group knapper information.

Along with lesser requirements for participation, the wider group received a much less intensive learning program with the focus on personal practice rather than multiple structured learning sessions. This is demonstrated by the hours members spent in taught knapping sessions with members of the core group attending between 11and 17 sessions while wider group knappers attended between four and seven. This was due both to the practical constraints of the project as well as to provide an interesting contrast to the more intensive learning of the core group. Along with the core group the wider group agreed to a minimum of two hours per week knapping practice averaged by month to ensure that they continued flintknapping even when there were no scheduled structured taught sessions. As with the core group, all wider beginners were based at the University of Exeter and were given access to the experimental facilities in the archaeology department for knapping practice. Here they were also provided with flint, hammerstones, antler and protective devices for this purpose.

Due to the less intensive nature of the wider groups learning the skill evaluation for this group was also planned to occur on a less frequent basis for the most advanced technology, Levallois. This was designed to reflect their slower learning process, as the core group's learning was more intensive and so would be expected to reach higher skill levels in each of the technologies more quickly.

3.3.3 Wider Experienced Group.

The wider experienced group was initially made up of 14 members although 10 dropped out over the course of the experiment for a variety of reasons. This group was distinguished from the wider beginners group as members had all had some previous knapping experience. The amount of this varied considerably between members so an initial skill assessment was carried out on the group to determine the level of their knapping. The wider experienced group came from a variety of institutions and backgrounds and was the most varied group in terms of age as well as experience. The age, sex and handedness of knappers in the wider experienced group is presented in Table 3.3.

Other than the initial skill evaluation the wider experienced group were treated in the same manner as the wider beginners, although the majority of training sessions for each group took place separately. In addition to this, new technologies were introduced to the wider experienced group at an earlier stage in the project than the wider beginners due to their pre-existing knapping skills. In all other respects the group followed the same path as the beginners with less intensive learning focussed more on personal practice than on structured

Knapper	Age	Sex	Handedness
R	30	Female	Right
S	21	Male	Left
T	54	Female	Right
U	22	Male	Right
V	28	Female	Right
W	23	Female	Right
X	37	Male	Right
Y	46	Female	Left
Z	33	Male	Right
Γ	25	Male	Right
Δ	28	Female	Right
Θ	21	Female	Left
Λ	24	Male	Right
Ξ	51	Female	Right

Table 3.3. Wider experienced group knapper information.

taught sessions and with less frequent skill assessments. Similarly they also agreed to two hours practice a week, averaged by month, throughout the course of the experiment. Although this level of practice was rarely attained by knappers.

The wider experienced group had much more varied backgrounds than the other two groups that were solely made up of students from the University of Exeter. Despite this all were given access to the materials and facilities at the University of Exeter. They were, however, expected to provide their own materials for knapping if it took place outside the University. Skill assessments and sessions for this group also took place at the University of Exeter.

3.3.4 Ethical Considerations

The nature of this long-term experimental study required that ethical issues involved with the study of people and data protection law be considered. Any study that involves human participants is subject to the University's ethical research policy and guidelines, and must be passed by the College of Humanities' ethics committee. In addition to this the study of a large group of people at this level of intensity necessitates the storage of a large amount of data that are subject to the data protection act. For this reason all the participants in the project were obliged to sign detailed agreements prior to their involvement in the project setting out the requirements of the project and detailing the efforts taken to protect the data produced. As all the subjects in the study were adult volunteers the only ethical considerations involved their rights to withdraw from the project without any consequences, their rights in regard to access to the project findings and our responsibilities for data confidentiality. The core and wider groups had separate agreement forms prepared due to their differing levels of involvement in the project. These forms can be seen attached in Appendix 1.

In summary, when volunteers agreed to participate in the project they formally accepted that they would practice knapping for two hours a week (averaged by month) and to participate in taught knapping sessions. All participants were free to withdraw from the project at any time they wished. All data gathered during the study was stored anonymously so no-one would be able to identify an individual’s data by name alone. Participants were given the rights to access to their own data if desired. In this way participants were treated in an ethical manner and had clear access to information about the project prior to agreeing to participate.

3.4 Methods:

3.4.1 Introduction

Apart from the recruitment of participants, the methodology of the project can be split into three main areas. These are aptitude assessments that took place prior to the start of knapping in the project, knapping learning and practice sessions, and skill evaluations. The methods used in each of these three areas were tightly focussed on answering the four main research questions as stated above:

- How is high level skill obtained in flintknapping?
- What role does practice, natural aptitude and teaching play?
- How is this reflected in connaissance and savoir-faire?
- Can we recognise this archaeologically?

Careful study was made of the methodologies of previous experiments into skill acquisition in flaked stone technologies before the methodology of this experiment was established in order to build on these works and establish secure methods based on the success of previous approaches (see Table 2.1).

3.4.2 Aptitude

Natural aptitude for flintknapping is not an area that has received much attention in previously studies. While it has been stated that no-one is born a flintknapper and you can not gain a high skill level in technology that requires a high level of know-how without a great deal of practice (Apel 2008, 99; Shelley 1990, 187), only one study has directly looked into the ways natural ability may precondition a knapper to achieve a certain level of skill (Olausson 1998; 2008). This study was based on a survey of modern flintknappers, most of whom were working commercially. Building on this work, the experiments described in this thesis represent the first full scale experimental work to address aptitude in flintknapping.

To identify potential areas of aptitude that are involved in flintknapping activities, studies such as Olausson's mentioned above, can be taken along with brain scan studies of experimental flintknappers to give indications of areas on which to focus. Brain scans of knappers have been carried out after they took part in Oldowan and Acheulean handaxe manufacture (Stout & Chaminade 2007; Stout et al. 2008). These revealed that in the case of Oldowan style flaking there were activations in areas associated with representation of the central visual field and perception of 3D form from motion (Stout & Chaminade 2007, 1096). In the case of the Acheulean handaxe technology, the scans revealed an increased demand for effective visuomotor co-ordination and hierarchical action organisation compared to the less advanced Oldowan style technology (Stout et al. 2008, 1946–7). This suggests that the cognitive abilities that need to be engaged when dealing with knapping tasks are the ability to visualise 3D shapes and the ability to control fine finger motions and manipulate objects as well as planning and strategic abilities. It was hypothesised, therefore, that high level ability in these areas would precondition someone to achieve high skill level results in flintknapping activities.

In order to test for pre-existing ability levels in these areas a number of aptitude tests were applied to the group before they started practising flintknapping. For the core group each volunteer took part in spatial ability tests, and filled in a questionnaire that related to their previous craft experience and contact with flaked stone materials. All these tests can be found attached in Appendix 2. The wider group also took part in these aptitude tests. Those in the wider experienced group who had had some previous experience of flintknapping also had their flaking skill tested at the start of the project.

The spatial ability tests were carried out in order to test each individual's ability to form mental images of shapes and to visualise change and movement between them in two and three dimensions. The particular tests carried out on the group were designed for use as a psychometric test for assessing ability to carry out certain career related tasks and required that people answer as many questions as possible out of 45 in a 20 minute period (Psychometric Success 2013). Two tests were carried out on the knappers prior to the start of the project and two at the end and the results averaged to give a spatial ability score.

Further to these aptitude tests, questionnaires were given to all the volunteers in the project that related to their past experience of crafts. Flintknapping is a practical activity and for this reason it seemed likely that those who had previously had wide experience of different craft skills and activities would have better developed muscles and be more used to working with their hands in a way that would be beneficial to their ability to develop a high skill level in knapping technologies. The questionnaires covered types of craft that had been previously practised, the length of this experience and asked volunteers to rate their ability in each craft they had been involved in. This information was then converted into a score out of 10 that related to their level of previous craft experience (details provided in Chapter Seven).

In addition to information on crafts, individuals were asked about the amount of contact they had previously had with knapped stone assemblages. They were asked to include any classes they had taken, knapping demonstrations they had attended or museum collections they had handled. This was in order to assess the effect of differing levels of familiarity with flaked stone assemblages on knappers' ability to achieve high levels of skill in flaked stone technologies. The level of experience they specified was converted into a score out of 10 in a similar manner to the craft experience score (details provided in Chapter Seven).

In addition to this, those in the wider group who had previously had experience of practical flintknapping were also asked specifically about the levels of contact and knapping practice they had had in the three main technologies that the project focuses on – Oldowan style simple flaking, Acheulean handaxe and Levallois preferential core technology. They were asked to assess their skill level on a scale of one to five (one being beginner, five being expert). After this, those who professed some level of practice in the individual technologies were subjected to a skill evaluation. The practicalities of skill evaluations in the project are discussed in further detail below. In short, the evaluation resulted in each individual being given two scores of one to five, one for their connaissance or understanding of how a technology should be carried out and one for their savoir-faire or physical ability to carry out a knapping task. This was in order to obtain a base level for their skill at the start of the project and from that it was possible to assess the amount of skill that had been gained as a result of knapping in the project.

As well as information on craft and knapping experience, information was also collected on the age and sex of the participants (see Tables 3.1, 3.2 & 3.3 above). Many researchers have sought information on the types of prehistoric individuals who would have taking part in knapping episodes. Knapping stone tools is often seen as an adult, masculine activity (Bamforth & Finlay 2008, 17). Data on age and sex allowed assessments to be made of whether these assumptions have a basis in ability based on sex or age, by investigating the propensity of different age and sex groups to achieve high levels of skill and the signs of this in the materials they produced.

Aptitude for flintknapping is a key area in which experimental studies such as this have the potential to provide new information that can be used to further our understanding of how high levels of skill are achieved by particular individuals. Identifications of areas of ability that might precondition someone to achieve a high level of success can also be used to give comment on the cognitive requirements of early technologies. If, for instance, a high level of spatial ability is required to achieve high levels of skill in handaxe technology while a similar pattern is not seen for earlier Oldowan technology, it could be hypothesised that developments in spatial abilities were important in allowing the innovation of handaxe technology. Information such as this can expand our understanding of early technologies even further.

3.4.3 Learning

After the initial aptitude assessments learning in the project progressed through a combination of structured taught sessions and personal practice. No attempt was made in this project to recreate prehistoric teaching practices. This is due to the limited nature of the evidence that we have for these, which is generally derived from refitted sequences that show the work of experts and novices on the same piece (e.g. Lohse 2010). This means that any attempts to recreate an actualistic teaching environment would be based on conjecture and unlikely to actually recreate past activities. In addition to this, the scope of the project covered three different technologies that were practised by different hominin species, all different to the modern *Homo sapiens sapiens* volunteers who were involved in the project. The simple aim of the teaching was to get each of the volunteers as expert in each of the technologies in the project as was logistically possible within the time frame of the experiment.

The focus of the teaching was Oldowan style flaking, Acheulean handaxe and Levallois preferential flake technology. The group, however, were not restricted to practicing these technologies and some teaching was provided in other later technologies. Individuals involved in the project were freely able to practice these technologies. The three technologies on which the project focused have been chosen as a result of the overarching aims of the Learning to be Human Project, which are to investigate the cognitive development of early hominin species that led to the development of flaked stone technologies. Oldowan, Acheulean and Levallois technologies are some of the earliest practised by hominins and each has unique features that could provide crucial evidence of the mental capacities of the individual hominin species who practiced them.

3.4.4 Structured Sessions

The three technologies mentioned above were initially introduced to the project volunteers in structured taught sessions. These sessions generally followed a set organisation, consisting of a demonstration by an expert in the particular technology on which the session focussed, followed by a chance for the attendees to practice the technology while being watched and assisted by the expert knapper as well as up to two other experienced knappers who also acted as instructors throughout the project. The expert knapper who led the majority of the session was Professor Bruce Bradley. Professor Bradley is a highly experienced flintknapper who has taught many courses on knapping both within academic settings and in bush craft skills contexts. He can perform each of the three technologies that the project focusses on to expert level having focused on Levallois technology for his PhD thesis and having had experience of biface technologies throughout his career (University of Exeter 2013). Professor Bradley is also the Principal investigator of the Learning to be Human Project to which the experiments described here belong.

The other regular instructors on the project were the author and Antony Whitlock. Whitlock has five years of experience as a flintknapper and has worked as a bush craft specialist teaching traditional skills. Whitlock received his first professional training in flintknapping when he took part in the experimental master's degree at the University of Exeter in 2008. His dissertation as part of this degree involved replicating Neolithic and Bronze Age arrowheads and throughout this degree he specialised in flintknapping. Prior to the start of the project Whitlock had had two and a half years of experience of handaxe manufacture and one year of Levallois technology. In addition to assisting in the sessions taught by Bradley, Whitlock also led additional sessions if volunteers were unable to attend the primary sessions and dealt with the photography and analysis of some of the materials produced during the skill evaluations.

The author was also involved in instructing the experimental volunteers. I have seven years of experience in flintknapping having first been introduced to it during a Lithics module as part of an Archaeology degree in 2006 at the

University of Exeter. This experience was expanded during a master’s degree in experimental archaeology, also at Exeter, which took place from 2007. During this degree I focussed on expanding my practical flintknapping experience which took the form of an advanced project focussing on the heat treatment of greensand silicate and a dissertation which involved the replication of Neolithic leaf-shaped arrowheads and Bronze Age barbed and tanged arrowheads using copper and antler pressure flakers. Prior to the start of the project I had had two years of experience of handaxe manufacture and one of Levallois technology. As well as assisting in sessions led by Bradley and Whitlock, I also led sessions for volunteers who could not attend those led by the more experienced knappers.

In addition to the main three instructors mentioned above, instruction was also given by expert knappers during trips to look at collections out of the country. These consisted of Mike Dothager, a flintknapper from Illinois who has worked primarily on the rocker-punch technique of indirect percussion (Lithic Casting Lab 2013) and Bo Madsen, an expert flintknapper with extensive knowledge of Danish flaked stone assemblages and technology types (Flintknapping Hall of Fame 2013).

For every structured taught session notes were kept on the duration of demonstration and practice time, the format of the teaching, the number of instructors and attendees and comments were made on the volunteers knapping progress. Since attendance at all the sessions was voluntary not all participants were involved in all sessions. The core group of volunteers attended between 11 and 17 sessions in total and the wider group between four and seven. The much higher number for the core group was due to their attendance of trips to Texas, Denmark and France to work with flintknappers in these areas and view collections. On each of these trips a number of taught sessions were held.

3.4.5 Personal practice

As well as structured sessions each volunteer was required to complete a certain amount of practice per week. This consisted of two hours per week although this was averaged by month so knappers were not required to practice every week. While many knappers in the project failed to knap the number of hours required by the project, most of the core group of knappers (with some exceptions discussed below) often surpassed this minimum level. To track personal practice knappers were required to fill in a form after every practice session (see Appendix 3). These forms detail the number of hours practiced, the technologies practiced, the level of instruction (if any) given and asked them to assess the success of the knapping session for each of the technologies practiced. It was thought these areas were of the most significance in mapping the nature of the practice sessions, thus allowing a clear picture to be built up of the importance of different numbers of practice hours in enabling an individual to reach a specific skill level in a flaked stone technology. The forms also included a section for knapper comments and these comments were useful in mapping how the volunteers felt about their own knapping progress and any breakthroughs they thought were significant. The data from these forms was entered into a Microsoft Access database to allow for data analysis and comparison with the data from the aptitude tests mentioned above and the skill evaluations discussed below.

3.4.6 Skill Evaluations

The volunteer participants' skill was tested at a number of points throughout the project. For Oldowan technology each knapper received four evaluations, for Acheulean and Levallois technologies they received three (the wider group only performed two Levallois evaluations due to lack of practice of this technique). The dates of the skill evaluations for the different groups of participants are presented in Table 3.4. Some participants were not evaluated as frequently due to leaving the project, health reasons (knapper H) or being unavailable for evaluation at particular times in the project (K, R, V,). Despite these issues skill was tested throughout the project for the majority of the knappers, with the core group of knappers being tested most frequently. The first evaluation of Oldowan skill took place after around ten hours of knapping had been carried out by each volunteer. The following assessments took place at arbitrary points through the project regardless of the number of individual knapping hours carried out by the knappers.

Knapper	Skill Evaluation	Oldowan Evaluation Dates	Acheulean Evaluation Dates	Levallois Evaluation Dates
A	Evaluation 1	26/1/11	6/12/11	11/10/11
	Evaluation 2	6/12/11	14/6/12	14/6/12
	Evaluation 3	14/6/12	30/10/12	30/10/12
	Evaluation 4	30/10/12	N/A	N/A
B	Evaluation 1	26/1/11	12/12/11	12/10/11
	Evaluation 2	12/12/11	20/6/12	20/6/12
	Evaluation 3	20/6/12	13/11/12	13/11/12
	Evaluation 4	13/11/12	N/A	N/A
C	Evaluation 1	26/1/11	08/12/11	28/10/11
	Evaluation 2	08/12/11	15/6/12	15/6/12
	Evaluation 3	15/6/12	23/10/12	23/10/12
	Evaluation 4	23/10/12	N/A	N/A
D	Evaluation 1	26/1/11	6/12/11	19/10/11
	Evaluation 2	6/12/11	15/6/12	15/6/12
	Evaluation 3	15/6/12	8/11/12	8/11/12
	Evaluation 4	8/11/12	N/A	N/A
E	Evaluation 1	26/1/11	8/12/11	28/10/11
	Evaluation 2	8/12/11	13/6/12	13/6/12
	Evaluation 3	13/6/12	23/10/12	23/10/12
	Evaluation 4	23/10/12	N/A	N/A
F	Evaluation 1	26/1/11	8/12/11	11/10/11
	Evaluation 2	10/1/12	26/6/12	26/6/12
	Evaluation 3	26/6/12	16/10/12	16/10/12
	Evaluation 4	16/10/12	N/A	N/A
G	Evaluation 1	8/4/11	4/1/12	12/10/11
	Evaluation 2	4/1/12	13/6/12	13/6/12
	Evaluation 3	13/6/12	6/11/12	6/11/12
	Evaluation 4	6/11/12	N/A	N/A
H	Evaluation 1	8/4/11	1/6/12	11/10/11
	Evaluation 2	1/6/12	13/11/12	1/6/12
	Evaluation 3	13/11/12	N/A	13/11/12
I	Evaluation 1	24/3/11	8/12/11	15/6/12
	Evaluation 2	8/12/11	15/6/12	16/11/12
	Evaluation 3	15/6/12	16/11/12	N/A
	Evaluation 4	16/11/12	N/A	N/A
J	Evaluation 1	30/03/11	N/A	N/A
K	Evaluation 1	25/3/11	16/12/11	N/A
	Evaluation 2	16/12/11	15/12/11	N/A
	Evaluation 3	15/12/11	N/A	N/A
L	Evaluation 1	25/3/11	16/12/11	10/7/12
	Evaluation 2	16/12/11	10/7/12	22/10/12
	Evaluation 3	10/7/12	22/10/12	N/A
	Evaluation 4	22/10/12	N/A	N/A
M	Evaluation 1	25/3/11	24/1/12	6/7/12
	Evaluation 2	6/7/12	6/7/12	15/11/12
	Evaluation 3	13/11/12	13/11/12	N/A
P	Evaluation 1	22/3/11	N/A	N/A
R	Evaluation 1	8/2/11	12/12/11	8/6/12
	Evaluation 2	8/6/12	8/6/12	20/11/12
	Evaluation 3	20/11/12	20/11/12	N/A
S	Evaluation 1	21/1/11	N/A	N/A

T	Evaluation 1	31/1/11	16/12/11	10/7/12
	Evaluation 2	6/12/11	10/7/12	28/11/12
	Evaluation 3	10/7/12	28/11/12	N/A
	Evaluation 4	28/11/12	N/A	N/A
U	Evaluation 1	10/1/11	N/A	N/A
V	Evaluation 1	31/1/11	21/12/11	N/A
	Evaluation 2	21/12/11	N/A	N/A
W	Evaluation 1	18/2/11	N/A	N/A
X	Evaluation 1	31/1/11	N/A	N/A
Z	Evaluation 1	31/1/11	N/A	N/A
Γ	Evaluation 1	9/2/11	N/A	N/A
Δ	Evaluation 1	11/2/11	N/A	N/A
Θ	Evaluation 1	31/1/11	7/12/11	14/6/12
	Evaluation 2	7/12/11	14/6/12	14/11/12
	Evaluation 3	14/6/12	14/11/12	N/A
	Evaluation 4	14/11/12	N/A	N/A
Λ	Evaluation 1	18/2/11	N/A	N/A
Ξ	Evaluation 1	21/3/11	N/A	N/A

Table 3.4. Dates of skill evaluations for all project participants.

This was both for reasons of practicality and to ensure that there was variety in the number of practice hours performed so the value of practice compared with teaching, spatial and motor aptitude could be assessed. Knappers were only evaluated on the three main technologies on which the project focusses: Oldowan flaking; Acheulean handaxe and Levallois preferential flake technology.

The forms used for the skill evaluations in each technology are attached in Appendix 3. The evaluations assessed the volunteers understanding of the technology (or connaissance) as well as their physical ability to replicate each of the required types (or their savoir-faire). To assess connaissance in Oldowan technology the volunteers were each given the same large greensand silicate core (Fig. 3.1). This same core was used for each volunteer, in each of the assessments to ensure comparability of results. Volunteers were asked to describe

Figure 3.1. Core used in connaissance evaluations (Photo: Whitlock 2012).

how they would remove five flakes from this core, indicating where they would strike, what angle they would strike at and asked to drawn with chalk on the core their prediction of the flake that would be removed. The volunteers were told the flakes should be large and useable either as tools or for altering the core surface to produce more useable flakes. In order to establish their ability to remove flakes from more than one platform – a feature of Oldowan technology (Butler 2005, 60) – they were told they may not remove a flake from the same platform twice in a row. This meant that if they used one platform for the first removal they would then have to turn the core and find another platform for the following removal before returning to the original platform if they wished. Position of strike, striking angle and the ability to use more than one platform to remove flakes have all been indicated as significant factors in successful flaking and in recognising high levels of skill in the archaeological record (Bamforth & Finlay 2008; Geribàs et al. 2010; Nonaka et al. 2010). A score from one to five was assigned based on a discussion between the experienced knappers who observed the assessment (usually Bradley and the author) of the accuracy of their flake prediction, the position of their strike, the accuracy of their striking platform and the wisdom of their strategy.

To assess savoir-faire in Oldowan style flaking technology volunteers were asked to choose a flint core, from a wide selection of different shaped examples, from which they believed they could remove five flakes using more than one platform. They were then asked to remove these flakes following the same rules as for the connaissance assessment in that they were not allowed to use the same platform two times in succession and they were to make large useable flakes. Volunteers did not have to explain what their intentions were or predict the flake that would be removed unless they wished. They were permitted to use any hammerstone they chose for the removal and to switch hammerstone as often as they chose. Platform preparation was also permitted but knappers were asked to indicate what they considered platform preparation and to inform the assessors when they intended to strike the flake. A second score out of five was then given based on the accuracy of their blows, their striking angle, the utility of the resulting flake, the presence of feathered as opposed to hinge or step terminations, the confidence and competence of their blows, their choice and use of hammerstones and the wisdom of their strategy.

The two scores for connaissance and savoir-faire allow a picture to be built up of their ability in this technology.

Skill evaluations for handaxe and Levallois technologies followed a similar form but with some variation. In the connaissance part of the evaluation instead of one core being presented to the volunteers three different pieces of progressively more complete examples of the technology were presented to the knapper. The same pieces were used for each assessment and for each knapper. In the handaxe evaluations the knappers were asked to describe how they would remove two flakes from each piece (Fig. 3.2).

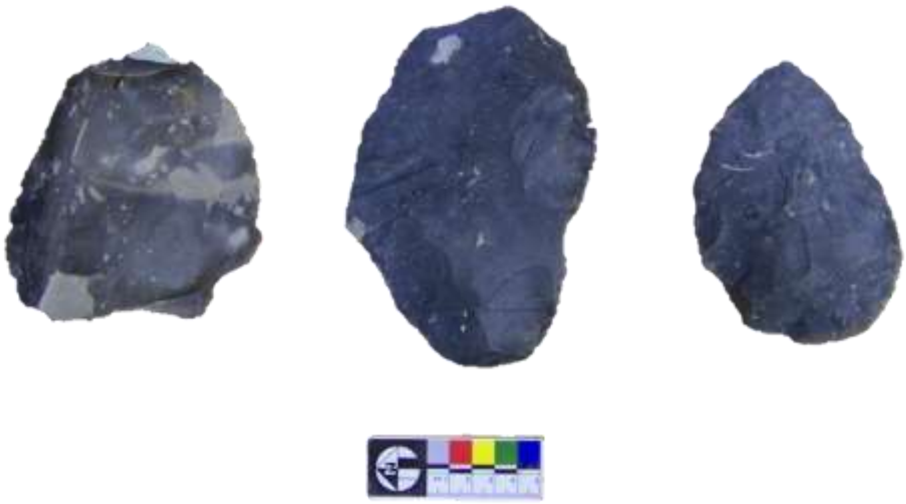


Figure 3.2. Sample handaxe cores used in connaissance evaluations.

These flakes were required to be the two next best flakes for progressing the technology – not simply two flakes that it would be possible to remove. They were asked to indicate where they would strike, asked to describe their striking angle and any platform preparation they would perform and to draw the flake they predicted would be removed onto the piece with chalk.

For Levallois technology the first two example pieces for the connaissance evaluations were dealt with in the same manner as the handaxe evaluations with the removal of two flakes described for each. The final most complete piece, however, had the dome set up ready for a first preferential flake removal (Fig. 3.3). For this piece each volunteer had to choose a place to strike, describe how they would prepare a platform, demonstrate the angle they would strike at and draw the preferential flake they would hope to remove from the

Figure 3.3. Sample Levallois cores used in connaissance evaluations.

piece. They were also asked to choose a hammerstone from a selection of different shape, size and texture options that they believed would be suitable for removing the flake. Similar to the Oldowan assessment described above volunteers were given a score out of five for their connaissance in each technology. Scores were based on the accuracy of their flake predictions, the suitability of their striking angles, the strategic soundness of their point of impact and the suitability of their removals for progressing the technology.

As well as assessing connaissance, savoir-faire was assessed for Acheulean handaxe and Levallois technologies. Again, the method used was similar to that used for Oldowan evaluation with volunteers observed as they knapped either a handaxe or Levallois core. For each technology the same initial piece was used, a moulded porcelain core shaped to mimic some of the flake features seen on cores made of flint or other naturally occurring knappable materials (Fig. 3.4; Table 3.5.).

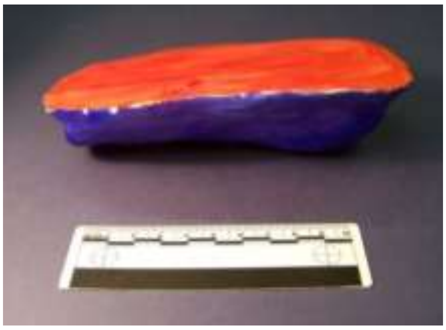


Figure 3.4. Porcelain pre-core used in handaxe and Levallois savoir-faire evaluations.

Dimension	Average Measurement
Mass	685.5g
Maximum Length	151.0mm
Maximum Width	89.8mm
Maximum Thickness	38.0mm

Table 3.5. Dimensions of porcelain pre-cores used in handaxe and Levallois savoir-faire experiments (sample size 20).

Porcelain is a ceramic material made up of a mixture of white china clay known as kaolin (an aluminum silicate), feldspar (a silicate of potassium and aluminum) and quartz or alumina (Carty & Senapati 1998, 5). When fired to high temperatures the feldspar vitrifies giving the material a glassy texture and the same conchoidal fracture properties as flint (Savage 1963, 26). The use of porcelain as a knapping material is known from the Australian aborigines who used to take the porcelain conductors from telegraph poles to knap due to the superior qualities of porcelain and their better availability to traditional knapping materials (Cotterell 2010, 95). Modern flintknappers have also been known to use porcelain as a knapping material for similar reasons (Whittaker 1994, 68). Porcelain was chosen for use in this experiment in place of flint or other naturally occurring knappable materials due to its homogeneity and the fact that it can be moulded into any required form. The use of moulds ensures that all the initial pieces given to the volunteers to knap have the same morphology and the material quality remains the same for the evaluations for each of the volunteers. The use of porcelain for lithic experiments was developed by Professor Bradley as part of the Learning to be Human Project and has already been used in a number of other lithic experiments including impact fracture and transmission chain experiments (Khreisheh et al. 2013; Stuart Page, pers comm).

For the savoir-faire section of the handaxe evaluations each volunteer was given a porcelain core and told to knap a handaxe. The handaxe could have any form they chose with no target shape presented to the participants. The participants were only allowed to use hammerstones, but could use as many of these as they wished, swap as often as they wanted and had free choice of which stones they used. The use of antler percussion was not permitted due to the varied proficiencies of knappers in the group in the use of this technique. While some knappers had a large amount of experience using antler, others never tried this. It was felt that the differences in the form of handaxes produced by hammerstone alone compared with those made with a combination of antler and hammerstone would restrict the comparability of the materials produced during the evaluations.

Knapping was recorded using a Panasonic SDR-H40 digital camera. Volunteers were told to continue either until they felt the handaxe was completed or that there was nothing further they could do to the piece. If the core snapped in half during knapping the volunteers were told they could either continue knapping one of the half pieces or stop knapping at this point as they chose. As with the Oldowan style flaking assessments scores were given out of five. Scores depended on their use of bifacing strategy, the angles and accuracy of their blows, their choice and use of hammerstones, their use of platform preparation, their choice of when to stop knapping, the confidence and competence of their blows and how they dealt with mistakes made such as step or hinge fractures. These scores were assigned after a discussion between the experienced knappers observing the assessment (usually Bradley and the author).

The Levallois savoir-faire assessment took a similar form with the same shape porcelain core being given to the knappers to make into a Levallois core. In this case the knappers were told to continue until they had removed one preferential Levallois flake. They were asked to inform the observers when they were about to remove the final flake. Participants were told to continue knapping either until this had been achieved or until they felt they could go no further with the piece. No instructions were given as to the shape or size of the flake they should produce and no target object was shown for them to copy. As with the handaxe assessment knapping was recorded using a Panasonic SDR-H40 digital camera. A score out of five was given to the knappers based on discussion by the experienced knappers observing the assessment. This score relied on their core shaping strategy, the angles and accuracy of their blows, their choice and use of hammerstones, their use of platform preparation, their choice of when to take the Levallois flake or to stop knapping, the confidence and competence of their blows, and how they dealt with mistakes made such as steps or hinges. The two scores out of five for savoir-faire and connaissance comprise the evaluation of each volunteer’s ability in the technology being tested.

3.4.7 Materials Analysis

In addition to the scores and the recording of the knapping for handaxe and Levallois technology materials from each assessment were kept for analysis. Measurements were carried out by Antony Whitlock and the author.

For the Oldowan assessment the cores and flakes produced in the savoir-faire section of the experiment were collected. These materials were also photographed (Appendix 4). A number of variables on each material type was analysed as discussed below. Full tables of results are provided in Appendix 5.

Oldowan:

Cores:

Maximum length:

- The maximum length of each core was measured; this was taken as the longest measurement on each core. Maximum core length was used as a comparison with the lengths of flakes in order that the maximum potential size of flake could be calculated and related to the size of flakes actually produced. The ability to produce pieces of unusually large size has been interpreted as indicative of high knapper skill levels (Bamforth & Finlay 2008, 5).

Maximum width:

- The maximum width of each core was taken as a measurement of the straight line distance perpendicular to the maximum length line at the widest point on the core (Andrefsky 1998, 97). This was again taken as a comparison of potential size for flake removal with actual size of flake removals. As volunteers were instructed to remove flakes from more than one platform the potential of the width of the core must be considered as well as the length.

Maximum depth:

- The maximum depth of each core was noted. This was taken as a measurement of a straight line distance perpendicular to the maximum width. Similar to the length and width measures this was taken as an indicator of maximum potential flake size to be compared with the actual size of flake removals.

Flakes:

Number of flakes:

- The number of flakes produced was recorded as it was thought likely that higher number of flakes produced would indicate higher levels of skill. Each knapper was asked to produce five flakes in the assessment.

Maximum Length:

- Maximum length measurements were taken for each flake. This measurement was defined as a straight line distance from the proximal to the distal end of the flake on a line perpendicular to the most remote point at the distal end (Andrefsky 1998, 97). The ability to produce exceptionally long pieces has been identified as being linked to highly skilled knapping (Bamforth & Finlay 2008, 5).

Maximum Width:

- Maximum width was defined as a straight line distance, perpendicular to the flake length line, intersecting it at the flake's widest point (Andrefsky 1998, 97). As above, this measurement was taken as size of pieces produced has been shown to be indicative of knapper skill level.

Maximum Thickness:

- Maximum thickness measurements were taken for each flake. This attribute was defined as the distance from the dorsal to the ventral surface of the flake, perpendicular to the flake length at its thickest point (Andrefsky 1998, 99). Width to thickness ratios have been used when analysing tools as an indicator of knapper skill (Bamforth & Finlay 2008, 5). This measurement was taken to see if similar measures could be applied to debitage analysis.

Platform Thickness:

- As well as the maximum thickness, the thickness of the platform of each of the flakes was taken. This was taken as a straight-line measurement from the point of percussion on the ventral surface to the most remote point on the dorsal edge of the striking platform. As beginners often have difficulty aiming, hitting either too close to the edge of the core or too far behind it (Bamforth & Finlay 2008, 6), it was thought that the thickness of the platform may show significant correlation with the skill of the knapper.

Termination Type:

- Termination type was also analysed. Terminations were defined as overshot, hinge, step or feathered (Fig. 3.5). Hinge and step fractures are well documented as knapping mistakes associated with novices in many flaked stone technologies (Bamforth & Finlay 2008, 6) and for this reason it was thought that they may show a significant correlation with knapping skill scores. Overshot termination have also been considered errors in a number of technologies (Butler 2005, 34).

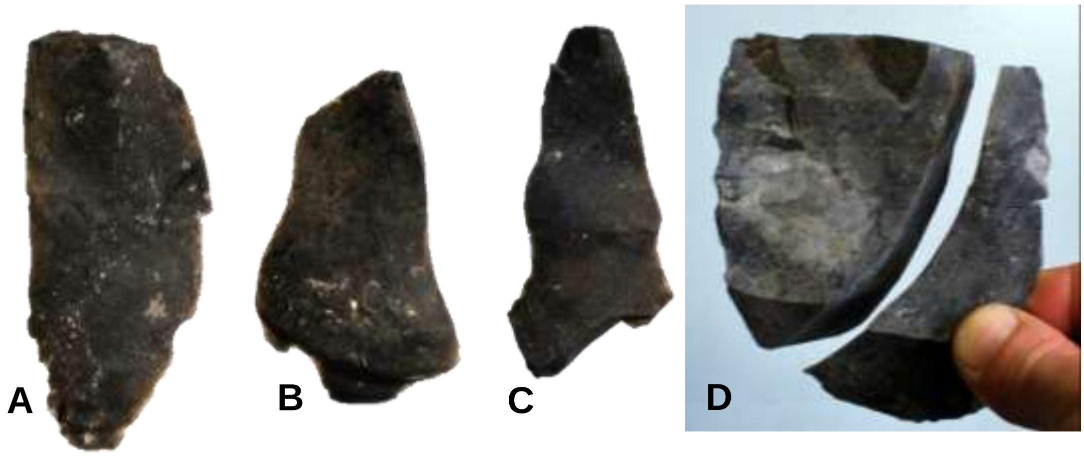


Figure 3.5. Termination types identified in the Oldowan skill evaluations. A) Feathered, B) hinged, C) step and D) overshot (photo: Whitlock 2013).

Handaxe:

Tool:

Completion:

- The completion of each tool was recorded, as some handaxes were broken during the evaluations. The handaxes were recorded as complete, broken and abandoned, or broken and one half worked further.

Breaking a tool during manufacture is a clear knapping error and it was considered that this would prove to be a significant indicator of skill.

Maximum Length:

- The maximum length of each handaxe was recorded, defined as for the flakes in the Oldowan evaluation described above. Producing long tools has been demonstrated to be a highly skilled aspect of knapping and a significant marker of skill in handaxe technology in particular (Winton 2005, 113). As each individual started with the same shape piece in the evaluation, as a result of the use of porcelain pre-cores, direct comparison of handaxe lengths could be made.

Maximum Width:

- The maximum width of each handaxe was recorded, defined as for the flakes in the Oldowan evaluation section above. The width was taken to produce a ratio with the thickness as width/thickness has been identified as being a significant indicator of skill in handaxe manufacture, with only expert knappers able to knap wide thin pieces (Winton 2005, 112).

Maximum Thickness:

- Maximum thickness, as defined for Oldowan flakes described above, was recorded. This was to produce width/thickness ratios already discussed.

Mass:

- The mass of the handaxes was recorded to give an indication of the amount of raw material that was used for the tool compared with the mass of debitage. Inefficient use of raw material has been identified as indicative of low skill levels (Bamforth & Finlay 2008, 6) and so this variable was recorded to calculate how efficiently the raw material was used, in the expectation that it would relate to knapper skill level.

Symmetry:

- Control over tool form and shape is often stated to be the result of highly skilled knapping (Bamforth & Finlay 2008, 5). For this reason the profile and plan view symmetry of the handaxe was calculated. This was done using the Flip Test software, introduced to the field of lithic studies by Hardaker and Dunn (2005). This method uses the deviation of handaxes from true symmetry by turning the artefact about its long axis to produce an index of asymmetry expressed as a score normally falling between 1-10, with higher numbers indicating greater asymmetry. Symmetry of stone tools has been stated as an indicator of skill level (Bamforth 1991, 310) and it can demonstrate the degree of control an individual is able to impose on an initial core of raw material.

Debitage:

Mass:

- The mass of the debitage was recorded as above to give an idea of the efficiency of the knapping, as discussed in the tool section above.

Number of flakes:

- Total number of flakes was recorded. This was the number of flakes larger than 10mm maximum dimension. This size was chosen as flakes smaller than this would be less likely to survive in an archaeological context and to allow the materials collected in the evaluations to be analysed efficiently. Number of flakes was chosen as a possible significant factor for identifying skill, when taken with the mass of the debitage, as ability to take large flakes has been connected with higher knapping skill levels (Bamforth & Finlay 2008, 5) A lower number of flakes for a particular debitage mass would indicate larger flakes were being removed without the need to measure each individual flake.

Platform type:

- Platform type was identified as flat, facetted or undetermined. Flat platforms consisted of the unmodified surface of the core without any signs of ridges or flake scars. Facetted platforms typically showed multiple ridges from previous small removals to adjust the edge before the flake was removed. Flakes were classified as having a facetted platform if at least one ridge showed on the striking platform. Counts of flat to facetted platforms can give an indication of the technical strategy of the knapper and it was thought likely this was indicative of their skill level.

Termination type:

- Termination type was assessed as either feathered, hinge, step, overshot or undetermined defined as for the flakes in the Oldowan evaluation above. As already stated, flake termination has been shown to be an indicator of knapping mistakes and thus knapper skill. Creating hinge or step fractures in bifacial technology such as handaxes can create stacks if not correctly removed at an early stage which affect the symmetry of a piece adversely and create problems for thinning and maintaining a consistent bifacial plane (Whittaker 1994, 109).

Levallois:

Core:

Maximum length:

- The maximum length of the Levallois core was measured. This was defined as the longest measurement on the core as for the Oldowan evaluation above. Size of Levallois core was considered as a likely indicator of skill as it would indicate the amount of reduction that each knapper had performed in order to achieve a Levallois flake or the stage at which the core was abandoned (while the core still had potential to produce a Levallois flake or not).

Maximum width:

- The maximum width of each core was defined as a straight line distance perpendicular to the flake length line, measured where it intersected the core at its widest point (Andrefsky 1998, 97). This measurement was taken for the reasons stated for maximum length above.

Maximum depth:

- The maximum depth of each core was defined as a straight line distance from the core's dorsal to ventral face, perpendicular to the length line that intersected the core at its widest point. This measurement was taken for the same reasons as stated for the length and width above.

Core mass (including and excluding Levallois flake):

- Core mass was recorded both including and excluding the Levallois flake (where a flake was achieved). This was recorded as a measure of the amount of reduction that was necessary for a flake to be achieved (or for the core to be abandoned) compared with the mass of debitage. Inefficient reduction has been shown to be indicative of low knapper skill level (Bamforth & Finlay 2008, 6).

Flake:

Presence of flake:

- Presence/absence of a preferential Levallois flake was measured. This was a reflection of the individual knapper's ability to achieve the object of the knapping evaluation – to produce a Levallois flake. This seemed a clear indicator of skill in this technology.

Maximum length:

- Maximum length was defined as for the flakes in the Oldowan skill evaluation. This was measured as size of tools produced has been shown to be an indicator of skill in flaked stone technologies, with exceptionally large sizes being identified as a characteristic of high knapper skill level (Bamforth & Finlay 2008, 5).

Maximum width:

- Maximum width was defined as for the flakes in the Oldowan skill evaluation described above. This was measured for the same reasons given for maximum length.

Maximum thickness:

- Maximum thickness was defined as for the flakes in the Oldowan skill evaluation above. This was measured for the same reason as stated for maximum length and width.

Platform thickness:

- Platform thickness was defined as for the Oldowan skill evaluation above. This variable was measured as the preparation of the final platform for the Levallois removal has been shown to need careful thought and planning (Wynn & Coolidge 2011, 90). As such the platform morphology and dimensions seemed likely to be an indicator of high level skill in this technology.

Termination type:

- As stated above termination type has been used as a clear indicator of skill to the extent that step and hinge fractures are often classified as knapping mistakes. In Levallois technology an overshot final flake also counts as an error, as it defeats the implied purpose of this prepared core technology, producing a flake with a long cutting edge (Eren et al. 2011, 237). For this reason termination type was recorded to give information on knapper skill.

Mass:

- The mass of the final Levallois flake was recorded, along with the core mass for comparison with the debitage mass to give information on knapper efficiency that could relate to skill.

Percentage of core surface area covered by flake:

- The percentage of the original core surface area that the flake comprised was calculated. This was because the ability to take the largest possible flake from the core upper surface without overshooting the ends has been indicated as a potential marker of skill in this technology, if that was the original intention of the original Levallois knappers (Eren et al. 2011, 231). During training knappers were instructed to take the largest flake possible when practising Levallois technology so it is likely that each, during the skill evaluations, were striving to take as much of the core surface area as possible in the final removal.

Debitage:

Mass:

- The mass of the debitage was taken, as discussed above to allow calculations of flaking efficiency that have been used as a measure of skill (Bamforth & Finlay 2008, 6).

Number of flakes:

- Total number of flakes larger than 10mm in diameter was counted. This was for the reasons discussed above in the handaxe section – for comparison with debitage mass to give an overall idea of size of flakes produced without the need to measure individual flakes.

Termination Type:

- Flake termination type was analysed. These were defined as for the Oldowan and handaxe flakes above, as feathered, hinge, step, overshot or undetermined.

Number of dorsal flakes:

- The total number of dorsal and ventral flakes were calculated. This was due to the fact that studies have shown that dorsal/ventral flake ratio is a variable that is influenced by the skill of the knapper (Eren et al. 2011, 244–5). These counts could also give information on the technological strategy of the knapper which is another factor that may prove to be a significant indicator of skill (Pelegrin 1990, 118). Dorsal and ventral flakes were identifiable due to the fact that each face of the porcelain pre-cores was coloured differently (Fig. 3.6).

Dorsal flake platform type:

- Dorsal and ventral flake platform types were analysed. These were assigned to one of three types – flat, facetted and undetermined. In Levallois technology, if performed by an expert, there is a clear disparity between the way dorsal and ventral flakes are removed (Butler 2005, 67–8). This extends to the degree of platform preparation for each and the form this preparation takes. For this reason it was thought that different proportions of flat to facetted platform counts would relate to the degree of platform preparation each knapper carried out (facetted platforms indicating platform preparation has taken place while flat platforms display the unaltered original surface of the core). This relates to the technological strategy of each knapper and thus their skill.

Number of ventral flakes:

- See above (number of dorsal flakes).

Ventral flake platform type:

- See above (dorsal flake platform type).

Number of undetermined flakes:

- The number of flakes that could not be assigned to a surface were also counted. These were flakes that did not show any colour from the outer surface of the porcelain pre-core. These were counted so they could be factored into proportions of dorsal to ventral flakes to provide a more accurate picture of this figure.

3.4.8 Summary

The above material attributes comprehensively cover the areas that have been most frequently related to knapper skill based on both experimental studies and studies of archaeological assemblages (see Figs 2.1 and 2.2, Chapter Two). Through a thorough analysis of these areas and comparison with the scores knappers received for their performance in the skill evaluations it was possible not only to investigate the links between these areas and knapper skill, but also to assess the utility of previous approaches to identifying skill based on archaeological assemblages. While it was, necessarily, not possible to fully analyse all aspects of the technology in the time period allowed by the project, all materials, recordings and data gathered during the skill evaluations were preserved which will allow future work to build on the findings of this project.

3.5 Conclusion

As discussed above and in the literature review (Chapter Two) the methods that researchers have used to investigate skill in flaked stone technologies are many and varied. The methods described in this chapter sought to build on previous work to provide a comprehensive means of assessing skill in a group of experimental knappers and relating this to archaeological assemblages by identifying material attributes that are most affected by knapper ability. While no attempt was made to recreate prehistoric learning conditions, as indeed would be impossible considering that modern human volunteers were being taught, the detailed records of attendance of taught sessions, private practice hours and the aptitude tests were designed to give information on the importance of these areas in determining skill levels achieved by knappers. Through these methods it was possible to map knappers learning through the project and build up a comprehensive picture of the factors that contributed to the skill achieved during this period.

4. Skill in Oldowan Technology

4.1 Introduction

Oldowan technology is the earliest known example of flaked stone manufacture, with its oldest occurrence dating to 2.6 million years ago (Semaw 2000). The earliest finds come from Gona in Ethiopia, but Oldowan tools are known from sites across East Africa and they continued to be the predominant technological type for a million years (Stringer & Andrews 2011, 208). The key principal that lies behind Oldowan style flaking and allows this technology to be achieved is the repeated and controlled removal of flakes from more than one platform on a core of flakeable material. These removals should be based on an understanding of the conchoidal fracture properties of these materials (de la Torre 2011, 58). Even from the earliest known examples of this technology there is evidence for good understanding of conchoidal fracture properties by the hominin species who manufactured them (Stout et al. 2010, 12).

Volunteer knappers in the Learning to Be Human Project were taught Oldowan style flaking first of the techniques on which the project focussed, as flaking is the key skill that is used in all flaked stone technologies. This technology was one of the least practiced by knappers in the group. Since all the technologies in the study involved flaking, however, the practice hours involved in these must also be considered as contributing to flaking skill achieved by knappers. Teaching in flaking took place for the core and wider groups in the sessions detailed in Table 4.1, with detailed descriptions of each session attached in Appendix 5.

Date	Group	Knappers	Time
20/1/11	Core	A,B,C,D,E,F	6hrs
21/1/11	Core	A,B,C,D,E,F	6hrs
26/1/11	Core	A,B,C,D,E,F	3hrs
27/1/11	Core	A,B,C,D,E	7hrs
31/1/11	Wider Experienced	R,S,T,U,V,Z,X,Θ	3hrs
2/2/11	Wider Beginners	I,J,K,L,M,N,O,P	3hrs
3/2/11	Core	A,B,C,D,E	3hrs
11/2/11	Wider Experienced	Δ	1hrs
18/2/11	Wider Experienced	W, Λ	1hrs
9/3/11	Core	G,H,Q, Ξ	2hrs

Table 4.1. Teaching sessions focussed on Oldowan style flaking

These taught sessions generally took the form of a demonstration by an expert knapper (usually Bradley) followed by the group knapping with input from competent knappers Whitlock and the author – see methodology for details of knapping experience). After the introductory taught session knappers were encouraged to practice these skills personally. The number of practice hours achieved by each knapper is discussed in the results section below. Throughout the project skill in Oldowan technology was tested at regular intervals. The timing of these assessments is presented in Table 4.2. The first evaluation took place after each knapper had performed around ten hours of knapping in taught and practice sessions. This represented, to some extent, the skill level each individual had at the start of the project.

While Oldowan technology is the simplest to master of the technologies that the project focussed on, it has the potential to show significant results that can give information on early hominin cognitive abilities. It represents a clear mental shift in the way hominins were able to create tools and in their mastery of physical actions and spatial ability. It is equally clear that it is a skill that only hominin species have been able to master fully and, more importantly, pass on to other members of the species. While apes can learn to cut using sharp stones, this is not a behaviour that appears in the wild and only occurs when prompted by humans (Davidson 2011, 187). For this reason the effect of different levels of teaching and personal practice for determining which individuals develop high levels of skill in this technology, could be of great interest here in terms of our understanding of the cognitive requirements of this technology.

4.2 Results.

4.2.1 Skill Evaluations.

The results of the skill assessments can be seen in Table 4.2. This table shows that the number of volunteers in the project was drastically reduced between the first and second assessments. For knappers who had no previous experience (core group and wider beginners) the first evaluation took place when they had performed around ten hours of knapping in taught and personal

	1st Evaluation - 19/01/11 - 8/4/11		2nd Evaluation - 6/12/11 - 10/1/12		3rd Evaluation - 1/6/12 - 10/7/12		4th Evaluation - 13/10/12 - 28/11/12	
Knapper	Connaissance Score	Savoir-faire score	Connaissance Score	Savoir-faire score	Connaissance Score	Savoir-faire score	Connaissance Score	Savoir-faire score
A	1	1	5	4.5	5	4.5	5	5
B	2	2	4	4.5	4	3.5	4	4
C	3	4	4.5	4.5	4.5	4.5	4.5	4.5
D	3	4	5	4.5	4.5	4.5	5	5
E	2	4	3.5	4.5	4.5	5	4.5	4.5
F	5	5	5	5	5	5	5	5
G	4.5	2.5	5	5	5	5	5	4.5
H	3	3.5		HR	4	HR	5	HR
I	3	3.5	4	3.5	4	3	4	4
J	4	2.5	LP	LP	LP	LP	LP	LP
K	2	2.5	3	3	U	U	4	3
L	3.5	3.5	2.5	3	4.5	4	3.5	3.5
M	3.5	3	U	U	4.5	3.5	4.5	4
P	4	4	LP	LP	LP	LP	LP	LP
R	4.5	4	5	5	U	U	5	4.5
S	4.5	3	LP	LP	LP	LP	LP	LP
T	4.5	2.5	4.5	4.5	4.5	2	5	3.5
U	4.5	4	LP	LP	LP	LP	LP	LP
V	3.5	3.5	4	4				
W	4.5	3	LP	LP	LP	LP	LP	LP
X	1.5	1.5	LP	LP	LP	LP	LP	LP
Z	2.5	1.5	LP	LP	LP	LP	LP	LP
Γ	1.5	1.5	LP	LP	LP	LP	LP	LP
Δ	2	1.5	LP	LP	LP	LP	LP	LP
Θ	5	5	5	5	4.5	5	5	4.5
Λ	5	4.5	LP	LP	LP	LP	LP	LP
Ξ	4.5	5	LP	LP	LP	LP	LP	LP

Table 4.2. Skill evaluation timings and scores: Blue = core group knappers, Red = wider group beginners, Green = wider group experienced, HR=unable to knap for health reasons; LP= left project; U= unavailable for assessment.

practice sessions. Even at this early stage there was wide variation in ability among those knappers who had had similar amounts of training and practice (all knappers excluding wider experienced). Scores range from one to five for connaissance and savoir-faire. This shows that there is some aspect of natural aptitude that influences ability in the initial stages of learning Oldowan technology. This is discussed in more detail in the aptitude chapter (Chapter Seven).

Looking at the results for the knappers who took part in more than one evaluation some patterns begin to emerge. The scores for connaissance are presented graphically below (Fig. 4.1). This shows that in general there is a sharp increase in knapping skill between the first and second evaluations, with skill level in connaissance remaining steady after this point. The second evaluation took place between 8 months to a year after the first and these results suggest that after this point the knappers had achieved the maximum level of understanding of simple flaking that they were able. The majority of knappers at this point were receiving scores from four to five. This indicates that a very high level of understanding of this technology can be achieved in a relatively short time period (see below for the numbers of knapping hours and teaching this involved).

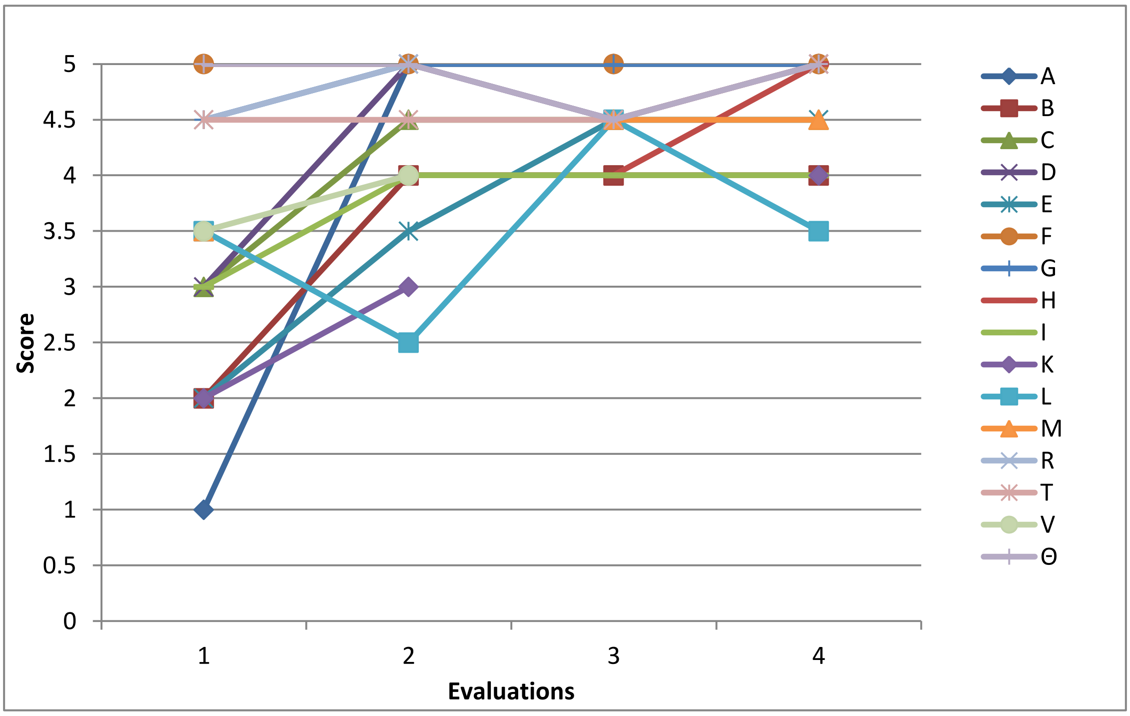


Figure 4.1. Scores for connaissance for each evaluation for knappers who took at least two evaluations

The scores for savoir-faire are presented in Figure 4.2. This shows a different picture to that seen for connaissance scores, with a much wider range of scores received by knappers. Individual knapper scores also appear more variable with loss as well as gain of ability.

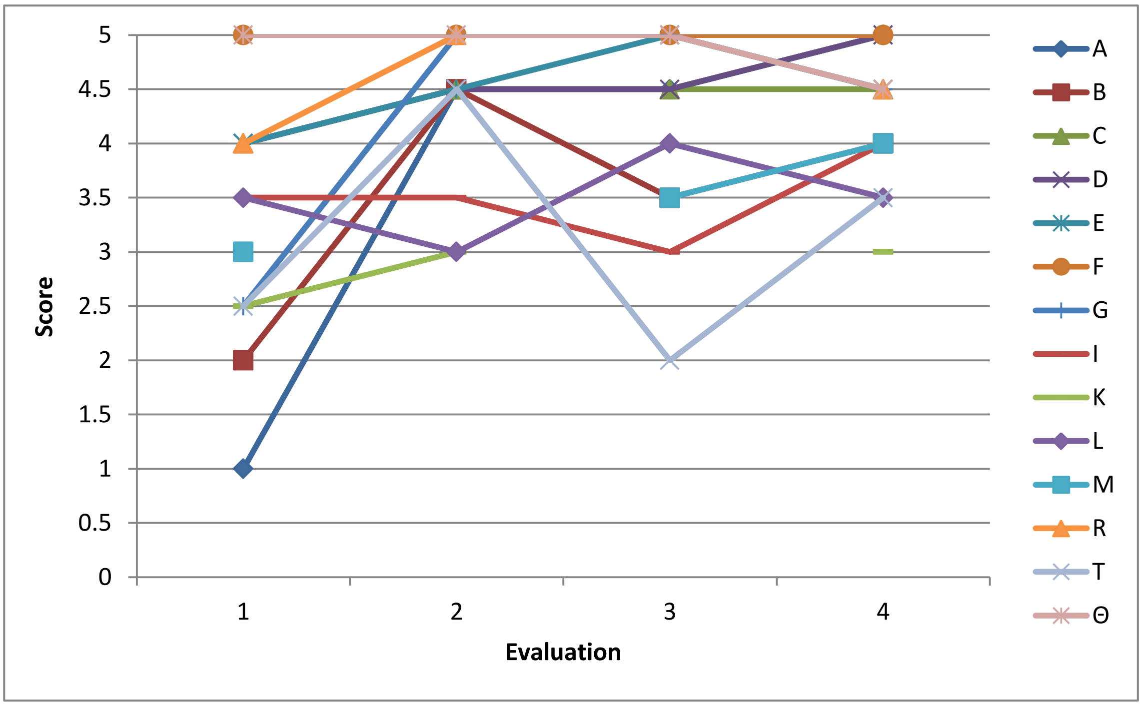


Figure 4.2. Scores for savoir-faire for all knappers who performed at least two evaluations

When scores are considered separately for the core and wider groups a much clearer picture emerges (Fig. 4.3). The core group shows the same general picture for savoir-faire as for connaissance scores, with a sharp increase in skill between the first and second evaluations followed by a general maintenance of that skill level with very little occurrence of skill loss. This suggests that for this group, in a similar manner to connaissance, their optimum achievable level of skill in simple flaking was achieved within 8 months to a year of knapping teaching and practice. From this point (with the exception of knapper B) all core group knappers achieved very high scores of 4.5 – 5. The wider group's scores show a very different picture with generally little improvement in ability over the course of the assessments and much greater score fluctuation. The wider group received a less intensive training program and in general performed less practice hours than the core group (see below for details). From this information it seems that these factors had a greater impact

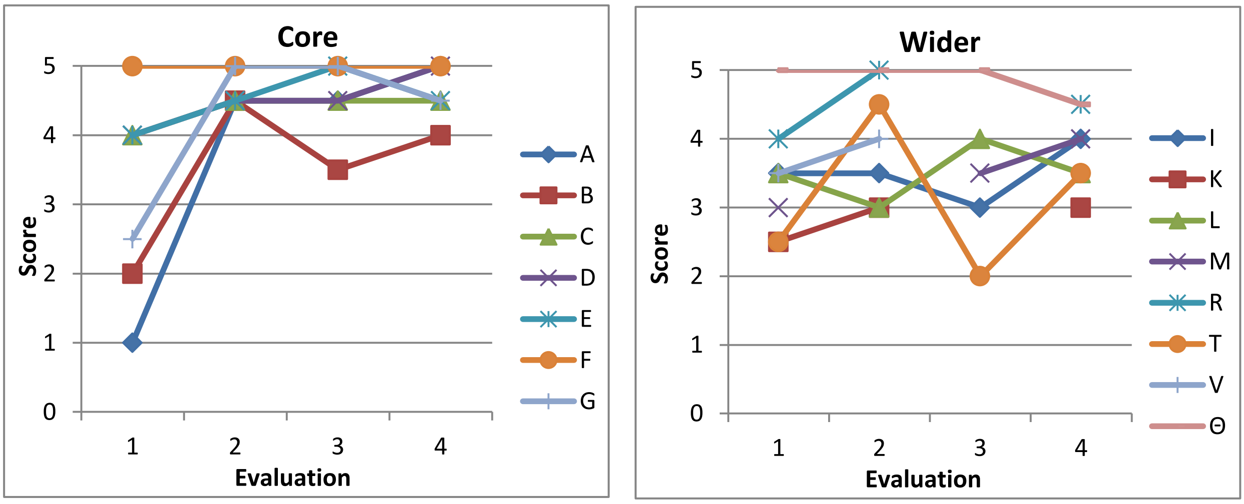


Figure 4.3 Savoir-faire scores for core and wider group who performed more than one evaluation

on the group's savoir-faire that on connaissance. This suggests that while the principles behind flaking can be easily understood with only a little explanation, the physical ability to carry it out requires greater levels of instruction and practice to achieve a high skill level.

An examination of the comments that were taken as the skill evaluations took place can give greater information on the areas of skill in Oldowan style technology that were most difficult for volunteers to achieve. An example evaluation form can be seen in Appendix 3. Aspects of knapping that were commented on include striking angle, number of miss strikes, position of blows, choice of hammerstone, follow-through, force of blow, degree and quality of platform preparation, production of shattered or split flakes and accuracy of flake predictions. The percentages of errors committed in each evaluation is presented in Figure 4.4. From this it can be seen that the most common errors at the first evaluation were those of flake positioning, followed by miss hitting and inaccurate predictions. Ninety-three percent of knappers made mistakes in flake positioning in the first evaluation, suggesting that identifying a suitable position for a flake removal is the most difficult concept for beginner knappers to achieve. Common mistakes made that fell under this bracket include attempting to remove flakes over very thin edges or flat sides, attempting to remove flakes over edge angles that are too obtuse, and positioning their blows too far back from or too close to the edge of the core. The second evaluation shows the same percentage (93%) making errors in choosing where to position their

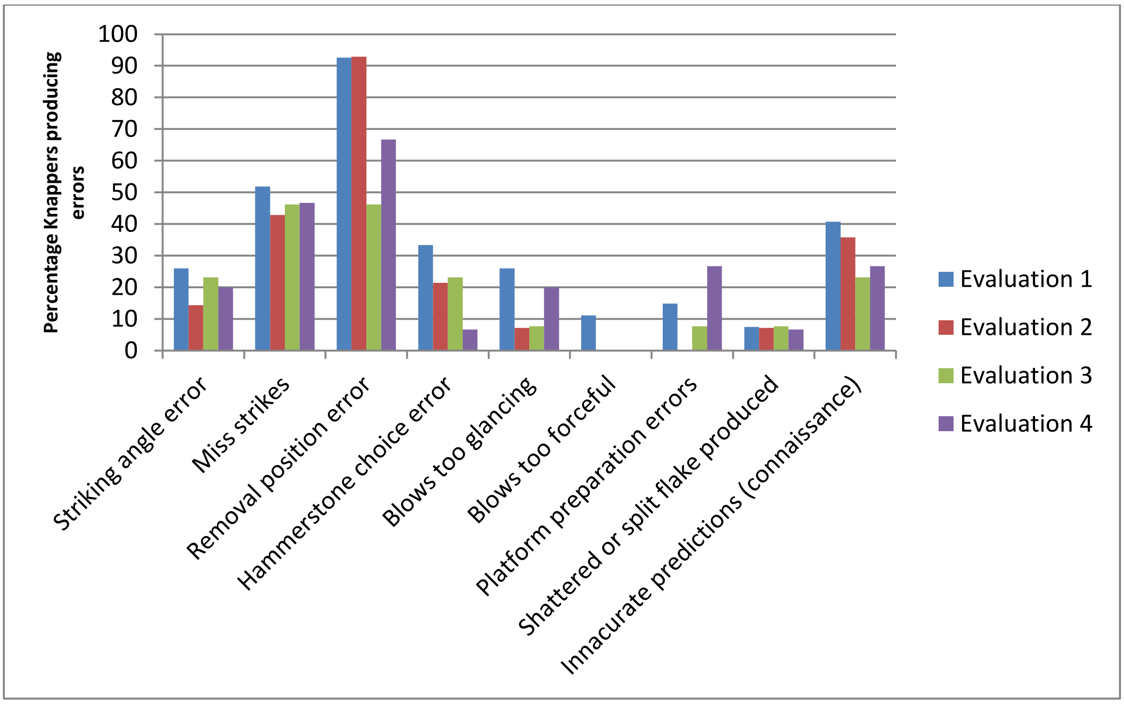


Figure 4.4. Percentage of knappers committing errors in different areas in all evaluations

blows. They also show similar levels of shattered/split flake errors to the first evaluation, but all other errors decrease in occurrence, with force of blow and platform preparation errors showing the largest decrease. By the third evaluation errors in attempted removal positions had decreased by half, with only 46% of knappers making a mistake in this area. This evaluation took place about a year and a half after knapping started, suggesting that significant levels of time investment are required for most knappers to become skilled in choosing where to take flakes. Most of the other areas of error show similar levels for this evaluation, suggesting knappers have achieved as much as they are able in terms of skill level and error reduction in these areas of the technology by this point in their learning. This view is backed up by the fourth evaluation, which shows a small increase in errors of positioning and platform preparation and a decrease in hammerstone choice errors but similar figures for all other errors to the previous evaluation. Interestingly, the majority of the platform preparation errors were that of over or unnecessary preparation. I would suggest this is a result of knappers using techniques learnt for more complex technologies and applying them unnecessarily to simple flaking in a counter-productive manner.

The results of the skill evaluations that took place during the project build up a picture of the knappers' learning. From the scores it can be seen that the majority of learning in understanding how to perform the technology took place within the first year of the project, whereas the ability to physically carry out the knapping task was a more gradual process throughout the project. The scores showed clear distinctions between the intensively taught core group and the wider group in terms of skill acquisition of physical ability, suggesting that high level skill in Oldowan style manufacture is not something that can be picked up without certain levels of teaching and practice. The errors committed by knappers during the evaluations highlight the key area of understanding that is essential for achieving the highest skill levels in flaking – the position of the flake removal. It is only through a thorough understanding of the effect the core surface has on removals that a high level of success can be achieved in this technology. This was true for the experimental knappers and must also have been true for the early hominin species that first practiced this technology.

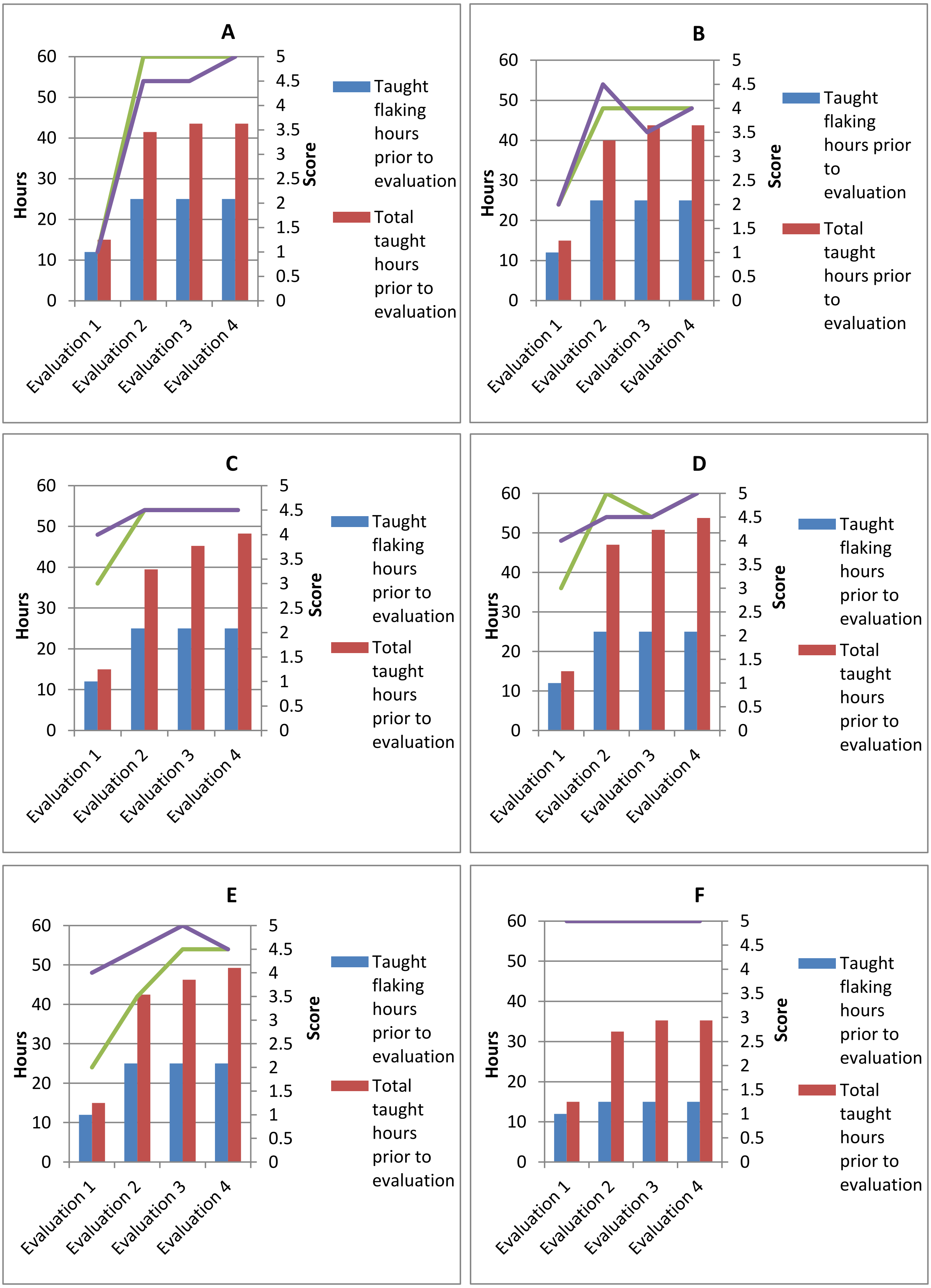
4.2.2 Teaching

Members of the core and wider groups received different amounts of training in simple flaking and training was often carried out in separate sessions. The dates and participants of taught sessions are shown in Table 4.1 above. From this it can be seen that, while the majority of members of the core group received training in multiple sessions, members of the wider group each only received one session of training in flaking. As well as training in Oldowan technologies the groups were also given training in more complex technologies. As all these technologies involve flaking these training sessions must also be taken into account when evaluating the effect of teaching on skill level achieved in Oldowan style flaking. The dates and participants for these sessions are displayed below (Table 4.3).

Looking at the results of the skill evaluations in terms of total number of hours spent in all taught knapping sessions for the knappers who took part in all four evaluations it can be seen that, for the core group of knappers (A-H) there appears to be some correlation between skill acquisition and amount of hours spent in taught knapping sessions (Fig. 4.5). This is shown by a significant

Date	Group	Technology	Knappers	Time
20/1/11	Core	Flaking	ABCDEF	6hrs
21/1/11	Core	Flaking and Retouch	ABCDEF	6hrs
22/1/11	Core	Levallois	ABCDEF	3hrs
26/1/11	Core	Flaking	ABCDEF	3hrs
27/1/11	Core	Flaking	ABCDE	7hrs
31/1/11	Wider Experienced	Flaking	RSTUVXZΘ	3hrs
2/2/11	Wider Beginners	Flaking	IJKLMNOP	3hrs
3/2/11	Core	Flaking	ABCDE	3hrs
9/2/11	Core	Levallois and Bladelets	ABCDEFΓ	3hrs
10/2/11	Core	Retouching	BD	3hrs
11/2/11	Wider Experienced	Flaking	Δ	1hr
18/2/11	Wider Experienced	Flaking	WΛ	1hr
9/3/11	Core	Flaking	GHQΞ	2hrs
15/3/11	Wider Beginners	Blade	DKLPQ	1.5hrs
16/3/11	Wider Experienced	Levallois	RSTVΓΘΞ	3hrs
17/3/11	Wider Beginners	Blade	IM	1hr
18/3/11	Wider Beginners	Blade	J	1hr
31/2/11	Wider Experienced	Levallois	U	3hrs
5/4/11	Core	Handaxe	ABCDEFG	2hrs
13/4/11	Core	Handaxe	H	2hrs
16/4/11	Core	Levallois	BCDEFGHΘ	1hrs
18/4/11	Core	Indirect Pecussion	ABCDEFGΘ	3hrs
14/9/11	Core	Levallois	ACDEFGH	1/2hr
15/9/11	Core	Handaxe	ACDEFGH	1hr
17/9/11	Core	Danish Square Axe and Dagger	ACDEFG	3hrs
21/9/11	Core	Pressure Flaking	ACDEFG	1hr
19/10/11	Wider	Handaxe	HIKLRTΘ	2hrs
31/10/11	Wider Beginner	Handaxe	M	2hrs
9/11/11	Wider Experienced	Levallois	T	2hrs
18/11/11	Wider Experienced	Handaxe	V	2hrs
19/11/11	Wider Beginner	Levallois	L	2hrs
20/3/12	Core	Platform Preparation for handaxes and blades	ABCDEFMTΘ	2hrs
3/4/12	Core	Upper Palaeolithic Blade making	BCDEFG	3/4hr
4/4/12	Core	Solutrean Laurel Leaf	BDEG	1hr
4/7/12	Wider Beginner	Handaxe and Levallois	L	1hr
2/10/12	Core	Knapping	CDEGIKM	3hrs

Table 4.3. Time spent in taught sessions for all knappers in all technologies.


A
B
C
D
E
F
Hours
Score
0
10
20
30
40
50
60
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Evaluation 1
Evaluation 2
Evaluation 3
Evaluation 4
Taught flaking hours prior to evaluation
Total taught hours prior to evaluation

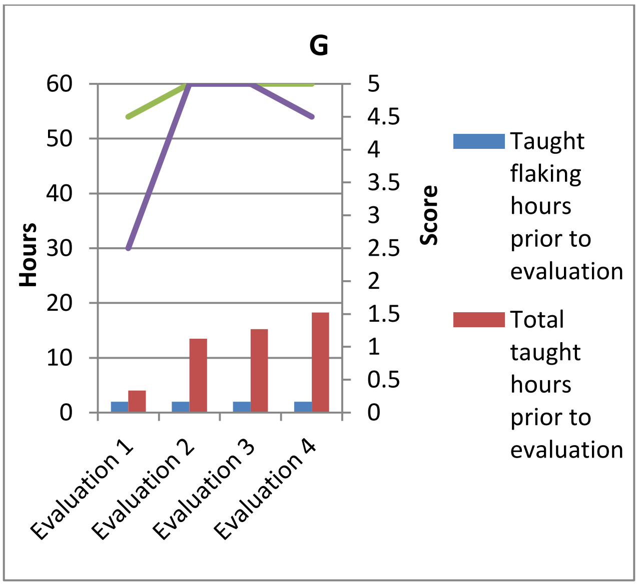
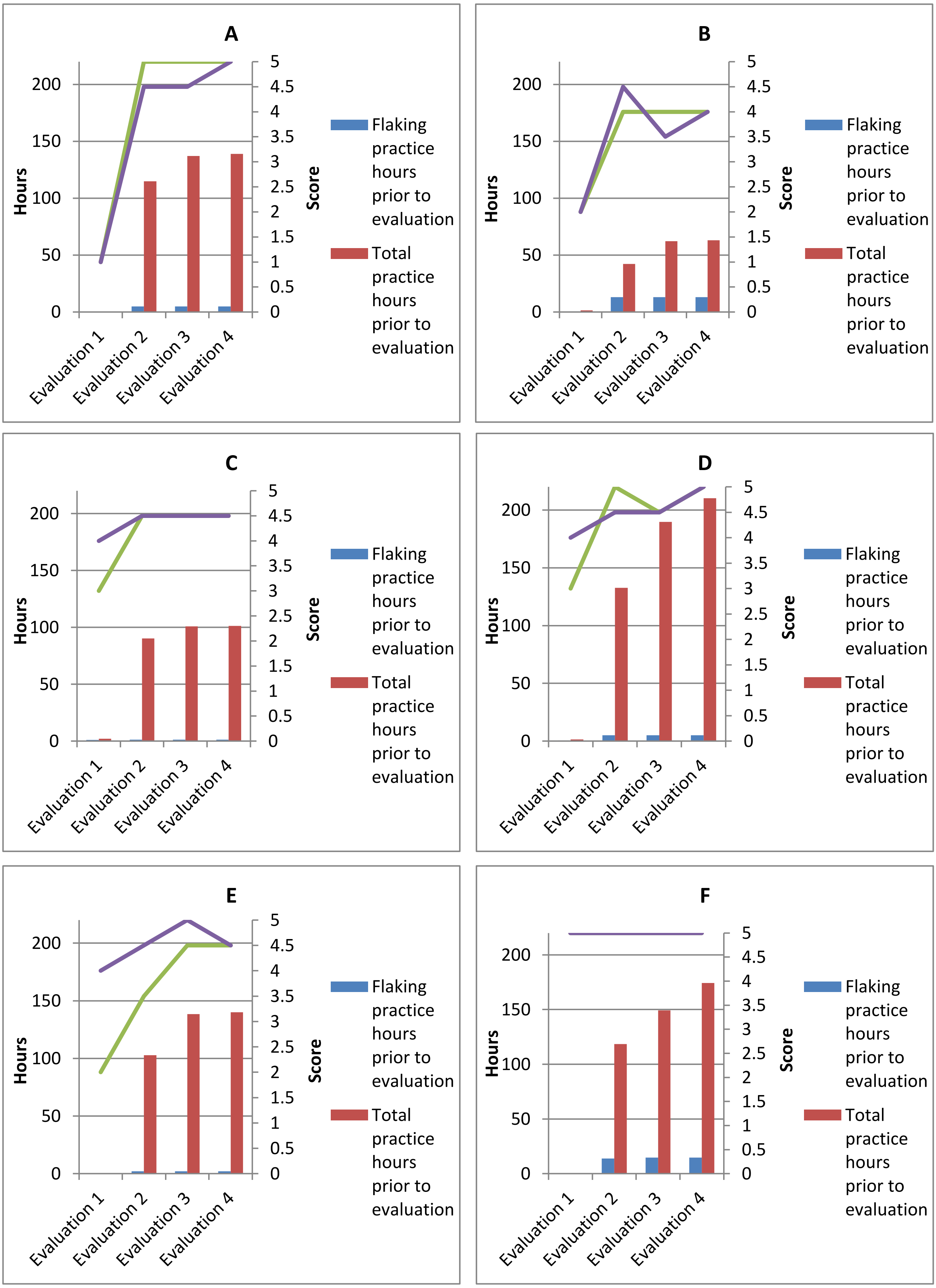


Figure 4.5. Taught flaking and total taught hours prior to evaluation compared with scores received for connaissance (green) and savoir-faire (purple) for core group knappers who performed four evaluations.

increase in skill between the first and second assessments for the majority of core group knappers, corresponding with a greater number of hours spent in taught sessions between these two assessments. After the second evaluation skill acquisition stabilises for the majority of knappers with little improvement in ability shown between the second and fourth evaluations. This corresponds with fewer additional teaching hours between these evaluations. Within the core group, however, there does not appear to be a link between those achieving the highest scores and those who attended the greatest number of taught sessions, with the consistently highest achieving knapper (F) attending 35.25 hours of sessions while the lowest achieving knapper (B) attended a larger number (43.75 hours). The wider group showed no clear pattern of relation between score and hours spent in taught sessions. These knappers all attended a significantly lower number of sessions than the core group, however, within this group high scores were still achieved, particularly for connaissance.

4.2.3 Personal practice.

As well as teaching, amount of personal practice was a variable that differed between individual knappers and may have an effect on skill level achieved. The number of hours spent practicing flaking as well as practice hours for all technologies prior to each evaluation are presented for each knapper who performed all four evaluations in Figure 4.6.


A
B
C
D
E
F
Hours
Score
0
50
100
150
200
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Evaluation 1
Evaluation 2
Evaluation 3
Evaluation 4
Flaking practice hours prior to evaluation
Total practice hours prior to evaluation

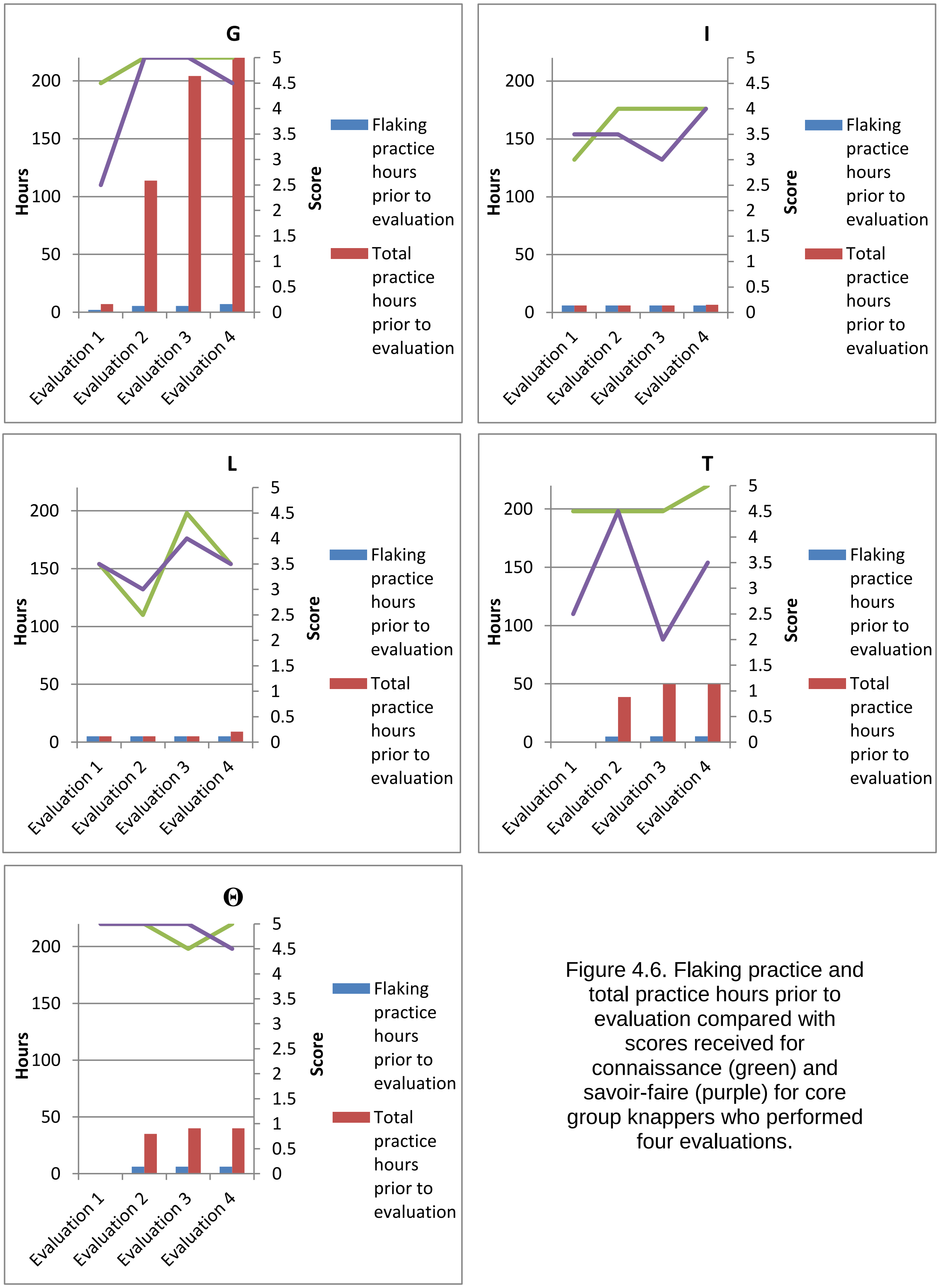


Figure 4.6. Flaking practice and total practice hours prior to evaluation compared with scores received for connaissance (green) and savoir-faire (purple) for core group knappers who performed four evaluations.

From this it can be seen that, while hours of practice were pretty consistent for the core group (knappers A-G), in terms of number of hours practiced and amount of specific flaking practice the wider beginners knappers (I and L) had very low levels of personal practice with very little additional knapping after the first evaluation. This group continued to knap in taught sessions, so it is from these sessions that improvements in skill seen in this group may stem. Comparing members of the core group, it can be seen that improvements in skill seem to correspond to increases in hours practiced. Between the first and second evaluations most knappers show a sharp increase in skill, corresponding with a sharp increase in hours practiced prior to the evaluation. From the second to the fourth evaluations the skill level is, in general, stabilised without much improvement at this point. This corresponds with a decrease in additional practice hours between the assessments, suggesting that improvements in skill are reliant on continued practice, although most core group knappers had already achieved a high level of skill by the second evaluation.

It is, however, also clear from the results of this analysis that the level of skill achieved is not simply determined by the number of hours practiced. This can be seen most clearly in the first evaluation. At this point the majority of knappers had performed similar levels of practice, for the most part less than five hours. Scores at this stage are very highly variable, however, suggesting that other factors as well as practice have an impact.

Practice does have some impact on skill and this can be seen clearly when comparing the results of the core group of knappers with that of the wider group. The majority of the core group (with the exception of those with very high initial skill levels) show a sharp increase in skill, in line with a sharp increase of number of hours practiced between the first and second evaluations. This sharp rise is not seen in the wider group where practice levels were low and most knapping took place in taught sessions. In this group skill level shows, at the most, only a small increase and shows frequent decreases as well as increases in ability throughout the project, particularly for savoir-faire ability. This shows the importance of continued knapping practice in allowing a high level of skill to be achieved in simple Oldowan style flaking. Other than teaching and practice hours the effect of knappers' individual aptitudes for flaking must be considered as a factor in determining skill level. This will be discussed in greater detail in the aptitude chapter (Chapter Seven).

4.2.4 Material skill markers

In order to connect the data derived from the experimental project with archaeological remains and use it to form inferences about skill level of prehistoric knappers it is important to look at skill in terms of the effect it has on the materials produced by the knappers as well as undertake analysis of their knapping styles and techniques. The materials produced in each skill evaluation were collected. This comprised the cores reduced in the evaluations as well as the flakes produced. Attribute analysis was carried out on these materials. The specific attributes analysed for the cores were:

- Maximum length.
- Maximum width.
- Maximum depth.

For the flakes the following attributes were analysed:

- Total number of flakes produced.
- Maximum length.
- Maximum width.
- Maximum thickness.
- Termination type.
- Platform thickness.

Each of the flake attributes will now be assessed in terms of their relationship to knapper skill level and the significance of these results where this is most relevant.

Total number of flakes produced:

Each knapper in the skill evaluations was asked to remove five flakes from a core of their choice, with the instruction that they may not use the same platform to remove a flake twice in succession. If number of flakes produced could be related to knapper skill it would be expected that number of flakes produced by each knapper would increase from the start to the end of the project and that the skill level assigned to each knapper would be reflected in the amount of flakes produced with a higher skill level corresponding to a greater number of flakes produced.

The figures for average flake number across the group for each evaluation support this with a gradual increase from 3.9 flakes at the beginning to 4.9 at the end of the project. As presented in Table 4.4, a paired sample *t* test demonstrated that the mean differences seen between evaluation one and all subsequent evaluations are statistically significant (α=0.05). This implies that the patterns seen are relevant to knapper skill development.

	Evaluation 1	**Evaluation 2**	**Evaluation 3**
Evaluation 2	p=0.035	-	-
Evaluation 3	p=0.011	p=0.723	-
Evaluation 4	p=0.001	p=0.096	p=0.166

Table 4.4. Results of paired t tests for mean number of flakes produced for each evaluation (α=0.05).

When individual knapper skill scores are observed in terms of number of flakes produced, it can be seen that, when taken against connaissance scores, there is no clear link between the number of flakes produced and score (Fig. 4.7). When taken against the savoir-faire scores, however, a variable that might be expected to be more connected with knapper ability in this area, it can be seen that there is a much clearer picture of increasing number of flakes

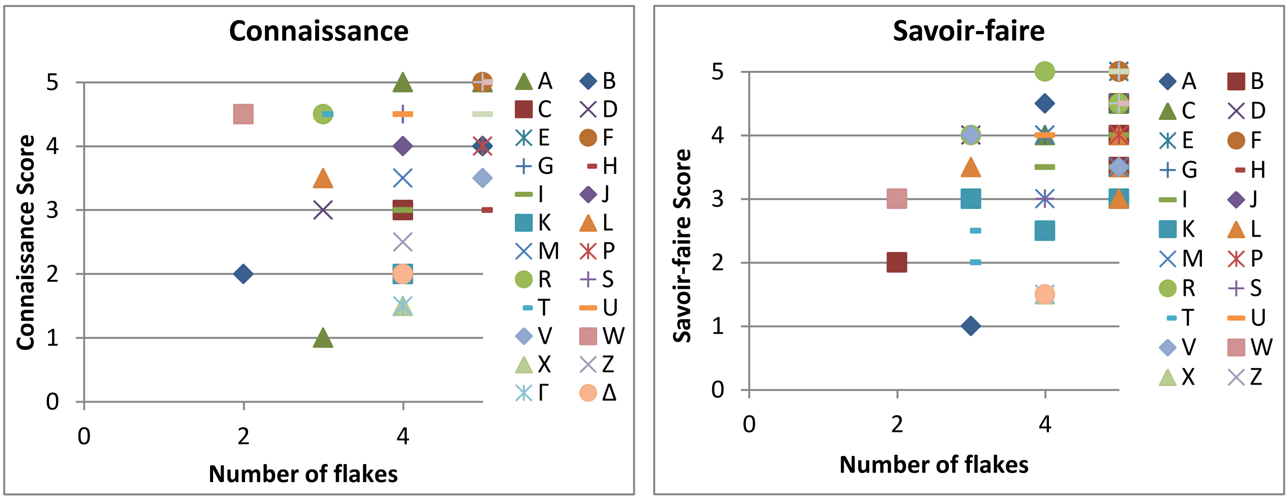


Figure 4.7. Correlation of number of flakes produced with scores for connaissance and savoir-faire.

following increasing score for savoir-faire (Fig. 4.7). This suggests that ability to remove a large number of flakes from a core is indicative of skill and the area of skill this concerns is savoir-faire rather than connaissance.

Maximum Flake Length:

Maximum length was recorded with the expectation that more skilled knappers would be able to produce longer flakes. As well as absolute measures of flake length, length as related to initial core size had to be considered as knappers had free choice of cores of a variety of different shape. The average maximum flake length for each evaluation is presented in Figure 4.8. Looking at the average maximum flake length for every flake taken across the group for each evaluation it can be seen that there is a slight but steady rise in flake length from evaluation one to evaluation three, presumably reflecting similar rise in ability, but from evaluation three to four there is a slight decrease in average flake length. This suggests that absolute flake length is an indicator of skill level but the differences between the means are not sufficient to demonstrate statistical significance, with the differences between evaluation one and four displaying the highest level of significance (p=0.251).

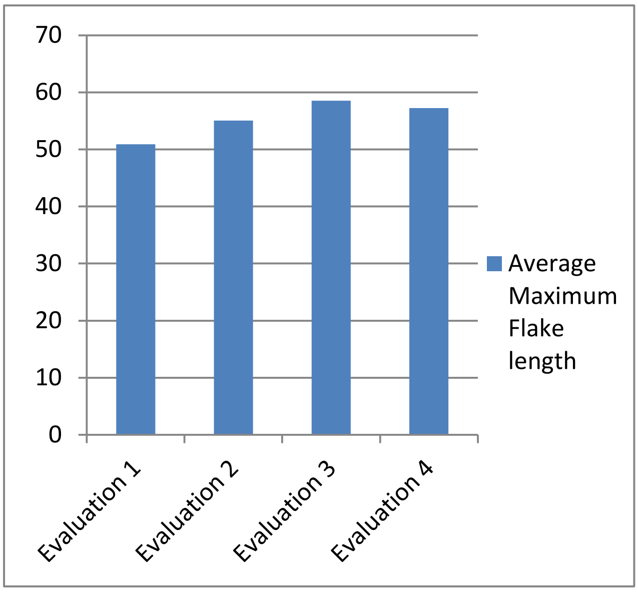


Figure 4.8. Average maximum flake length for all knappers for each assessment.

If maximum flake length is considered as a proportion of initial core maximum length, the changes in averages are slightly different with less increase in length between evaluations one and two but a larger shift between evaluations two and three (Fig. 4.9). The core maximum length was taken as the longest measurement on the core and should reflect the maximum possible length for flakes taken from the piece. Thus, considering the flake maximum length as a proportion of this should give an idea of how successfully the knapper managed to utilise the material properties of the initial piece. The

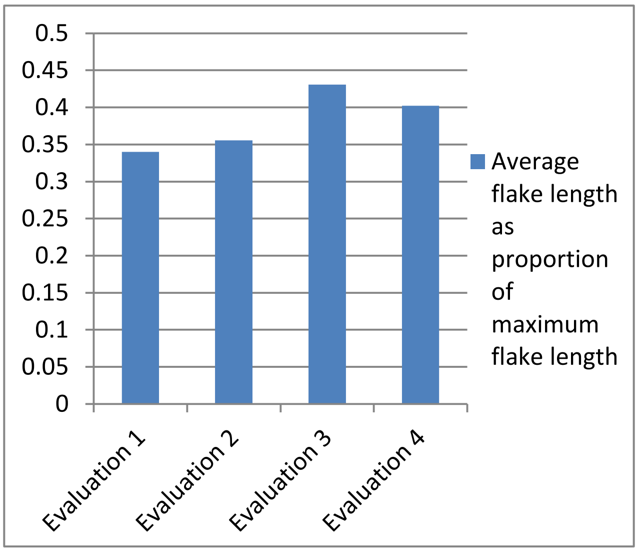


Figure 4.9. Average flake length proportions for each evaluation.

proportion figures show a similar decrease between evaluation three and four as for the length values. This decrease corresponds with a decrease in additional practice hours between evaluations three and four when compared to additional practice hours between evaluations one and two, and two and three. Between evaluations two and three there was an average of 25 additional practice hours among the knappers, whereas between three and four this dropped to only five additional hours. This decrease in practice may be a factor in causing the decrease in flake length seen between these two evaluations, suggesting that continued practice is necessary in flaking for the highest skill levels to be maintained and for this to be apparent in the materials produced.

Looking at this data in terms of the divide between the core and wider groups it can be seen that only the core group average for maximum flake length shows a clear increase from the first to the last evaluations. The wider beginners flake length averages were larger than the core group for the first assessment, but reduced quite considerably after that. By the last evaluation the core group were achieving the longest flakes. This information backs up the picture of flake length being affected by continued knapping practice as the core group were the only volunteers in the study who maintained practice throughout the project, although even in this group the amount of practice decreased as the project progressed. The wider beginners group had particularly low levels of personal practice throughout, with little additional practice taking place after the first flaking evaluation. This suggests that it is indeed continued practice that allows knappers to continue to produce long flakes from a core. This data is backed up by the consideration of flake length as a proportion of maximum core length with similar patterns being apparent in this, although the core group data does show a decrease in flake length proportion between the third and fourth evaluations. As mentioned above this could relate to a lower number of additional practice hours between evaluations three and four compared to previous evaluations. This lower number of additional practice hours is also accompanied by a lower number of additional teaching sessions for the core group which may similarly have an effect on flake length achieved.

When these figures are considered in terms of the score achieved for the evaluation in question, it can be seen that for the average maximum flake length values and the flake length proportion values there is not a clear picture of correlation between flake length and connaissance score (Fig. 4.10). When this is considered with savoir-faire score, however, there is a seeming slight correlation between both average maximum flake length and average flake length proportion with the score. This suggests that flake length and flake length as a proportion of initial core length are factors that are affected by skill with greater lengths and greater proportion of maximum core utilised being associated with greater levels of skill. The particular area of skill that is most associated with increased flake length is savoir-faire. Savoir-faire skill is often stated to be reliant on practice for improvement (Apel 2008, 99; Pelegrin 1990, 118). This idea is backed up by the influence of continued practice on flake length achieved.

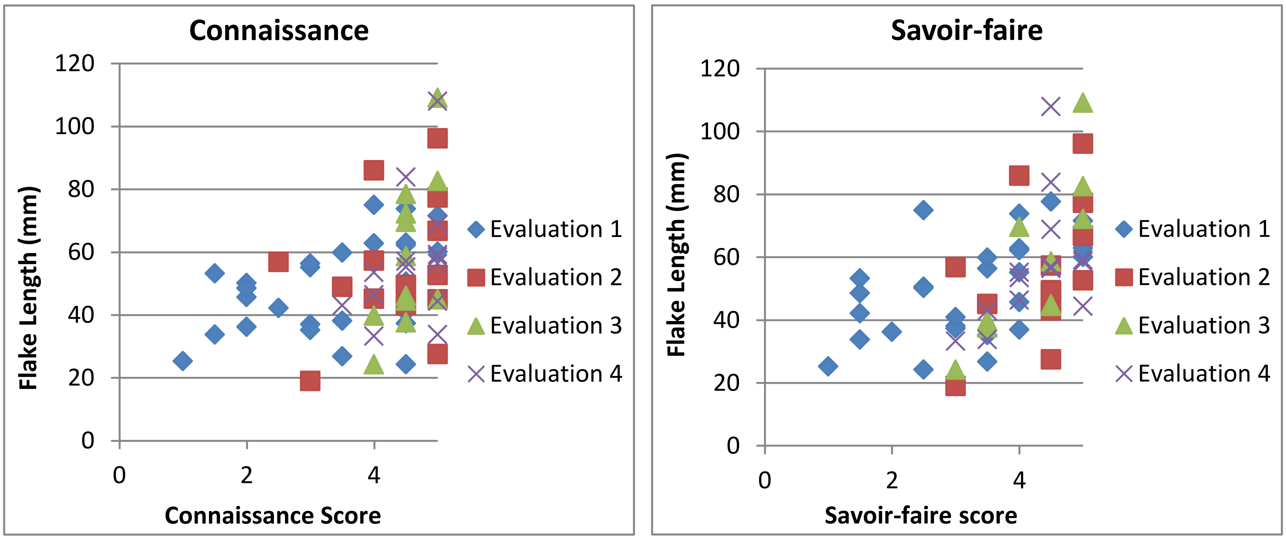


Figure 4.10. Average maximum flake length, compared with scores for connaissance and savoir-faire.

Maximum Width:

In addition to maximum length, maximum width measurements were taken in order to establish whether other size measures could be used to assess the skill of a flintknapper. As with maximum length above both absolute measures and width as a proportion of initial core maximum length were considered, in order that the size of flakes produced could be related to the initial size of the material reduced. The figures for average maximum width for each evaluation are presented in Figure 4.11. Looking at the average widths for each evaluation it can be seen that there is no clear increase or decrease in average flake maximum widths with subsequent evaluations. The width as a proportion of maximum core length measurements show a similar picture, with no significant difference in average proportion in any of the evaluations. This shows that maximum width was affected by the initial size of the core and the average proportion of the maximum length of this core that the width represents stayed constant throughout the project. This suggests that maximum width is a variable that is related to initial material size rather than to knapper skill.

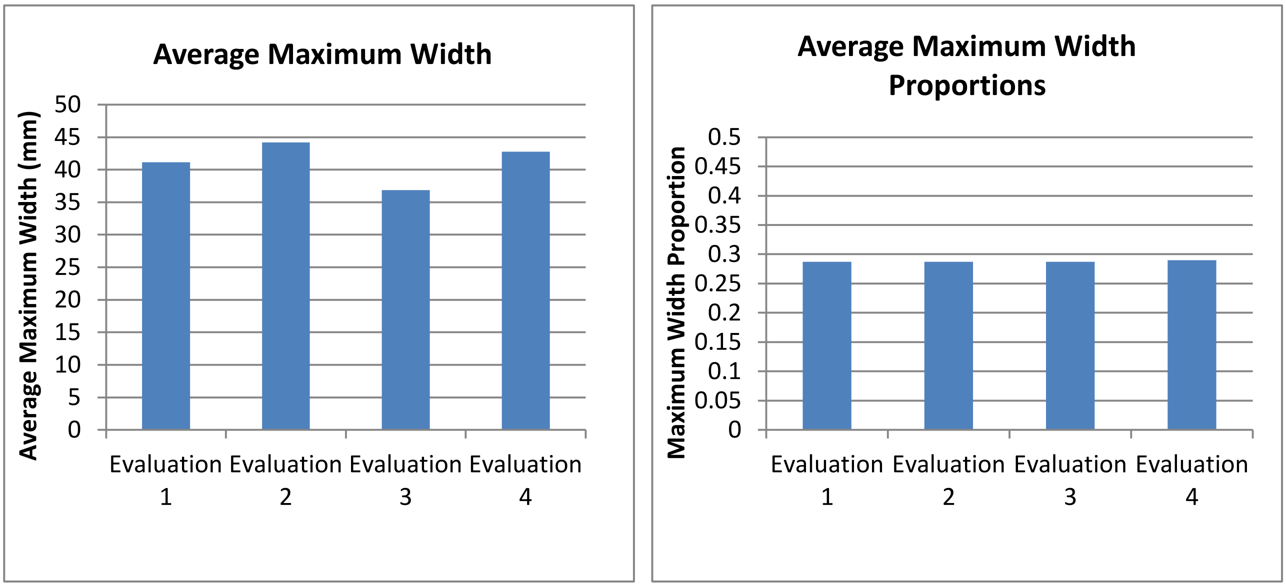


Figure 4.11. Average maximum width and maximum width as a proportion of core maximum length for each evaluation.

Maximum thickness:

Measurements of maximum thickness were taken with the intention of establishing whether size measures other than length could be used as a measure of knapper skill. Width to thickness ratios have been indicated as a measure of skill in flaked stone tools with wider, thinner tools being associated

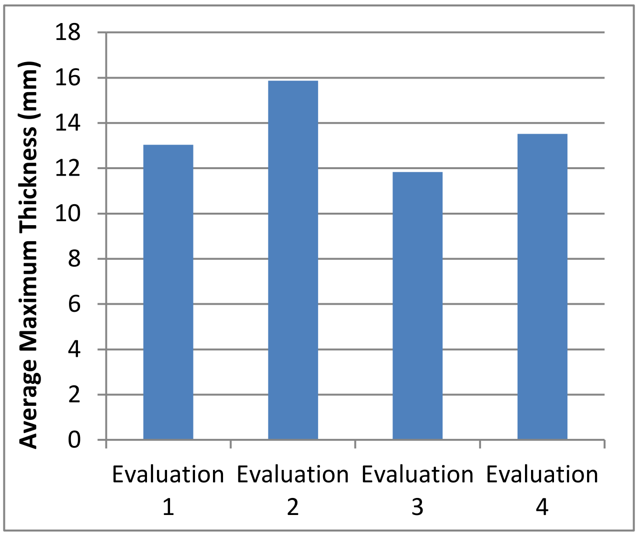


Figure 4.12. Average maximum flake thickness for each evaluation.

with higher skill levels in bifacial technologies (Bamforth & Finlay 2008, 5). For this reason this variable was also considered as a possible indicator of skill in debitage assemblages. The average maximum flake thickness measurements for each assessment are shown in Figure 4.12. The average maximum thicknesses achieved for each evaluation show no clear pattern of increasing or decreasing with each evaluation. As well as absolute measures of thickness, thickness was also expressed as a proportion of maximum core length as above with maximum width and thickness to relate this to initial raw material size. The average thickness proportions similarly show no pattern of increasing or decreasing thickness with each subsequent evaluation. This suggests that maximum thickness was not a factor that is affected by knapper skill.

To look at this in more detail, maximum thicknesses and thickness proportions were plotted against scores for connaissance and savoir-faire to give an indication of whether there was a correlation between these two variables. The results of this can be seen in Figure 4.13. From these figures it can be seen that there does appear to be a slight correlation between connaissance score achieved and maximum thickness and a slightly stronger one between savoir-faire score and maximum thickness. The data for thickness proportion shows a similar pattern of correlation with connaissance and savoir-faire. The correlation is slightly less clear than for absolute maximum thickness measures. This indicates that thickness as well as length of flakes produced is a factor that is influenced by the skill of the knapper and that both connaissance and savoir-faire ability is utilised for producing thicker flakes.

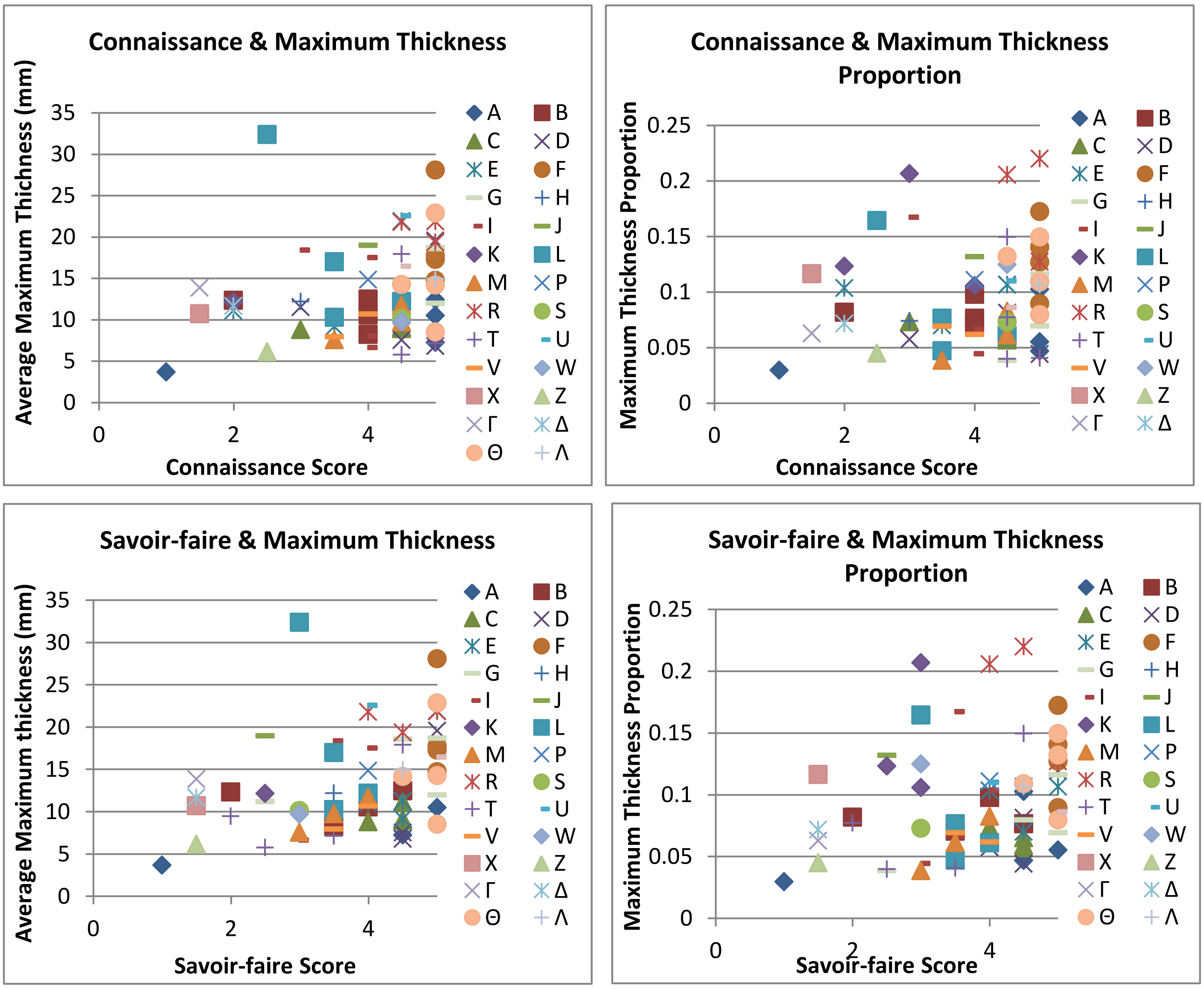


Figure 4.13. Average maximum thickness and thickness proportions with scores for connaissance and savoir-faire for each knapper in each evaluation.

Platform Thickness:

Platform thickness measurements of each flake produced were taken. This variable was considered to be a potential indicator of skill as it had become clear from the observations noted during the skill evaluation that position of blows was a significant area of error throughout the process. Among other considerations this included knappers striking the core either too close to or too far away from the edge of the piece. For this reason the thickness of the platform was considered a possible indicator of this aspect of skill as it comprises a record of the distance from the edge that a knapper struck. The results of this aspect of the evaluations are displayed in Figure 4.14. From this it can be seen that, when the averages for platform thickness for each evaluation are calculated, there is no clear picture of increasing or decreasing platform

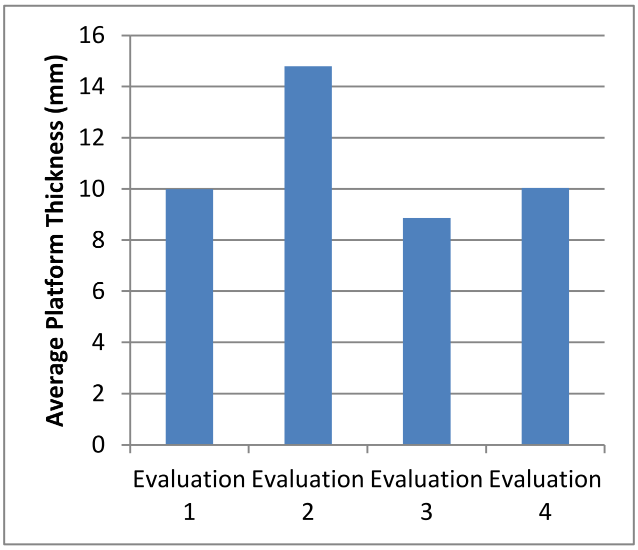


Figure 4.14. Average platform thicknesses for each evaluation.

thickness throughout the project. To investigate this more thoroughly the platform thicknesses were related to the initial core size by expressing them as a proportion of the maximum core lengths which were assessed as the longest measurement on each core. The results of this show a similar picture with no clear increase or decrease in platform thickness proportion through the project.

The platform thicknesses were also related to the scores for connaissance and savoir-faire as can be seen in Figure 4.15. The results of this show no clear pattern relating platform thickness or proportion to connaissance score, although the final evaluations show a narrower band of results for platform thickness than the earlier evaluations, suggesting that more uniformity within the group is seen as the project progressed. When these results are looked at in terms of savoir-faire scores a similar picture can be seen, with no clear correlation between platform thickness and score, but a narrower range of thicknesses and thickness proportions achieved for the final two evaluations,

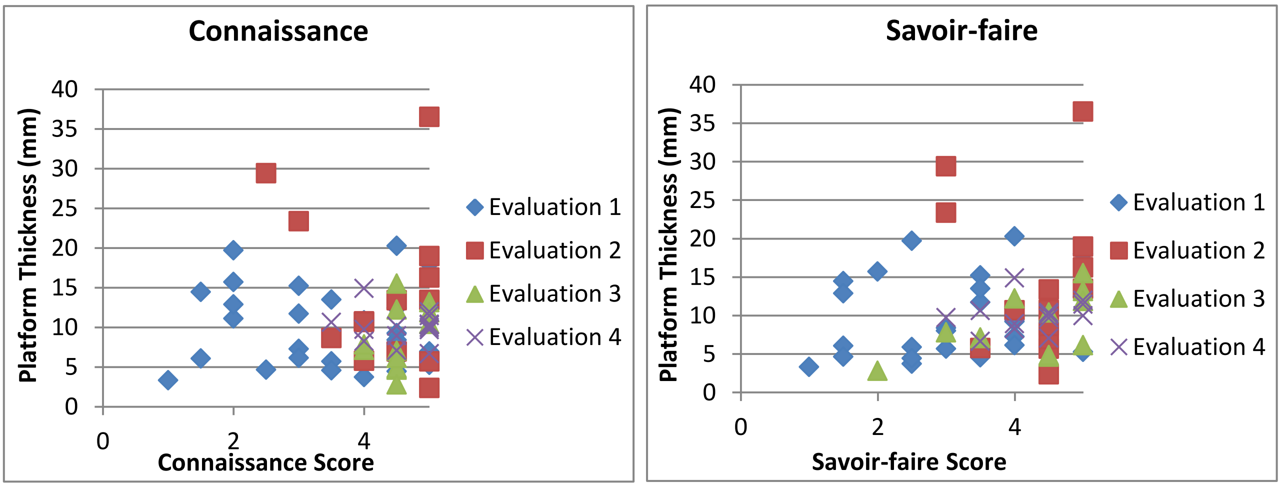


Figure 4.15. Average platform thicknesses plotted against scores for connaissance and savoir-faire.

compared with the first two evaluations. From this it seemed likely that the results were linked with decreasing variability in performance as the project progressed, suggesting more uniform group performance is linked with increasing skill.

Termination Type:

Termination type has long been identified as a significant variable that relates to knapping skill (Bamforth & Finlay 2008, 6). In the majority of technologies, hinge and step fractures are considered knapping errors. Overshot terminations are also generally considered to be errors in simple flaking technology due to their inefficient use of raw material and detrimental effect on the core (Butler 2005, 34). In this study feather, hinge, step and overshot terminations were identified in the flakes produced during the Oldowan skill evaluations. The percentages of each for each successive evaluation are shown in Figure 4.16. The data reveal no clear pattern of increasing percentages of flakes with feathered terminations, or decreasing levels of hinge, step or overshot terminations through successive evaluations. This suggests either that knapping errors continued to be made as skill in the group increased or that termination type can not be so clearly linked with knapping mistakes.

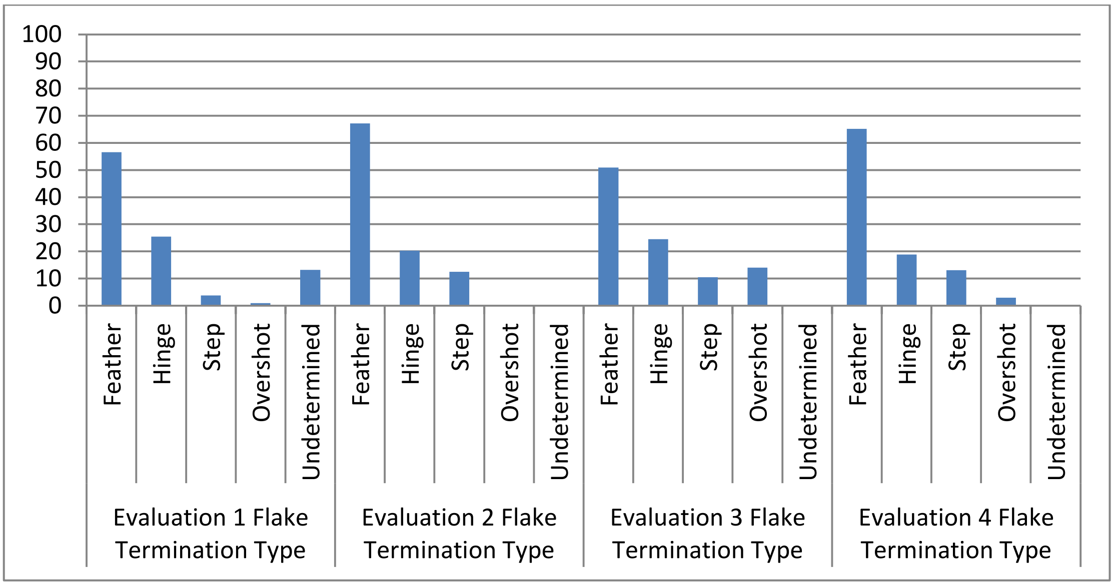


Figure 4.16. Percentage of individual termination types produced in each evaluation.

To look at this variable in more detail, flake termination percentages for each knapper were plotted against scores achieved for connaissance and savoir-faire in each evaluation in order to observe if any correlation existed. The results of this can be seen in Figure 4.17. These charts show that there appears to be no correlation between percentage of feathered flakes achieved and connaissance or savoir-faire score. This suggests that when five flakes are produced in a knapping sequence termination type is not a good indicator of knapper skill. Longer reduction sequences may show different results.

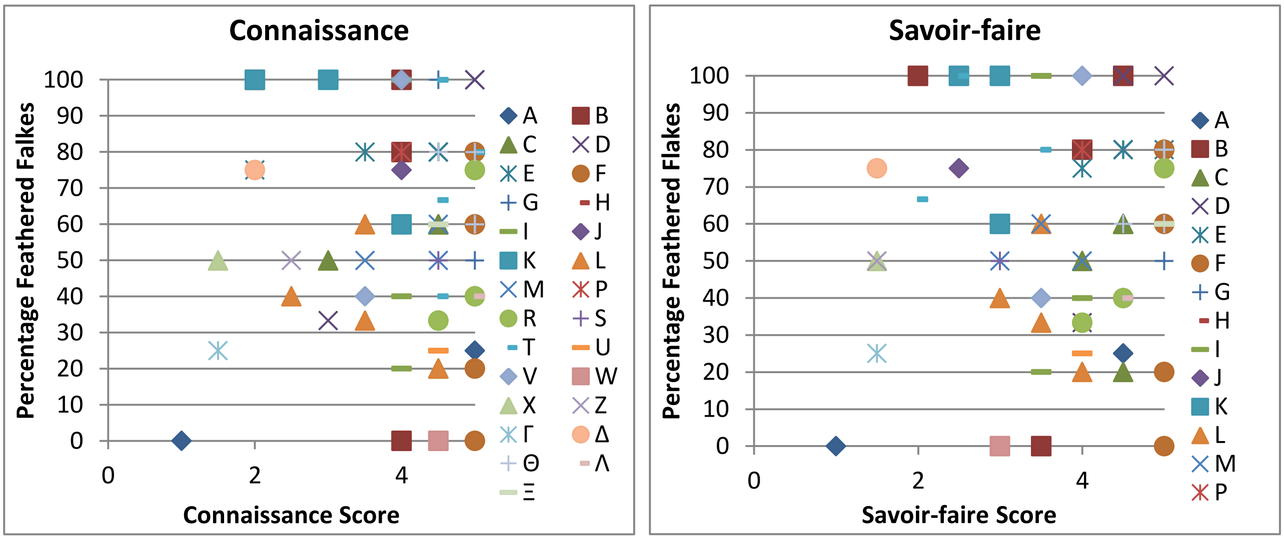


Figure 4.17. Percentage of feathered flakes produced by each knapper in each evaluation plotted against connaissance and savoir-faire score.

4.3 Discussion.

Based on the information presented in the results section above a picture of skill and learning in Oldowan technology in the group of experimental knappers can be built up. The information on number of hours spent practicing knapping and number of hours spent in taught sessions, when related to the scores achieved for savoir-faire and connaissance, reveal that although this is a technology in which a basic level of ability can be achieved in a relatively short time, hours spent practicing and in taught sessions are crucial in determining what levels of skill are achieved beyond this. This affects skill both in connaissance and savoir-faire. Interestingly it seems that continued as well as accrued practice is necessary in ensuring skill levels are maintained for savoir-faire, whereas in connaissance once high levels of skill were obtained, these were maintained with very little skill loss across all groups in the project. The relative times needed to achieve high level skills in connaissance and savoir-faire are also interesting. Across the groups involved in the project most knappers had achieved a score of three or higher for connaissance by the second evaluation. This level is reached despite the wider group in general only attending ten or fewer hours of taught session and only two or three on this technology exclusively, and with the wider beginners achieving no additional practice hours between evaluations one and two. This suggests that a small amount of teaching can have a large impact on connaissance ability in this technology. Skill in savoir-faire was more strongly affected by number of hours practiced. This is demonstrated by the wider group, who had very low levels of practice, showing in general very little improvement in ability over the course of the project. This suggests that while teaching is important to gain an understanding of the concepts of flaking, it is not possible to gain a high-level of skill in physically carrying out the technology without personal practice. It is interesting to note, however, that some members of the group achieved a higher score for savoir-faire than for connaissance in skill evaluations; knapper E from the core group in particular achieved a higher score for savoir-faire than connaissance consistently for the first three evaluations. In the first evaluation 26% of knappers achieved a higher score for savoir-faire than connaissance, in the second evaluation this had dropped to 21%, by the third it was only 17% and no knappers achieved this result in the final evaluation. The fact that this result shows the highest percentage of occurrence in the first evaluations suggests that this may be related to knapper aptitude, with knappers who have natural flaking ability being able to successfully remove flakes without a thorough understanding of how this takes place.

One of the aims of this thesis is to assign skill levels to the knappers in each of the technologies that the project focusses on at each evaluation point. Assignment of skill levels builds on the work of Lohse on skill in Clovis blade technology (2010). Here Lohse assigned skill levels based on differing amounts of connaissance and savoir-faire he observed in the Clovis blade cores found primarily at the Gault site, Texas. Lohse identified four different skill levels based on these criteria (Fig. 4.18).

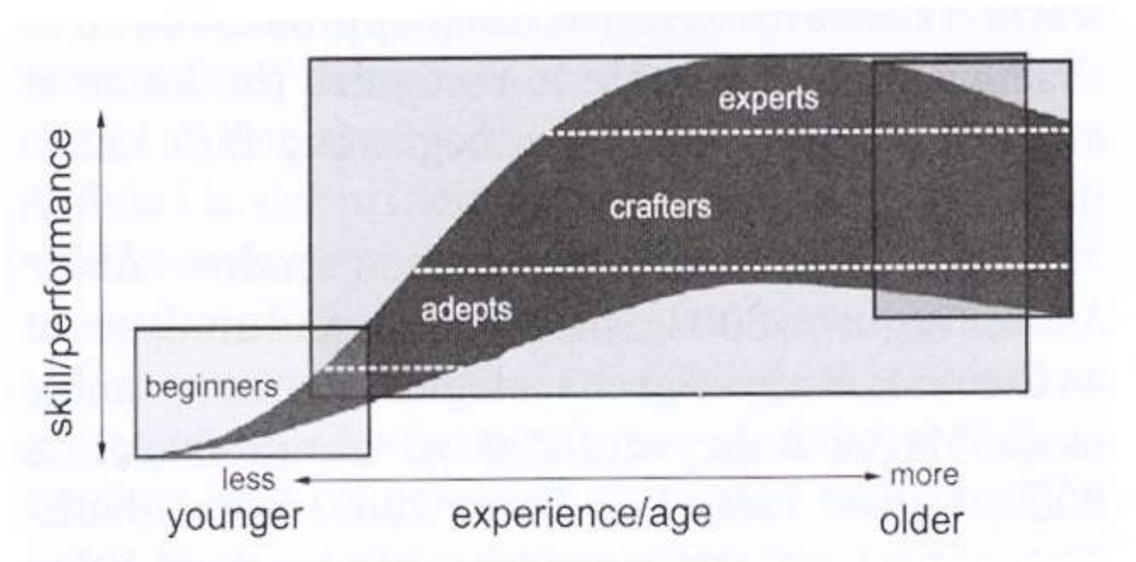


Figure 4.18. Skill levels identified by Lohse (source: Lohse 2010, Fig. 7.2, 159)

Moving on from this work, five different skill levels were assigned to the knappers in the Learning to be Human study group for the Oldowan skill evaluations. These were assigned based on the amounts of connaissance and savoir-faire shown by each of the knappers. The lowest skill level “beginners” represents an individual who has low connaissance and low savoir-faire represented by a score of two or less in each of these skill areas in the evaluations. The next level was the only one in which the knappers connaissance was significantly lower than their savoir-faire. This was identified as “novice natural” and defined as a knapper with low to medium connaissance (a score of 1-3) and high savoir-faire (4-5). While the majority of knappers never showed a higher level of savoir-faire than connaissance where it was identified it occurred in the earlier assessments and thus was considered a lower skilled level. The next two levels were identified as “adepts”, those showing medium level connaissance (2.5-3.5) and low to medium savoir-faire (1-3.5) and “crafters”, those showing high connaissance (4-5) and medium savoir-faire (2.5-3.5). The highest level of skill was identified as “expert” and defined as an individual with high scores in savoir-faire and connaissance (4-5).

To apply this data to archaeological assemblages it is necessary to identify whether these skill stages are identifiable from the physical material markers of each. The knappers assigned to each skill level are presented in Table 4.5.

	Beginners	Novice Natural	Adept	Crafter	Expert
Evaluation 1	ΑΒΚΧΓΔ	CDE	HILMVZ	GJSTW	FPRUΘΛΞ
Evaluation 2		E	KL	I	ABCDFGRTVΘ
Evaluation 3			L	BIMT	ACDEFGLΘ
Evaluation 4				KT	ABCDEFGIMRLΘ

Table 4.5. Knapper skill level for each evaluation.

None of the knappers in the lowest skill level, beginners, produced more than four flakes with knapper B only managing two flakes. An average of 3.5 flakes was produced by this group. The flakes were often shattered and short with the average maximum flake length for the group being 41.2 mm, compared with an overall average of 55.4mm for the whole group. Other variables considered were maximum thickness of flake and flake termination which in this group showed an average of 12.6mm for thickness and an average of 58.3% flakes showing feathered terminations. This skill level only appears in the first evaluation which is consistent with the identification of this as the lowest skill level. The next skill level, novice natural, is only identified in three knappers and only in the first and second evaluations. This is the only skill level in which knappers display a significantly lower connaissance than savoir-faire. Knappers in this group produced 3-5 flakes per evaluation, with an average of four flakes produced. This suggests that, in terms of flake numbers, this group is distinguishable from the beginners group. In terms of flake length this skill level shows a slightly higher average flake length than for the beginners level at 46.7mm. The average maximum thickness and termination type percentage were not significantly different from the beginners group, at 10.2mm in thickness and 59.5% feathered terminations, suggesting that these measures are not useful for distinguishing between skill levels.

The next two skill level groups, adepts and crafters, both show a significantly higher level of connaissance than savoir-faire. Seven knappers were identified as adepts and this level of skill was identified in the first, second and third skill evaluations. This group produced an average of 4.2 flakes per assessment suggesting that while this skill level may be distinguishable from beginners in terms of number of flakes produced it is not easily distinguishable from the novice natural group. In terms of average flake length this group show a slightly longer result than for the beginners at 44.9mm but shorter than the novice natural group. This group showed the largest average maximum thickness measure at 15.4mm of all the groups, however, the thickness scores show no pattern of increasing or decreasing size with skill level. For this reason it seems likely that this is not a useful measure for distinguishing between groups. The termination type data show a similar picture with an average percentage of 59.2%, a figure not significantly different than for the beginners or the novice naturals. Nine knappers were identified as crafters and this level of skill was identified in all four evaluations. As with the adept group above, knappers in this group produced an average of 4.2 flakes per assessment suggesting that, on these terms, crafters are not distinguishable from adepts or novice naturals but are distinguishable from beginners. In terms of flake measurements this group shows a lower score than for the other less skilled groups for average flake length at 40.65mm suggesting this measure will not distinguish crafters from the other groups. The thickness data similarly do not distinguish crafters from the less skilled levels, as they show the smallest average maximum thickness at 9.8mm, revealing no pattern of increasing or decreasing thickness with ability level. Crafters showed the highest percentage of feathered terminations at 66% which appears significantly different from the other groups but as no pattern is revealed of increasing or decreasing percentage of feathered terminations with ability this measure can not be used to distinguish between ability levels.

The skill level that indicates the highest level of ability in Oldowan technology, expert, was identified in 16 knappers and in all four evaluations. This group produced on average 4.8 flakes per assessment suggesting this group is distinguishable from the less skilled levels on these terms. In terms of flake measurements this group shows a distinctly longer average flake length at 64mm than all other less skilled levels identified. The average measures for thickness, however, do not show a similar pattern with a figure of 14.7mm achieved. This measurement is not significantly different from that of the adept group, which in fact achieved a greater thickness. The information from termination type does not reveal useful information for distinguishing between skill levels, with an average of 58.8% feathered terminations achieved in this group, a number that is not distinct from that for beginners, novice naturals or adepts.

From the above information a number of conclusions can be formed about the archaeological visibility of the skill levels assigned to the knappers. In terms of number of flakes produced per assessment three levels of skill can be distinguished: beginner, intermediate (including novice natural, adept and crafter) and expert. Flake length is shown to be a less reliable means of distinguishing between skill levels with only the expert level of skill being clearly distinct from the other skill levels. When flake length as a proportion of maximum core length is considered rather than absolute flake length, however, a clearer picture of distinction between novice natural and beginner is apparent suggesting that on these terms three skill levels may be determined: unskilled beginner (including beginner, adept and crafter), beginner with natural ability (including novice natural) and expert. The results of the maximum thickness and percentage of feathered terminations do not reveal useful information for distinguishing between different skill levels, despite promising results indicating relation to skill in the above sections of analysis for the thickness measure and documented evidence of hinge and step terminations being associated with knapping error (Bamforth & Finlay 2008, 6). From the material, therefore, it seems likely that it will only be possible to identify three skill levels – beginner, intermediate and expert.

In addition to looking at averages in order to distinguish between groups, it is also important to look at the range of results to see the degree of overlap between them and assess the affect this will have on the archaeological visibility of these groups. The material markers that showed the most potential for distinguishing between the identified groups were number of flakes produced and flake length as a proportion of maximum core length. Looking at the range for the number of flakes produced figures it can be seen that there is significant overlap between the groups. All of the groups produced examples of knappers who produced three or four flakes, while only the beginners group were unable to produce five flakes. The results for flake length show a similar picture. Each group shows a similar lower range result with an increasing upper range being the most significant difference between the groups. For this reason it seems that for determining between groups average results are more useful that individual flake measurements. This demonstrates the importance of refitting studies in identifying skill in archaeological assemblages as it is only through studies of this sort that a large amount of flakes can be identified as belonging to an individual knapper and their average production output be assessed. It is also through these studies that the number of flakes produced from each core can be identified, a factor that has been demonstrated to be have the most potential for distinguishing skill level.

From the above results it is possible to form some conclusions about the identification of material attributes that relate to connaissance or savoir-faire ability. Two variables were identified as being significant for distinguishing between different skill levels – number of flakes produced and maximum flake length. Of the skill levels mentioned above ‘novice natural’ is the only group in which connaissance is significantly higher than savoir-faire. In terms of number of flakes the novice natural group achieved the same sorts of numbers as the adept and crafter groups, whereas for flake length the novice natural group achieved a higher score than these two groups. This suggests that ability in terms of connaissance is more significant in allowing a larger number of flakes to be produced, whereas savoir-faire is more significant in determining the length of the flakes that are produced, allowing knappers with high ability in savoir-faire to produce longer flakes. The number of flakes produced by individual knappers was strongly affected by their understanding of flake positioning and necessary surface features to allow a removal. These factors may relate to an individual’s spatial awareness and their ability to visualise forms in 3D. Savoir-faire ability relates more to individuals’ motor abilities and control over physical actions. Ability in this area allows knappers to produce longer flakes even when their connaissance means the positioning of these flakes is not always ideal.

Previous studies have focussed on the cognitive significance of the abilities needed to successfully create Oldowan technology. These have involved brain scanning studies carried out by Stout and Chaminade (2007) and Stout et. al (2008). These studies concluded that skill acquisition in Oldowan tool making involve perceptual-motor adaptation to the requirements of flaking rather than planning and problem solving abilities (Stout & Chaminade 2007, 1098). Other studies that have focussed on an understanding of the cognitive requirements of Oldowan technology have included considerations of flaking as grammars of action (e.g. Moore 2010), comparison studies with the tool use of modern non-human primates (e.g. McGrew 1987; 1992), attempts to teach flaking to bonobos (e.g. Davidson & McGrew 2005; Roffman et al. 2012; Toth et al. 1993) and assessments of the technical competence of the earliest flintknappers (de la Torre 2011). From these previous studies a picture of the cognitive requirements of Oldowan technology can be built up that reveals a technology that requires a level of cognitive ability that can not be fulfilled by other primates. It appears that from the earliest evidence of the Oldowan, hominins were able to control flaking and showed competent knowledge of the mechanics of conchoidal fracture (de la Torre 2011, 58). The ability to flake Oldowan tools has been linked to a geometrical understanding and control over fine motor abilities.

The results of the skill evaluations from the Learning to be Human Project can add to this picture. These reveal that the most common errors made whilst learning to perform Oldowan style flaking were those of flake positioning – choosing where to take the next flake removal and correctly positioning the blow in relation to the edge of the core. This supports the idea that a strong cognitive ability in terms of geometrical understanding is essential for high level performance in Oldowan technology. Miss hitting was also a common error in the early assessments demonstrating that the knappers were unable to strike a blow as they desired. This can be linked to developing motor abilities which, as stated above, have been indicated as important for allowing Oldowan techniques to be mastered. This information provides important supplementary data to previous studies of the cognitive implications of Early Palaeolithic technologies and suggests new areas for future studies to focus on. More details are provided in the Aptitude Chapter (Chapter Seven) below.

4.4 Conclusion.

The results of the analysis of the evaluations have revealed a wide range of information about the ways in which skill is acquired in Oldowan technology. Much of this information supports the conclusions of earlier studies, for instance the significance of flake length as an indicator of skill in flaking has previously been established and the importance of motor abilities and understanding of geometry have been understood to be the key cognitive elements in allowing this technology to be realised. The length and experimental nature of this study, however, and the number of participants involved are unprecedented in this field and ensure that the results are more complete and reliable than those of previous experimental studies. From this work a picture can be built up of the requirements for high level skill in Oldowan technology that rely on a high level of practice and teaching but also require a certain level of initial aptitude.

While distinguishing skill in an experimental study group is fairly straightforward, applying this data to an archaeological assemblage has been shown to be more complicated. To get a clear understanding of the skill of an individual refitting studies have been shown to be key and single examples of a technology or single flakes are not sufficient to distinguish between individual skill levels. The analysis of a range of materials and different aspects of these materials is essential if an individual knapper's skill level is to be determined.

4.5 Summary of Results

- In the early evaluations knapper performance varied widely even among knappers who showed similar levels of practice and teaching.
- Skill in connaissance increased sharply between the first and second evaluations and remained stable after this point.
- Skill in savoir-faire is more variable with loss as well as gain of ability.
- Flake positioning was the most common area for errors followed by miss hitting and inaccurate flake predictions.
- There is some correlation between hours spent in taught sessions and improvement in skill level.
- There is some correlation between hours practised and improvement in skill level but continued practiced is essential for maintaining high levels of skill in savoir-faire.
- Number of flakes produced and maximum flake length were the most significant material attributes for distinguishing skill level.

- Five different skill levels could be determined in the performance of the experimental knappers.
- Based on material markers only three skill levels are likely to be distinguishable in archaeological assemblages.

5. Skill in Acheulean Handaxe Technology

5.1 Introduction

Acheulean handaxe technology is widely regarded as an indicator of revolutionary new behaviour in the hominin species that first practiced it (Mithen 1998, 100; Roche 2005; Wynn 1995). Archaeologists have identified the symmetry and defined shape of many handaxes as indicative of mental templates in the hominins who practiced this technology and linked this evidence of increasing mental complexity with the emergence of language (Ambrose 2001; Holloway 1969). Other researchers, however, dispute this link with language and see no sign of a mental template or imposed symmetry in handaxe form (Noble & Davidson 1996, 195). As a result of the theories that put Acheulean handaxe manufacture controversially as revolutionary concept, this technology was chosen as one of the focuses for flintknapping in the Learning to be Human project. Handaxe technology was taught to the experimental knappers to test the hypothesis that the study of their acquisition of this skill over an extended period would help support the ideas of an increasingly complex technology appearing at this period in prehistory.

The first known occurrences of handaxe technology date to the Lower Palaeolithic and are found in Africa. While the earliest are generally agreed to date from 1.76-1.4 mya ago (Torre & Mora 2013), handaxes spread rapidly across the near-east and are found in Western Europe (Stringer & Andrews 2011, 208–9). There is great debate about the hominin species that were involved in handaxe manufacture. Popular candidates for the earliest users include *Homo ergaster* or *Homo erectus* but handaxes continued to be made by *Homo heidelbergensis* and *Homo sapiens* in some areas (Stringer & Andrews 2011, 208).

Handaxe technology represents a clear shift from the techniques used in Oldowan technology. While Oldowan technology simply requires the removal of flakes from a core, handaxes were often carefully and bifacially shaped to a specific form (Butler 2005, 62–4; Roche 2005, 43). To do this most successfully some degree of platform preparation is required beyond the simple identification and utilisation of suitable edge angles as is required for Oldowan (Newcomer 1971, 89–90). While some handaxe technologies involved the use of soft hammer percussion with an antler billet (for example the Boxgrove handaxes: Hosfield 2011, 1499) many were made using predominantly hard hammer percussion (Petraglia 2003, 148). Knappers in the group were taught to use antler hammers if they desired, but skill evaluations used only hard hammer in order to ensure a degree of uniformity in tool type which would be useful when analysing the material produced. For the Learning to be Human Project knappers were taught handaxe production in the sessions detailed in Table 5.1. This technology proved to be a popular one, with the majority of the knappers undertaking many practice as well as taught session hours during the project (see below for further details).

Date	Technology	Knappers	Time
05/04/2011	Handaxe	ABCDEFG	2
13/04/2011	Handaxe	H	2
15/09/2011	Handaxe	ACDEFGH	1
19/10/2011	Handaxe	HIKLRTΘ	2
31/10/2011	Handaxe	M	2
18/11/2011	Handaxe	V	2
04/07/2012	Handaxe and Levallois	L	1

Table 5.1. Taught handaxe sessions for all knappers.

Skill was evaluated in this technology at three points during the project. The first evaluation took place in December 2011 at a stage when all the knappers had been introduced to the technology but were still likely to show signs of inexperience in their knapping. The next evaluation took place in June 2012 when the knappers had six months additional experience and the final evaluation took place at the end of the nearly two year period of the project to give an idea of how far their skills in this technology had progressed. Evaluation in this technology consisted of knappers describing how they would remove flakes from a series of example flint bifaces to assess their connaissance skill, followed by the manufacture of a handaxe on a porcelain pre-core to assess their savoir-faire skill. The results of these evaluations are presented below.

5.2 Results

5.2.1 Skill Evaluations

The scores that each knapper received in the skill assessments throughout the project are presented in Table 5.2. This figure shows that 16 knappers took part in handaxe skill evaluations although only 13 undertook all three evaluations. Tracking the scores of these knappers who performed more than one evaluation it can be seen that, as for the Oldowan assessment scores, there is a clearer picture of progression with the connaissance scores (especially those for the core group) than for the savoir-faire scores (Fig. 5.1). As with the Oldowan assessments, the connaissance scores for the core group show a sharp increase from the first to the second evaluations with skill generally maintained at the same level between the second and third. The savoir-faire scores in contrast show no clear picture of increasing ability through the assessments with some individuals maintaining the same skill levels throughout and others losing as well as gaining skill in this area.

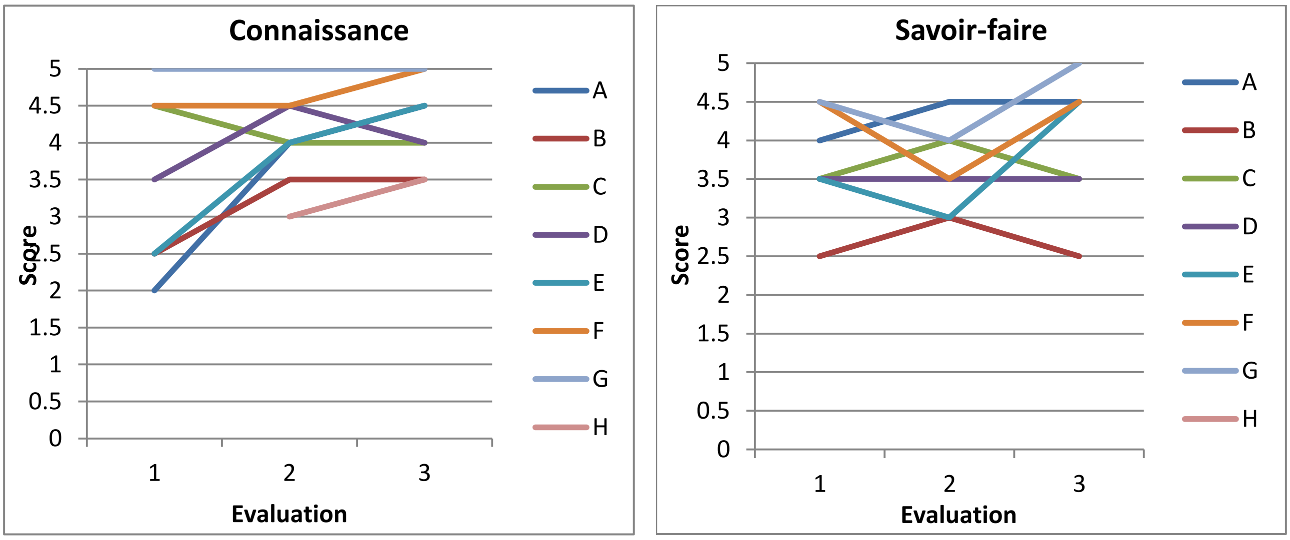


Figure 5.1. Skill scores for connaissance and savoir-faire for core group knappers.

The wider group show a far more confused picture in terms of score both in connaissance and savoir-faire. Some (T, L, I) show a gain in connaissance from evaluations one to two, followed by a stabilisation or loss of skill between evaluations two to three (Fig. 5.2). For savoir-faire, however, the knappers in the wider group are clearly divided in behaviour between those who had no knapping experience at the start of the project (wider beginners) and those who had previous knapping experience (wider experienced) (Fig. 5.2). The wider

	Evaluation 1 - 6/12/11-24/01/12		Evaluation 2 - 01/06/12-10/7/12		Evaluation 3 - 16/10/12-28/11/12	
Knapper	Connaissance Score	Savoir-faire Score	Connaissance Score	Savoir-faire Score	Connaissance Score	Savoir-faire Score
A	2	4	4	4.5	4.5	4.5
B	2.5	2.5	3.5	3	3.5	2.5
C	4.5	3.5	4	4	4	3.5
D	3.5	3.5	4.5	3.5	4	3.5
E	2.5	3.5	4	3	4.5	4.5
F	4.5	4.5	4.5	3.5	5	4.5
G	5	4.5	5	4	5	5
H			3		3.5	
I	2	2	3.5	3	3	2.5
K	1.5	1			3	1.5
L	2	1.5	3.5	3	2	2.5
M	4	2	2.5	2.5	3.5	3
R	5	5	5	4.5	5	5
T	3.5	4.5	4.5	4	4.5	4
V	4.5	4.5				
Θ	5	4.5	5	5	5	4.5

Table 5.2. Knapper evaluation scores for connaissance and savoir-faire for each evaluation. Orange= unable to be evaluated for health reasons, red= unavailable for evaluation, grey = left project.

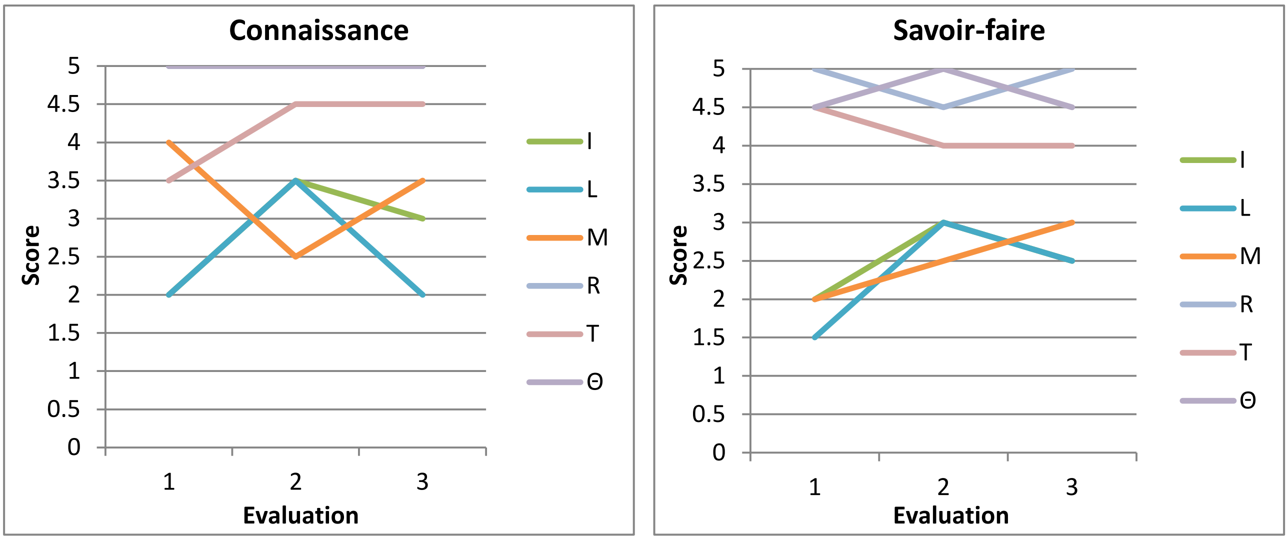


Figure 5.2. Skill scores for connaissance and savoir-faire for the wider group.

beginners showed increased skill in savoir-faire from the first to the third evaluations although none achieved a score higher than three, whereas the wider experienced group in general started the project with a high level of skill in handaxe savoir-faire and this was maintained with small variation through the evaluations.

In addition to the scores for savoir-faire and connaissance comments on knapping performance were recorded during evaluations that covered knapper strategy and errors committed during knapping and in the connaissance part of the evaluations. An analysis of the errors identified throughout these evaluations helps to build up a picture of the learning process and the aspects of handaxe technology with which the knappers had the most difficulty. Errors identified during the evaluations were:

- Poor technological strategy;
- Errors in use of platform preparation;
- Incorrect flake predictions (connaissance);
- Striking angle errors;
- Platform angle errors;
- Production of stacked step or hinge fractures;
- Errors in choice and use of hammerstones;
- Problems maintaining a bifacial plane;
- Problems turning the edge to remove flakes from the dorsal surface;
- Hitting with too much force;

- Hitting with too little follow through;
- Problems thinning the piece;
- Difficulties removing the hinge end of the pre-core;
- Difficulties dealing with the bulb end of the pre-core;
- Abandoning the piece while there was still opportunity for improvement;
- Continuing working after the piece should have been abandoned.

A much wider range of errors was identified in the handaxe evaluations than in the flaking evaluations, reflecting the more complex nature of the later technology in terms of strategic as well as physical requirements.

Figure 5.3 shows the percentage of knappers who committed each error for each evaluation performed by the group. As can be seen from this, the most common errors were poor technological strategy, problems creating or maintaining a suitable bifacial plane, problems thinning the piece and errors in platform preparation. These areas of error can be related to ability to plan ahead in the case of strategy and platform preparation errors and of having a strong mental template of the desired handaxe shape and size in the case of bifacial plane maintenance and piece thinning as well as suitable hand-eye co-ordination. The ability to thin and perform suitable platform preparation are

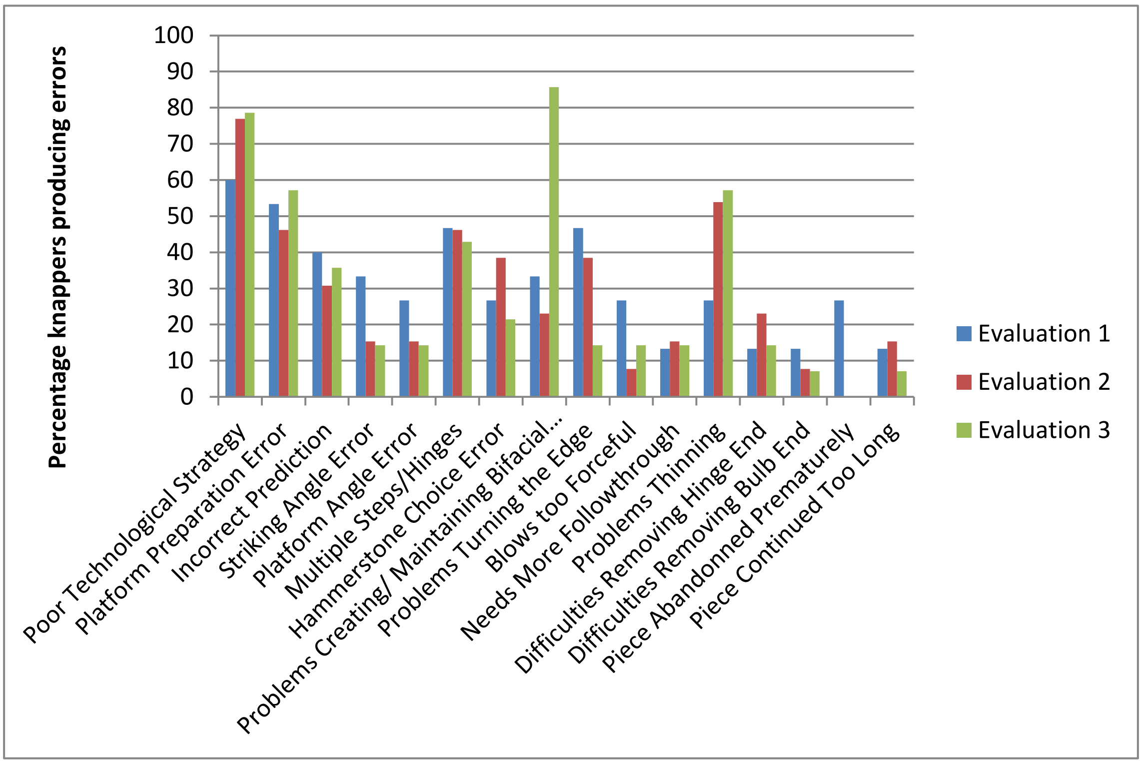


Figure 5.3. Errors committed by knappers during skill evaluations.

strongly linked as it is not usually possible to efficiently thin a piece without preparing suitable platform angles (Whittaker 1994, 194–9). Interestingly, while most error types show a decrease from evaluation one to three, four areas of errors show a decrease from evaluation one to two followed by an increase in percentage of knappers committing them from evaluations two to three. It seems likely that this can be related to differential practice and teaching hours in this technology from evaluations one to two and two to three, discussed in more detail below.

Two types of error show a steady increase from evaluation one to two; technological strategy errors and thinning errors. The increase in technological strategy errors could be due to knappers experimenting more as they gained more skills in the technology, moving away from a strict following of a mental plan of how to make a handaxe. The increase in thinning errors could be due to knappers taking the technology further than they were able to in the earliest evaluation. The further a handaxe is worked and the smaller the piece becomes the more difficult the thinning process will be. In the earliest evaluations knappers might abandon the piece early in the process. This could mean that thinning would have been largely not attempted at this stage so errors in this area would not be identified.

In summary, an analysis of the errors recorded during knapping performance suggests that in, terms of connaissance, errors were most common in areas associated in planning ahead and preparing suitable removals. In terms of savoir-faire, errors were most common in thinning the piece effectively and the creation of stacked hinge and step fractures. Hinge and step fractures can be caused by hitting with unsuitable angles into flat surfaces or choosing unsuitable platform angles for removals. This suggests that the preparation, striking and choice of platform angles was the most difficult part of this technology to master in terms of savoir-faire.

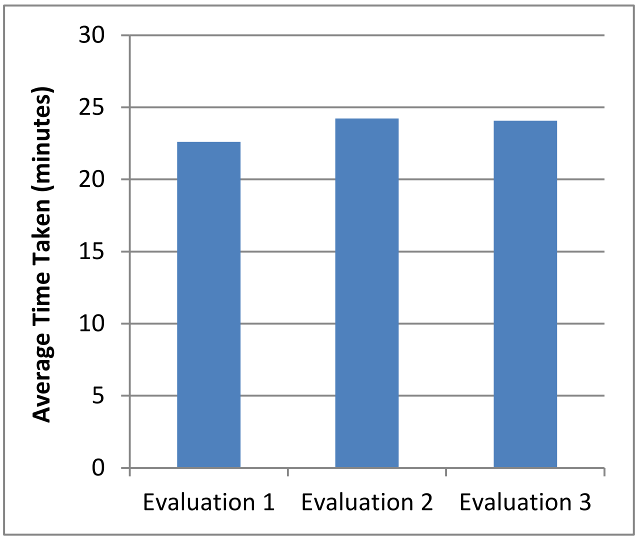


Figure 5.4. Average time taken to produce a handaxe for each skill evaluation.

In addition to the performance errors the time taken for the knappers to make a handaxe in the savoir-faire portion of the evaluations was recorded with the expectation that as they gained skills in knapping their flaking would be more efficient and time taken would decrease. As can be seen from Figure 5.4, when average time taken is considered, this did not appear to be the case with similar figures for each evaluation. When individual knapper data are considered (Fig. 5.5) there again appears to be no picture of increasing or decreasing time taken from evaluation one to three. There is a strong pattern of individual knappers consistently producing similar times across the three evaluations.

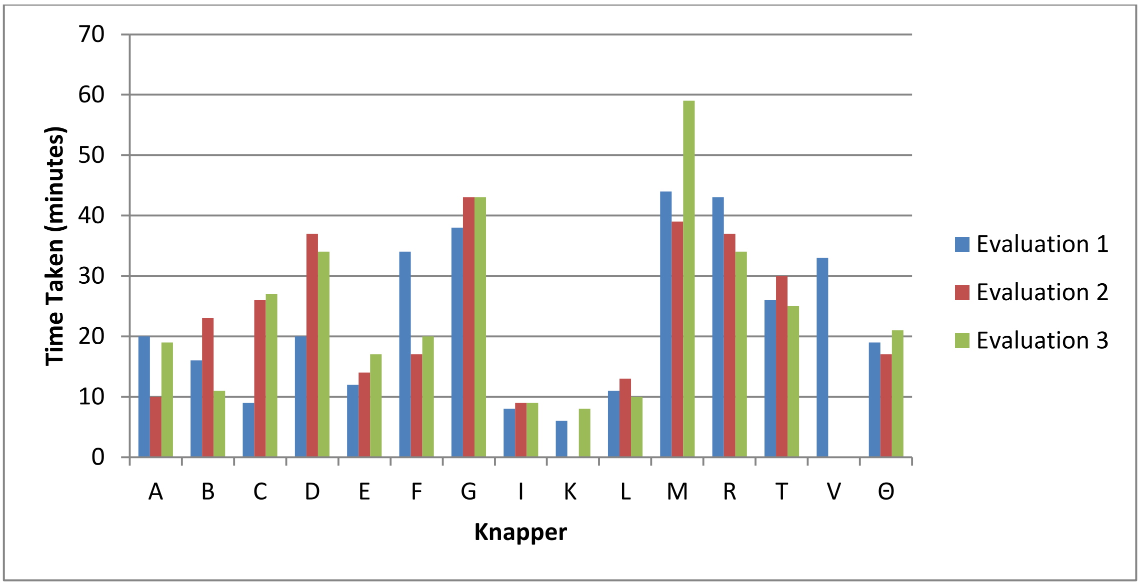


Figure 5.5. Individual knapper times for handaxe manufacture in each skill evaluation.

In order to address whether individual variation could be related to skill, times were plotted against the scores achieved for connaissance and savoir-faire across the three handaxe evaluations (Fig. 5.6). When connaissance is considered, it can be seen that although the lowest skilled individuals take some

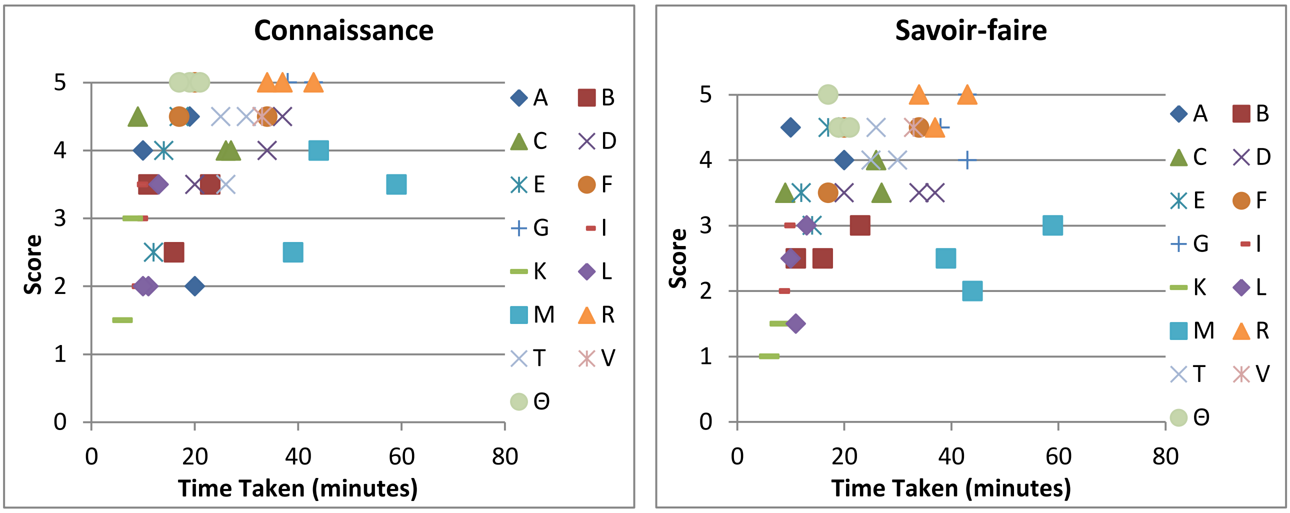
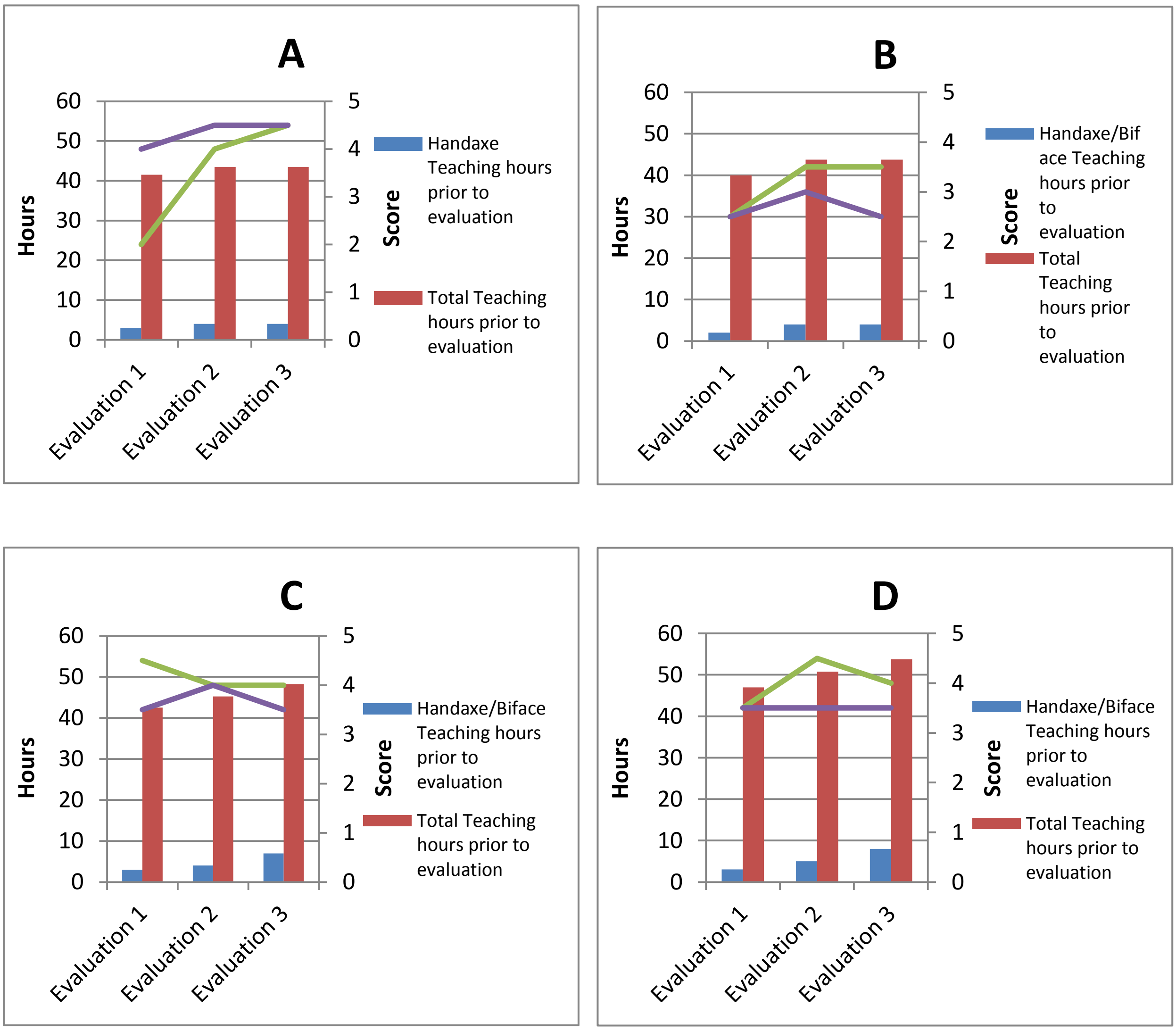


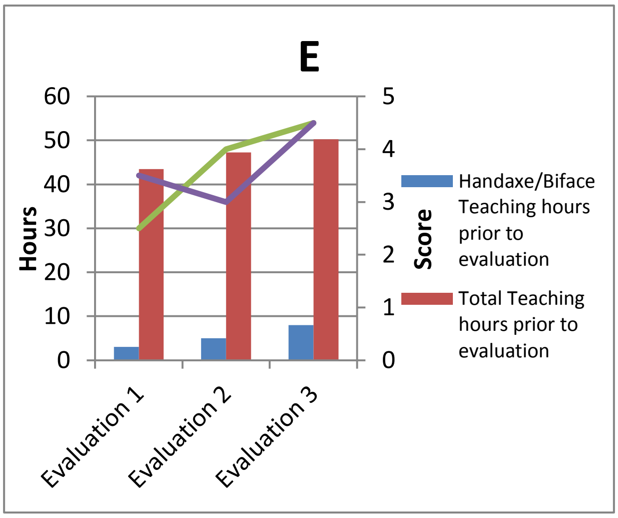
Figure 5.6. Correlation of scores for connaissance and savoir-faire with times taken for handaxe manufacture in skill evaluations.

of the shortest times, similar times can be seen in highly skilled individuals. When savoir-faire score is considered a similar picture can be seen, with the lowest skilled only producing short times whereas the highest skilled produce a wide range of times. This suggests that time taken does show some correlation with skill in that the lowest skilled take short times to produce what they consider a finished handaxe. Variation in time taken, however, can not be entirely attributable to skill level and it seems that individual knappers, once they have achieved a certain skill level, have a preferred time to spend on handaxe manufacture which is not altered by subsequent practice or skill acquisition. Difference in teaching and practice hours may also have an impact on time taken as it is noticeable that the three shortest times consistently belonged to members of the wider beginners groups who received far fewer teaching hours than the core group and performed far fewer hours of practice.

5.2.2 Teaching

Handaxe production was the third technology introduced to the core group and wider experienced and the third to the wider beginners group. The dates, hours and participants of the taught handaxe sessions are shown in Table 5.1 above. From this it can be seen that the core group attended a greater number of sessions than the wider groups and was introduced to the technology earlier in the project. All knappers had, however, received some instruction in handaxe manufacture by November 2011. To address the impact teaching had on the skill level achieved by knappers in the project individual scores achieved were plotted against teaching time for each of the knappers who performed all three skill evaluations (Fig. 5.7). This shows that for the core group (A-H) there seems to be some correlation between time spent in taught sessions and increase in score achieved, although this is not strong. The wider group show no such correlation with widely variant and variable scores achieved despite all members receiving a similar (low) number of hours in taught sessions.

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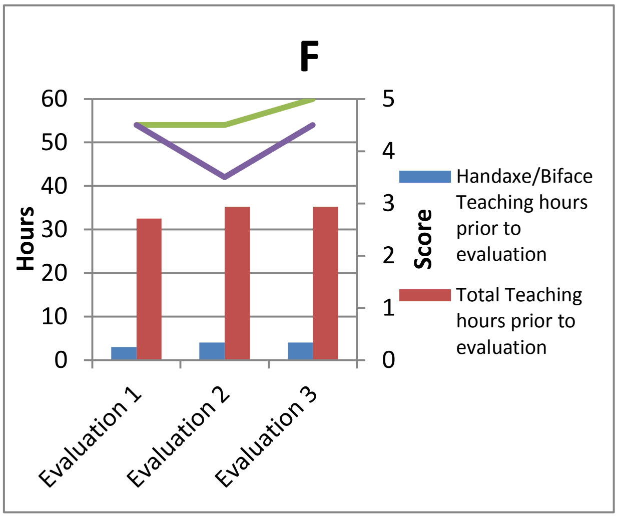
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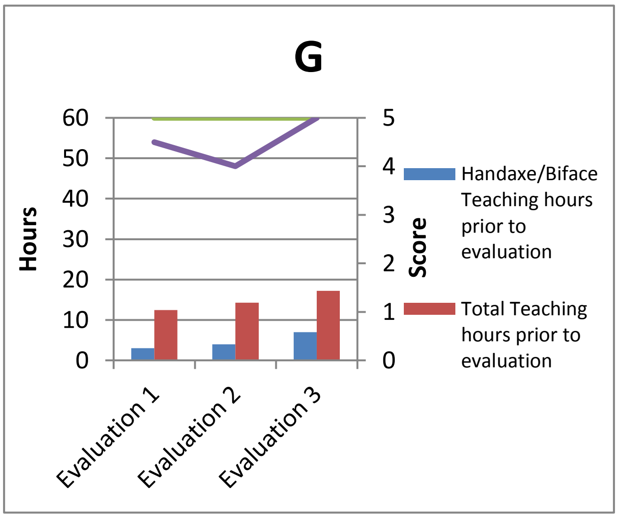
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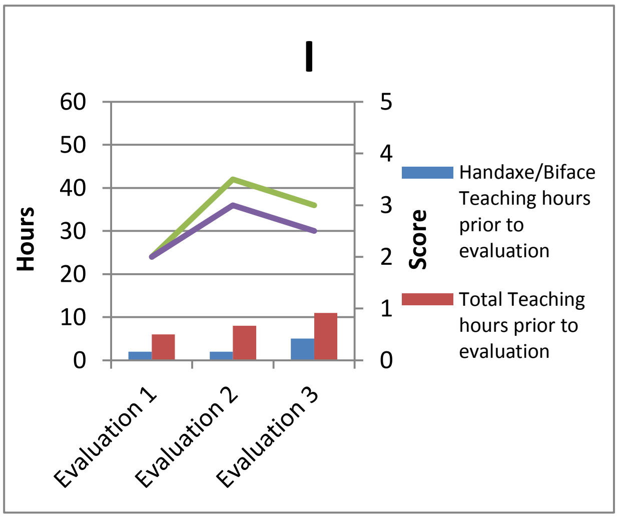
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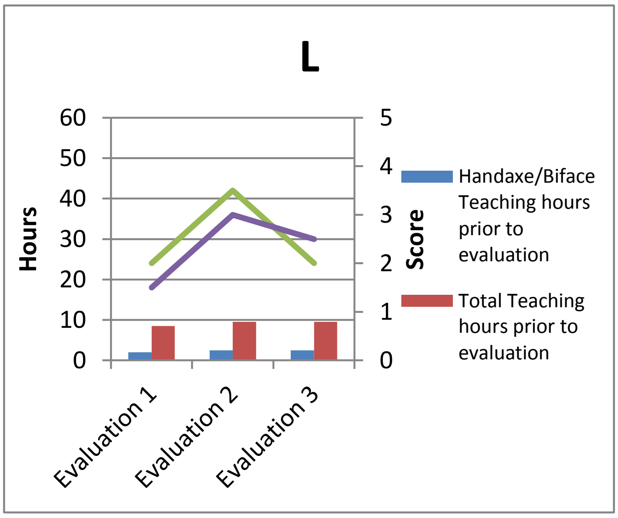
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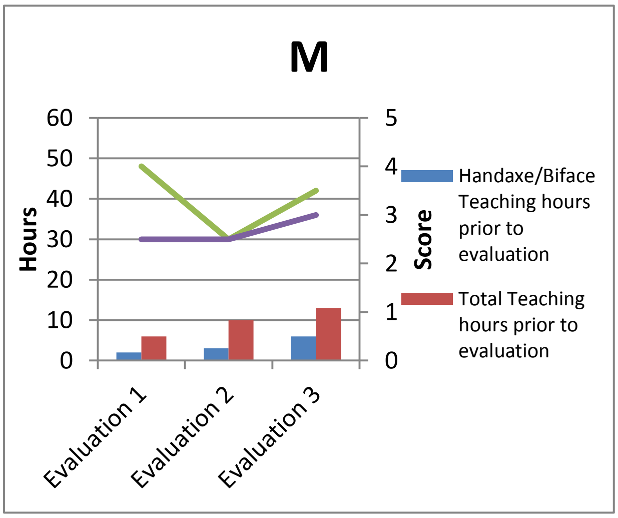
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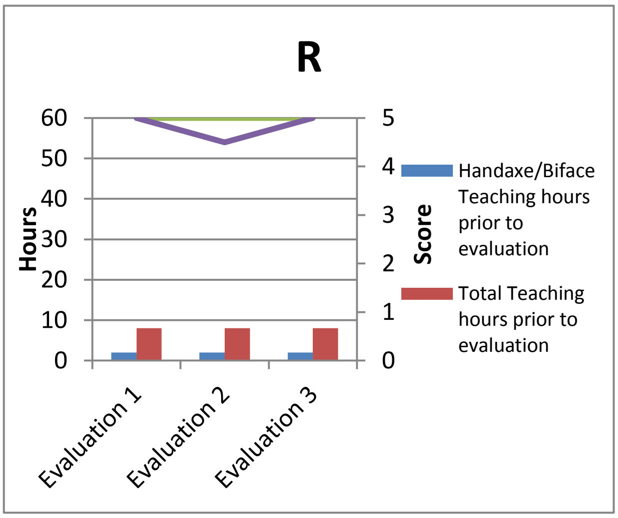
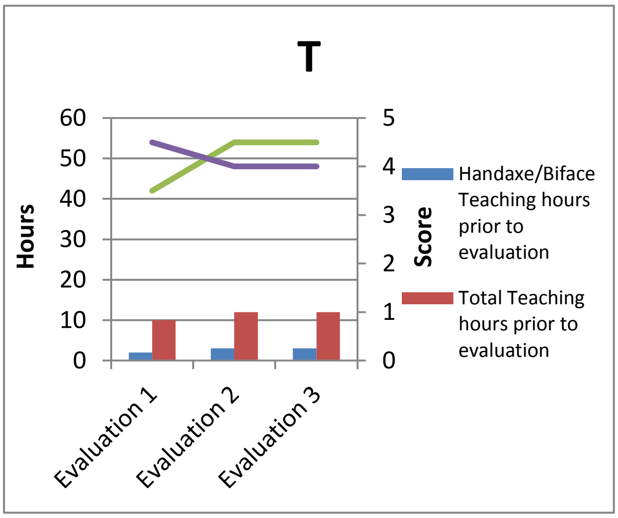




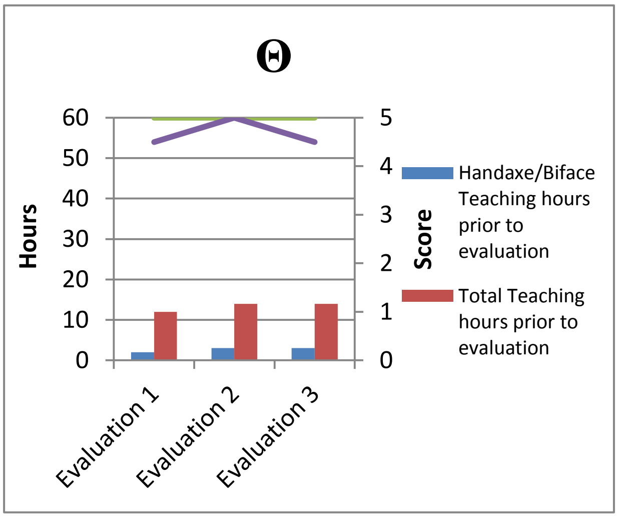
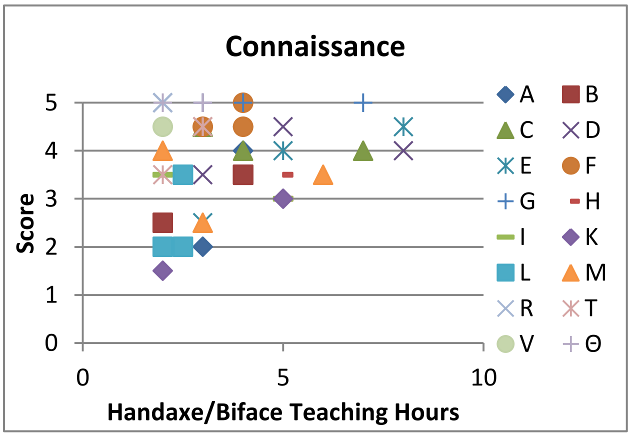


Figure 5.7. Scores for connaissance (green) and savoir-faire (purple) with teaching hours prior to evaluation for each knapper who performed more than one evaluation.

To look at this in more detail, for all the individual evaluations, score and hours spent in taught sessions prior to the evaluations were plotted against each other to see if there was a correlation (Fig. 5.8). From this it can be seen that the connaissance scores show some correlation with teaching hours in that those knappers who had the most teaching hours showed high scores,



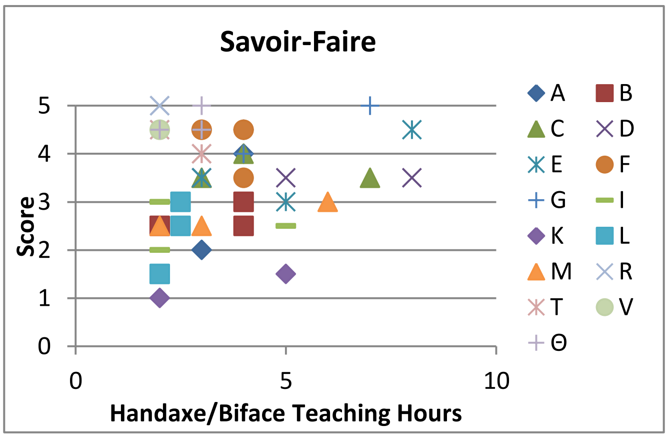
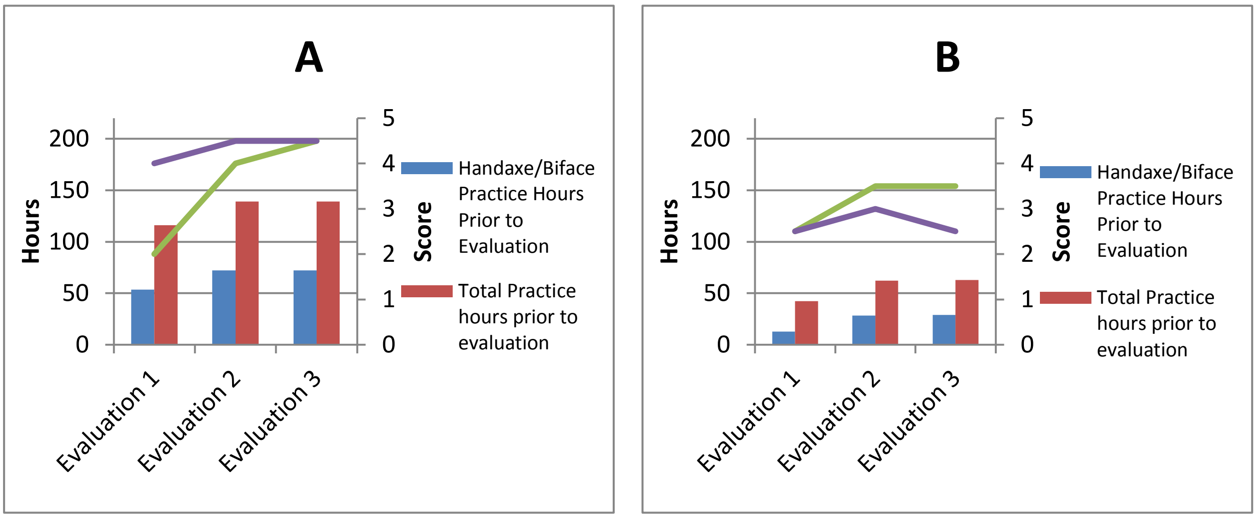


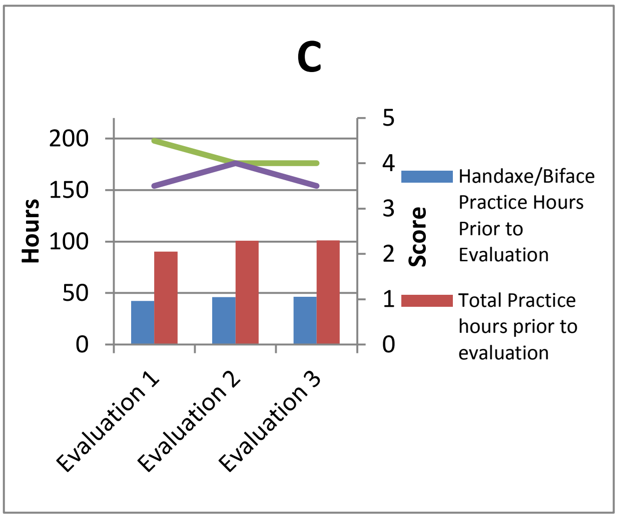
Figure 5.8. Correlation of time spent in taught sessions with skill scores for connaissance and savoir-faire.

however, high scores were also seen in knappers who only performed a low number of taught hours. Savoir-faire scores show a similar picture with a few additional outliers. This suggests that while initial skill level is very variable (and likely influenced by natural aptitude – discussed in more detail in later chapters) teaching in a specific technology can increase this skill level. While these results are seen for the handaxe/biface teaching hours, observing the total teaching hours does not show the same correlation suggesting that specific training in bifacial technologies is necessary to increase skill in handaxe technologies.

5.2.3 Practice

In addition to time spent in taught sessions knappers performed variable amounts of practice throughout the project. The results of this have been plotted against individual connaissance and savoir-faire score for each of the knappers who performed all three evaluations in the project (Fig. 5.9). This shows that for the core group (knappers A-H) there is some correlation between time spent practicing and increases in score achieved in assessments. This seems to be most strongly linked to time spent practicing handaxe/biface technology specifically rather than practice totals for all technologies and is most evident in connaissance scores. The wider group do not show the same pattern, perhaps due to the low levels of practice of any technology in this group and the fact that the wider experienced group (R-Θ) had a wide range of initial skill levels at the start of the project.

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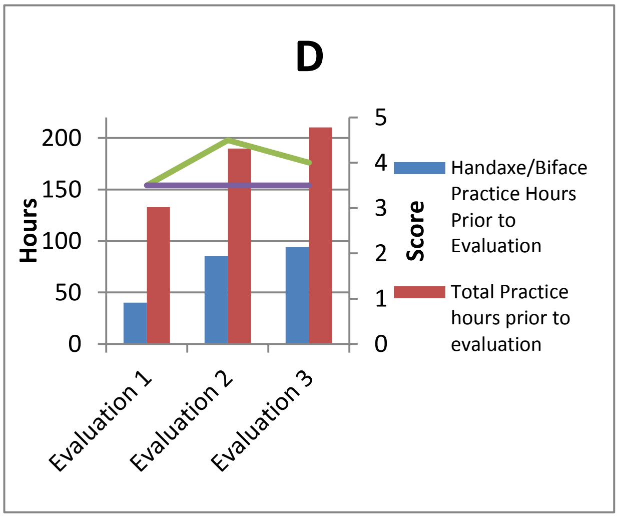
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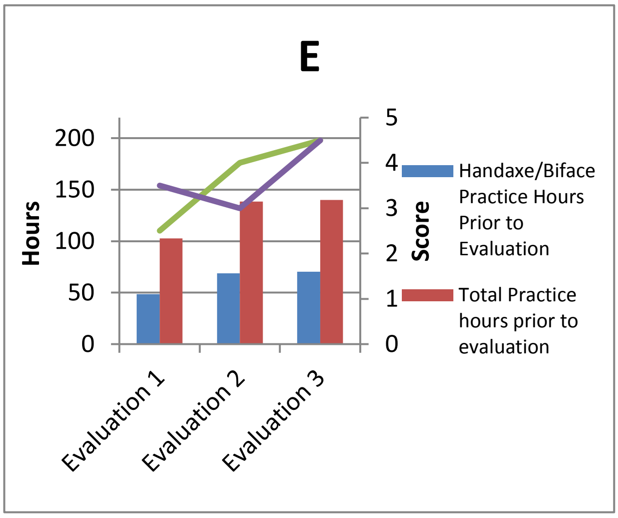
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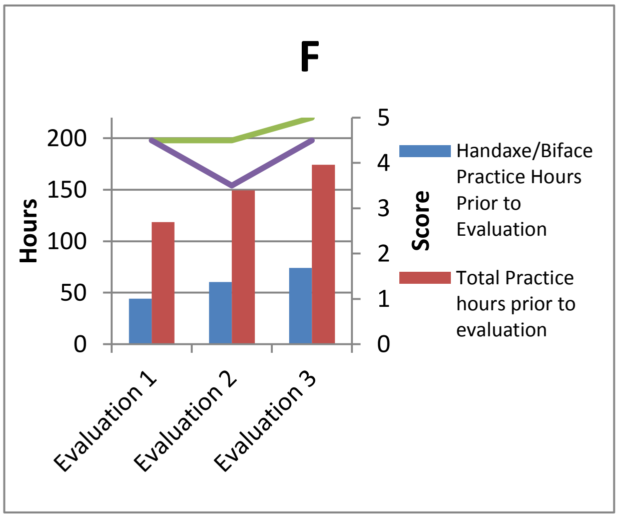
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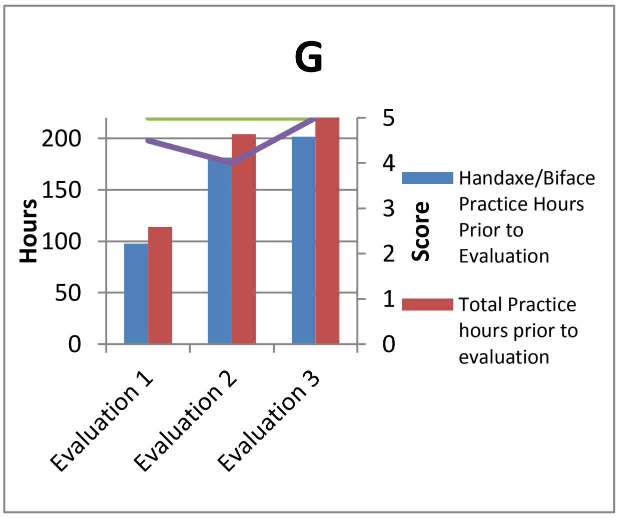
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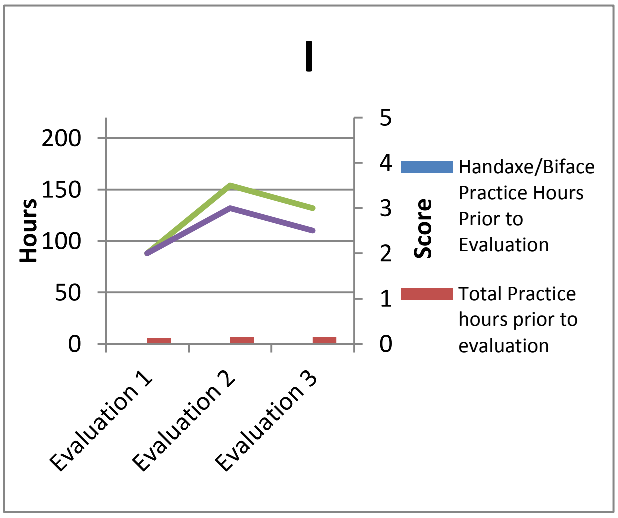
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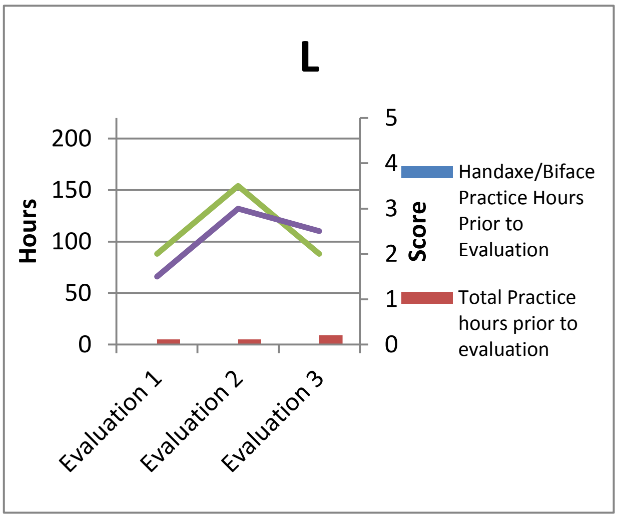
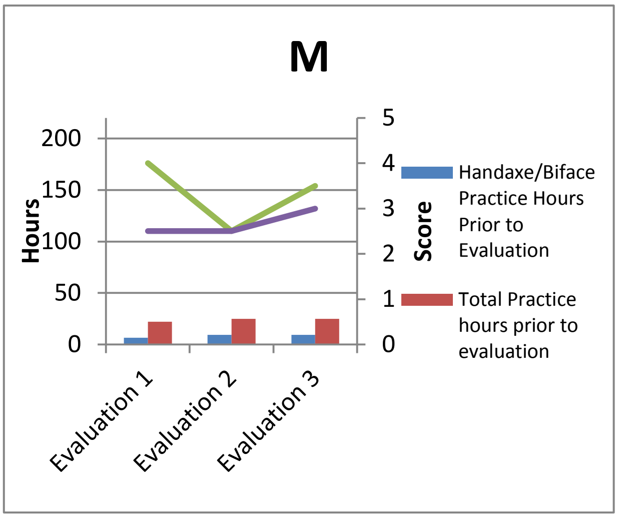
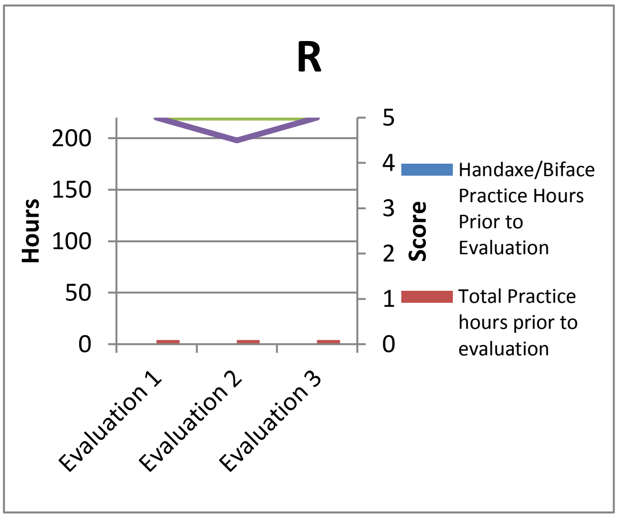
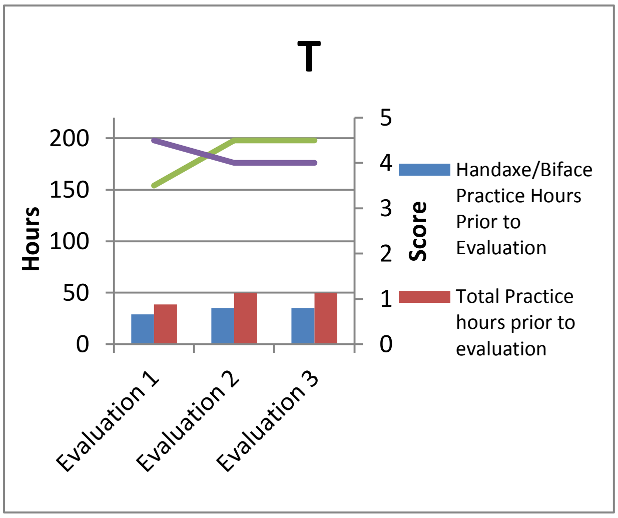








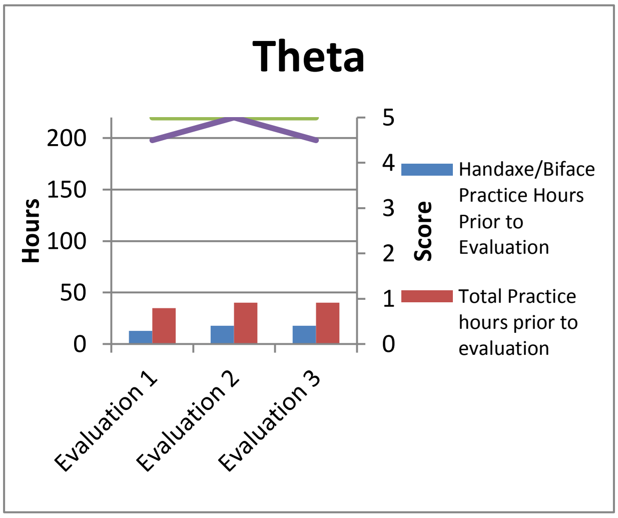


Figure 5.9. Practice hours compared with scores for connaissance (green) and savoir-faire (purple).

As for the teaching hours above, each evaluation score and hours spent practicing prior to the evaluation were plotted against each other to observe correlations (Fig. 5.10). The results of this show that there is some correlation between connaissance score and handaxe/biface hours practiced prior to evaluation in that those who practiced the most hours received the highest scores. As for the teaching hours discussed above, however, there is a wide range of scores among those who practiced the least with high scores achieved in this group too. This suggests that, as was seen in the teaching section, initial skill level is very variable but can be increased with practice. The savoir-faire scores show a similar picture suggesting that both these areas of skill are affected by practice equally. When total practice hours are plotted against score, the correlation is not so clear suggesting that technologically focussed practice is more significant in increasing skill in handaxe technology than general practice in flintknapping. The results of savoir-faire score are interesting here, in that it seems that knappers who undertook at least 100 hours of practice received scores of no less than three, however, beyond this scores were not correlated with hours practiced. This suggests that it is only through focussed technological practiced that the highest skill levels in savoir-faire can be achieved.

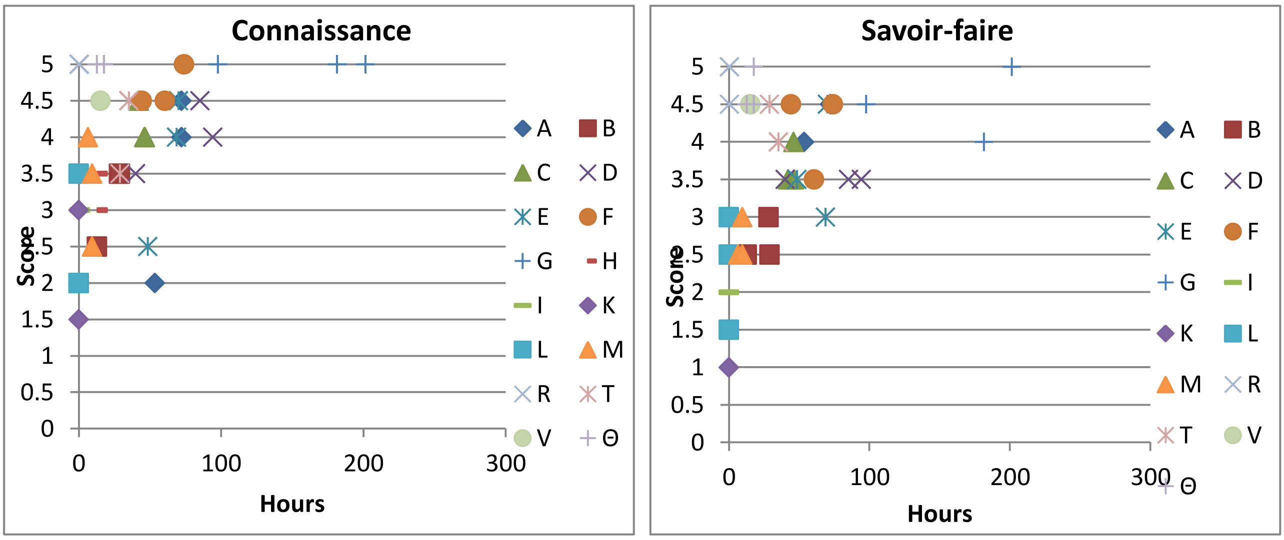


Figure 5.10. Scores received for connaissance and savoir-faire with number of hours spent practicing handaxe and biface technology.

From the results of the practice and teaching hours analysis it can be seen that, unlike in the case of simple flaking, training and practice that focuses on handaxe or bifacial technology is essential for increasing skill in handaxe performance. This is particularly the case for the impact on savoir-faire skill. Similar to the flaking assessments, however, it can be seen that initial skill is widely varied, with some knappers able to perform to a high level with little time spent in training sessions or practicing the technology.

5.2.4 Material Skill Markers

In order to relate the skill results from an assessment of performance with the archaeological record, the materials produced during the evaluations were collected and analysed with the assumption that the scores produced would correlate with some of the features seen in the materials. Both the handaxes and debitage produced were analysed using attribute analysis. Attributes assessed were, for the handaxes:

- Completion of the handaxe;
- Maximum length;
- Maximum width;
- Maximum thickness;
- Width/thickness ratios;
- Mass;
- Symmetry;

For the debitage the following attributes were analysed:

- Mass;
- Number of flakes;
- Platform Type;
- Termination Type;

Each of these attributes was assessed in terms of their relationship to knapper skill and the relative significance of each attribute in displaying knapper skill.

5.2.5 Handaxe

Completion:

During the skill assessments each knapper was instructed to produce a handaxe. They were told to continue knapping until they believed they had produced a successful handaxe or until they felt that there was nothing more they could do to improve the piece. During this process a number of knappers broke the handaxe they were working on. If this occurred they were told they may continue working on one half of the piece or abandon the piece if they felt there was nothing more they could do to turn it into a handaxe. Handaxes and bifaces that were broken during manufacture are found in the archaeological record and are sometimes assessed as the work of inexperienced or unskilled knappers (Lohse 2011, 98). In order to assess how broken handaxes related to skill in the experimental group of knappers the percentage of handaxes broken for each assessment was calculated (Fig. 5.11). This shows similar percentages for each evaluation with no picture of increasing or decreasing numbers of broken handaxes with each evaluation.

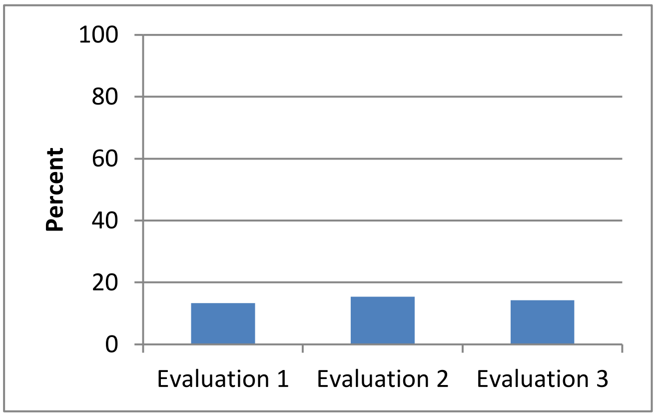


Figure 5.11. Percentage of handaxes broken for each evaluation.

To look at this in more detail the skill level achieved for each broken handaxe produced was assessed to observe whether only low or high skill was seen in those individuals involved (Fig. 5.12). This showed that only four knappers broke handaxes during their evaluations and, of these, three knappers were producing

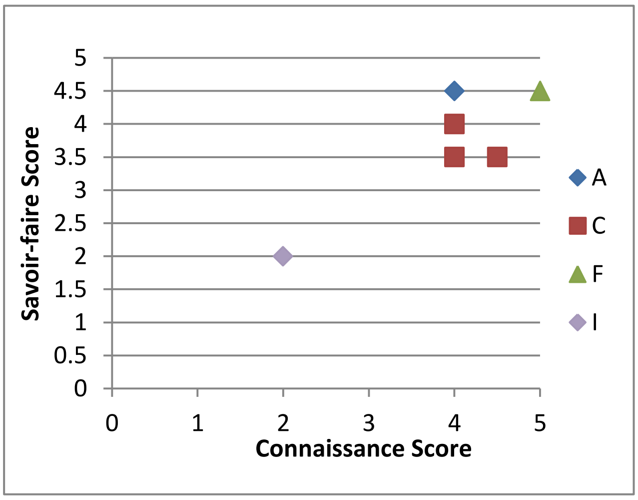


Figure 5.12. Skill scores for knappers who broke handaxes.

high scores of 4-5 for connaissance and 3.5-4.5 for savoir-faire. This suggests that breaking handaxes is not necessarily correlated with low skill levels in either connaissance or savoir-faire and must be the result of other variables. By examining the comments made during the skill evaluations the reasons behind each handaxe break can be explained. Of the knappers showing high skill scores knapper C is the only individual to break handaxes in each evaluation. In this case the knapper showed a tendency to apply too much force when striking blows, which in each evaluation resulted in handaxe breakage. Knapper A, similar to C, was striking the piece with too much force when it broke and Knapper F also struck too hard after excessively thinning the piece. This suggests that force of blow is most significant in determining whether a handaxe breaks during manufacture if the knapper has an initially high skill level. This may mean that the strength of an individual has an effect on whether a piece breaks or not, with greater strength, if incorrectly applied, being a disadvantage in this situation. Knapper I, the knapper showing a lower skill level, was striking at incorrect angle, without using a glancing blow causing the piece to fracture due to end shock when it was struck at one end. This suggests that for lower skill levels the striking angle is a significant factor in determining if a piece will break as this aspect of the technology has not yet been mastered.

Maximum Length:

Maximum length measurements were taken for each of the non-broken handaxes produced in the evaluations. Length of tools has been considered an indicator of skill with more skilled individuals expected to be able to achieve longer tool lengths (Bamforth & Finlay 2008, 5). To investigate this, average handaxe lengths for each evaluation were calculated to see if increases in length through time could be observed (Fig. 5.13). Contrary to expectations the averages show a decrease in length from evaluation one to two, followed by a slight increase from evaluation two to three. If only the core group data is

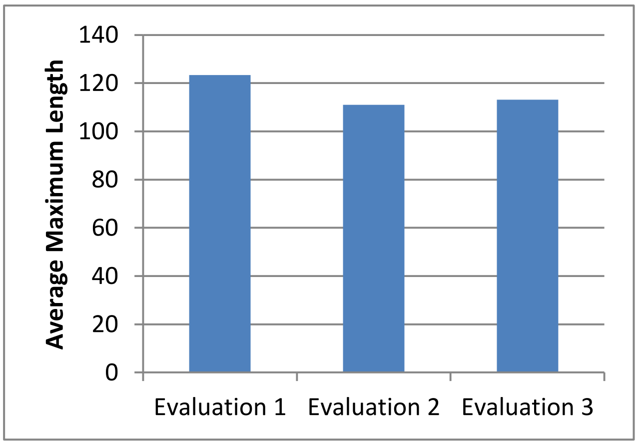


Figure 5.13. Average handaxe lengths for each evaluation.

considered this decrease is even more marked. A paired sample *t* test ($\alpha=0.05$) revealed that the differences in whole group mean seen between evaluation one and two, and one and three are statistically significant ($p=0.039$ and $p=0.022$ respectively) while those between two and three were not ($p=0.772$).

To observe more closely how this relates to skill the scores for connaissance and savoir-faire were plotted against maximum lengths achieved for each evaluation (Fig. 5.14). From the results of this it seems that handaxe length is, contrary to the results of other studies, negatively correlated with score. This means that the more highly skilled individuals were producing smaller handaxes than the lower skilled. This appears to be the case in terms of both connaissance and savoir-faire skill. This is probably the result of lower skilled individuals abandoning pieces at an early stage due to being unable to recover from mistakes made or adjust angles appropriately to make further removals. Higher skilled individuals would be able to continue to shape and thin the piece despite making mistakes, and thus reduce the length as they worked. This suggests that we should be cautious in assigning long handaxes in the archaeological record to highly skilled individuals if no other features of the piece indicate a high skill level.

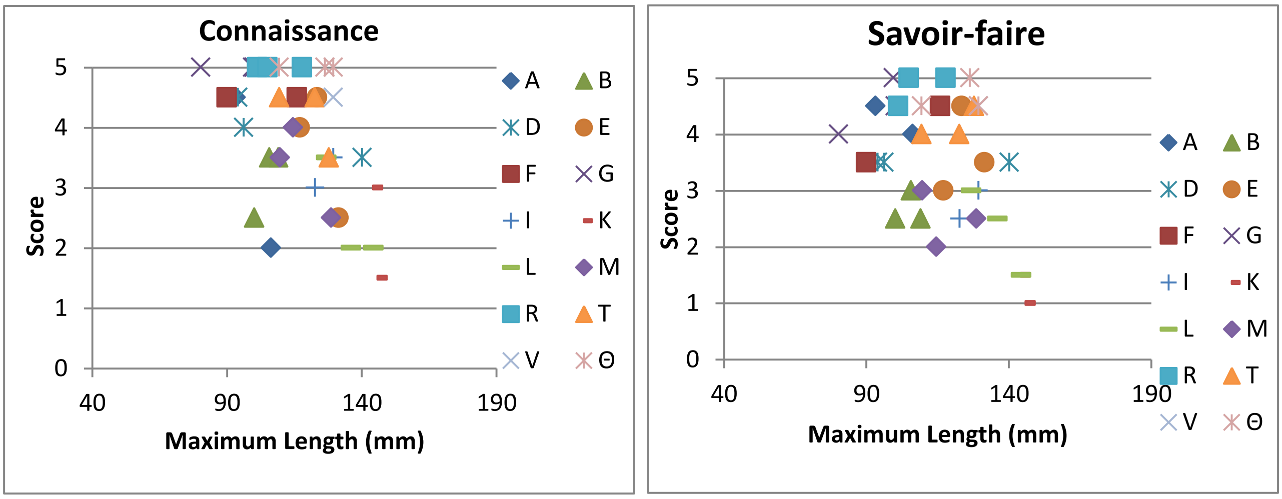


Figure 5.14. Handaxe maximum length negatively correlated with scores received for connaissance and savoir-faire.

Interestingly here while the averages from evaluation one to two show a decrease in handaxe length, from two to three there is an increase. This is probably due to a decrease in practice times from the second to the third evaluations (see practice hours section above). This suggests that it is not simply a total of hours practiced that allows an individual to achieve a high skill level. Continued practice is also necessary if this high level of skill is to be maintained.

Maximum Width:

In addition to maximum length measures, maximum width was also recorded to see if skill had an influence on this measure. As for length, the average maximum width for each evaluation was calculated to see if increases or decreases could be observed through subsequent evaluations (Fig. 5.15). The results of this show, similar to the length measures discussed above, a decrease between the first and second evaluations, followed by a slight increase in width from the second to the third. The differences here are, however, very small and were not statistically significant.

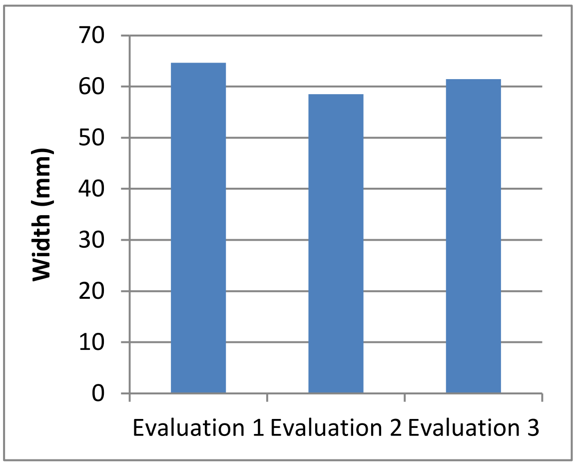
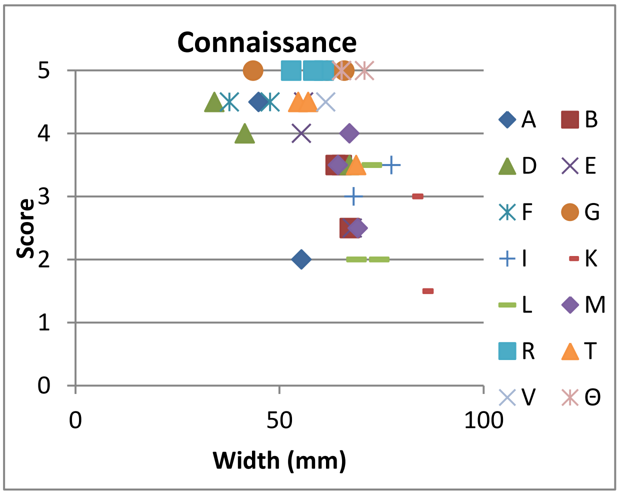


Figure 5.15. Average maximum width for each evaluation.

In order to look at this in more detail skill scores for connaissance and savoir-faire for each assessment were plotted against maximum width measures (Fig. 5.16). This reveals that for both savoir-faire and connaissance skill there appears to be some negative correlation with maximum width. This means that the knappers who were receiving higher scores for skill were making less wide handaxes. This is probably a result, as discussed above, of knappers with greater skill being able to work the piece further than those with less skill due to their ability to alter edge angles and deal with mistakes made in the piece.



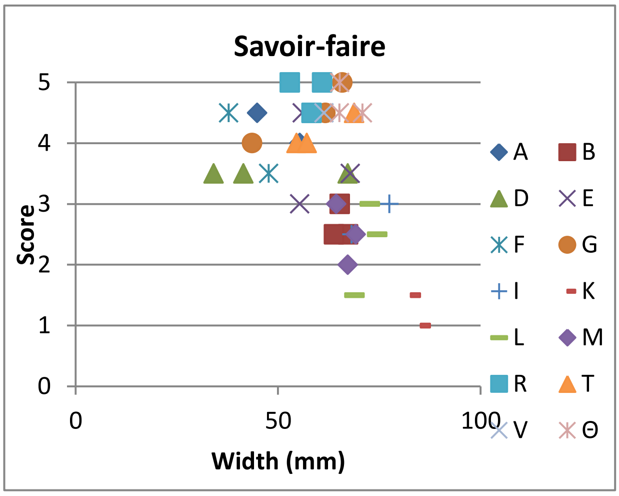


Figure 5.16. Maximum width and scores received for connaissance and savoir-faire.

Maximum Thickness:

Maximum thickness measures of the handaxes were another attribute examined. Thickness measurements are often used as indicators of skill as thinning is a key aspect of bifacial technology that many novices find difficult to master in the early stages of learning (Apel 2008, 103). As a result of this, it is often assumed that the ability to produce thin bifaces is an indicator of a high skill level in a knapper (Bamforth & Finlay 2008, 5). Average thickness for each evaluation was calculated to observe changes in this measure throughout the project evaluations (Fig. 5.17). From this it can be seen that the core group show a steady decrease in thickness through the three evaluations in the project, whereas the group as a whole show a decrease in thickness from evaluations one to two followed by a slight increase from two to three similar to that seen in the length and width averages. The decrease in thickness seen in the core group is as would be expected in a group whose skill shows an increase, however, the whole group increase in skill from evaluations two to three could reflect the lack of continued practice for most knappers

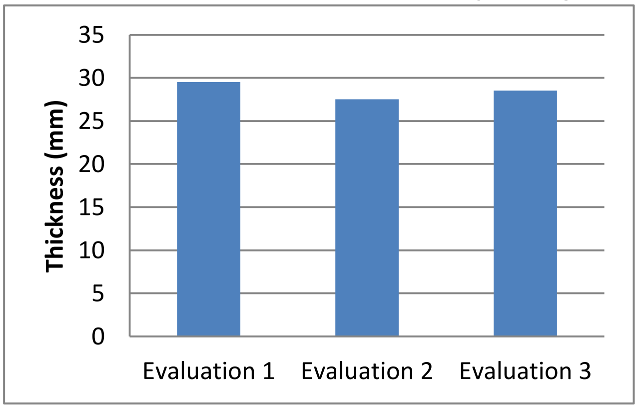


Figure 5.17. Average handaxe maximum thickness for each evaluation.

discussed above in the maximum length section.

To observe more closely whether handaxe thickness could be strongly associated with skill, skill scores for savoir-faire and connaissance were plotted against maximum thickness measures for each evaluation (Fig. 5.18). This demonstrated that there is strong correlation between decreasing thickness and savoir-faire score and to a lesser extent also to connaissance score. This suggests that measures of thickness are potentially strong indicators of knapper skill, especially in terms of their savoir-faire ability. The ability to affectively thin a bifacial tool is thus a key concept that must be learnt and mastered to achieve a high level of skill in this technology. This must be accomplished both through an understanding of the principles involved in removing thinning flakes and in obtaining the motor skills and habits necessary for its successful achievement.

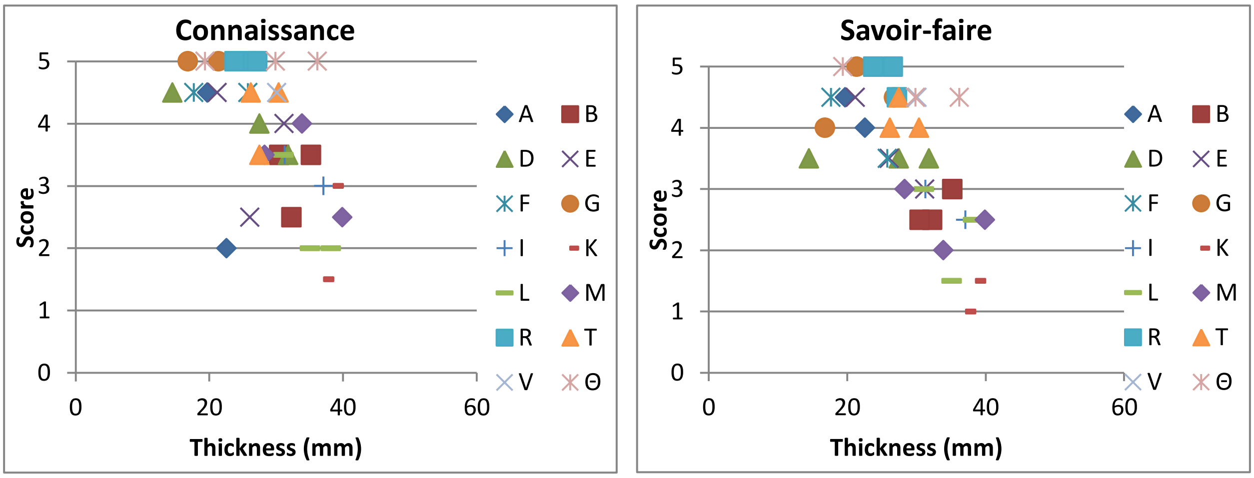


Figure 5.18. Negative correlation of maximum thickness with skill scores for connaissance and savoir-faire.

Width/Thickness Ratios:

Width/thickness ratios are another measure that has been used extensively as an indicator of knapper skill level in bifacial technologies (Ferguson 2008, 59). This measure is calculated by dividing the maximum width value by the maximum thickness value (Andrefsky 1998, 180). Handaxes in general are not excessively thinned tools with width/thickness ratios generally falling between two and three (Emery 2010, 242). To successfully produce this tool, however, some thinning is necessary. Maintaining width whilst effectively thinning a tool is acknowledged as a technique that requires a large amount of

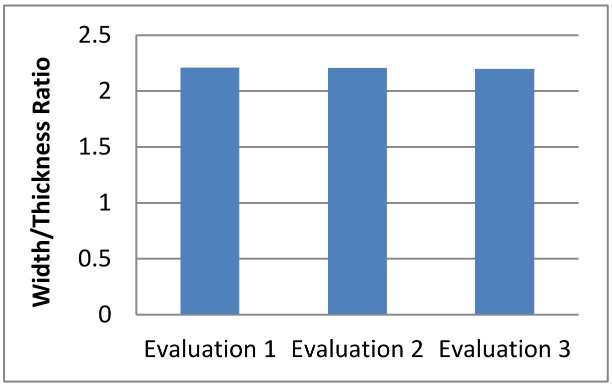
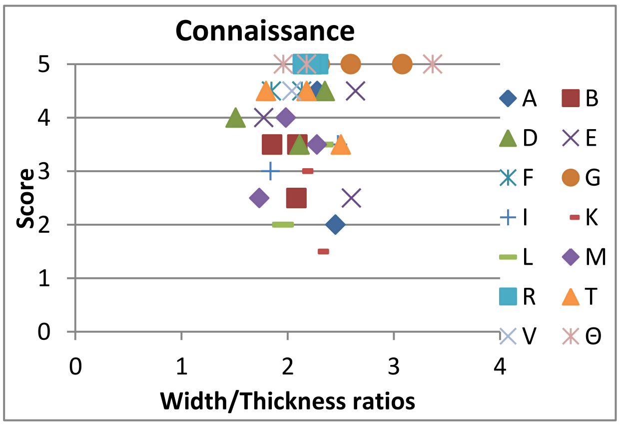


Figure 5.19. Average width/thickness ratios for each evaluation.

skill to master with only expert knappers able to achieve ratios as large as four or five and above (Apel 2008, 103). For this reason it was expected that width/thickness ratios would increase as skill was acquired throughout the project. To investigate this, average ratios were calculated for each evaluation to observe change through time in the project (Fig. 5.19). The results of this revealed very similar average ratios for each evaluation with no clear picture of increase or decrease through time, suggesting this measure would not effectively distinguish skill in this group.

In order to see if individual data would give a clearer picture of correlation with skill, individual width/thickness ratios for each knapper for each evaluation were plotted against connaissance and savoir-faire skill scores (Fig. 5.20). From this it can be seen that while there is no clear correlation between skill score and width/thickness ratio, the two individuals who achieved the highest ratios also scored highly for skill both in connaissance and savoir-faire in the evaluation. The lack of correlation otherwise could be due to knappers not believing extreme thinning to be necessary in this technology. Handaxes generally have a ratio of between two and three (Emery 2010, 242) and the evaluation averages fall in the lower end of this range. On the other hand the time frame of the project may simply have been too small to allow for large improvements in thinning that would be necessary to achieve the highest ratios.



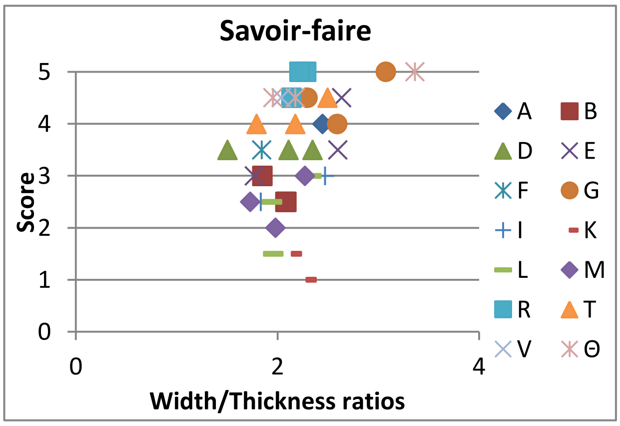


Figure 5.20. Width/thickness ratios plotted against scores received for connaissance and savoir-faire.

Mass:

In addition to the measurements discussed above, mass of the handaxes was also considered as it was believed this might be an indicator of the efficiency of reduction and thus the skill of individual knappers. As standardised pre-cores were used in the evaluations direct comparisons could be made between handaxe mass without need to account for the initial mass of the core. The upper limit for the handaxe mass was the initial mass of the pre-core which was on average 685.5 grams with very little variation between cores (See Methodology, Chapter Three, for more details). Averages for each evaluation were calculated (Fig. 5.21). This revealed that for the core group there was a decrease in handaxe mass between evaluations one and two and a small increase between evaluations two and three. For the group as a whole the increase between two and three is far more marked. This suggests that, similar to the results seen for maximum length, width and thickness, more skilled knappers were able to continue working on a piece for longer due to their ability to deal with problems they had caused, such as stacked step fractures and had knowledge of platform preparation to adjust edge angles. Inexperienced knappers were unable to deal with these issues and so would abandon the piece at an earlier stage of reduction resulting in a heavier tool. This suggests that there are problems in making strong links between efficiency and skill based on the mass of a tool compared to its debitage. Fewer removals may be a result of less skill rather than efficiency of manufacture.

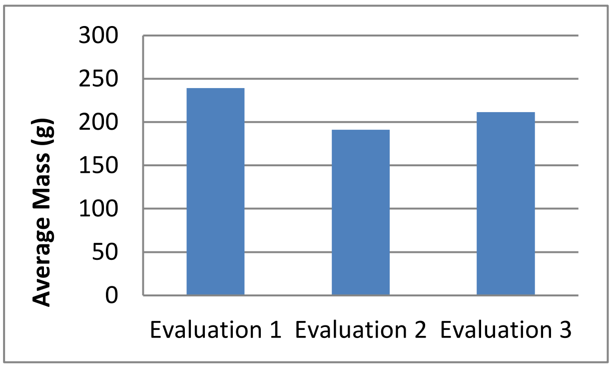


Figure 5.21. Average handaxe mass for each evaluation.

To look in more detail at the correlation between skill and handaxe mass, savoir-faire and connaissance scores were plotted against handaxe mass for each knapper in each evaluation (Fig. 5.22). The results of this show a negative correlation between both areas of skill and handaxe mass, so that the least skilled knappers were producing the heaviest handaxes. This also suggests that the increase in average mass seen from evaluation two to three is a result of fewer additional practice hours between evaluations two to three than one to two, indicating again that maintenance of skill is dependent on continued practice in this technology.

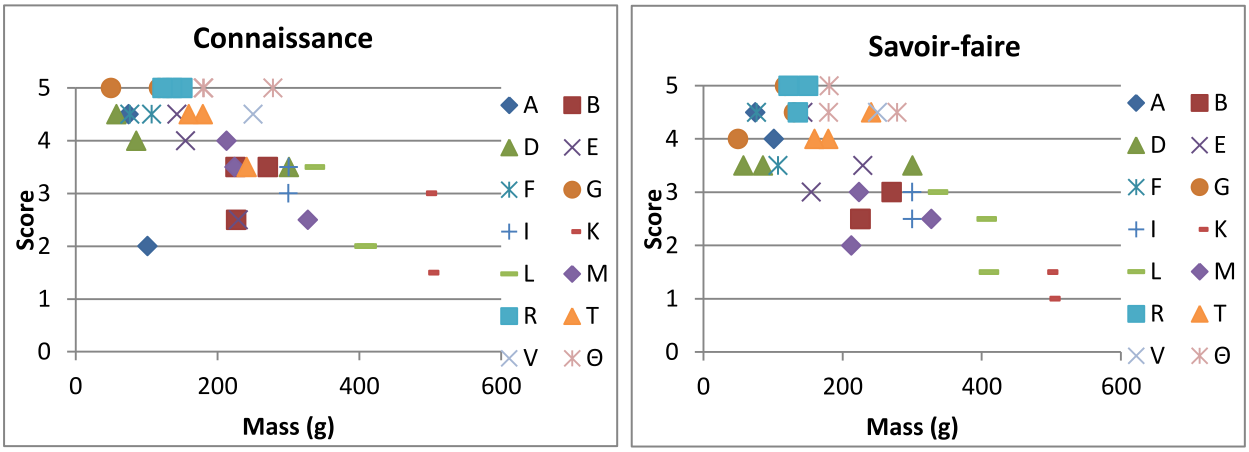


Figure 5.22. Negative correlation of handaxe mass with scores received for connaissance and savoir-faire.

Symmetry:

In addition to the measurements mentioned above symmetry of handaxes was calculated using the fliptest program developed by Hardaker and Dunn (2005). The symmetry visible in archaeological handaxes is one aspect of their design that has led to claims that the hominins that constructed them had the capability to form mental templates (Ambrose 2001; Holloway 1969, 405–6). The ability to enforce symmetry on a tool has also been surmised as an indicator of a high level of knapper skill (Bamforth & Hicks 2008, 150). Both plan and profile measures of symmetry were assessed and averages taken of each measure to observe change throughout the evaluations in the project (Fig. 5.23). The plan view symmetry shows a lowering of the index of asymmetry from evaluations one to two, followed by a slight increase from two to three.

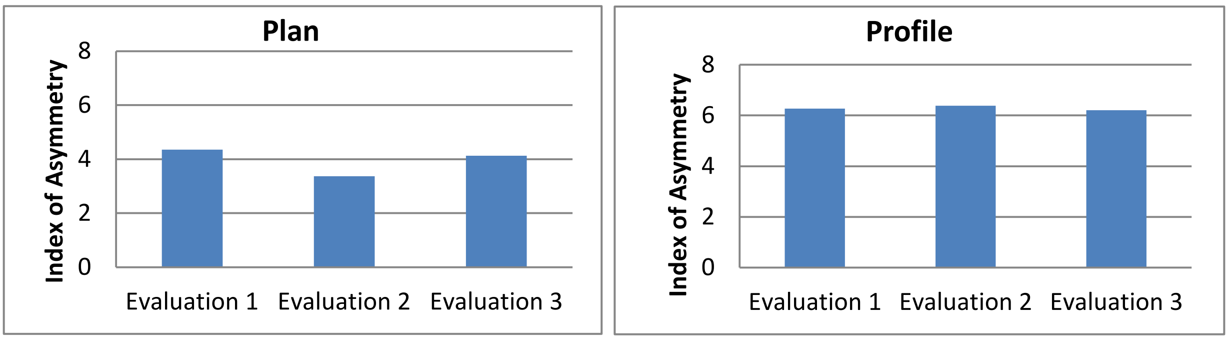


Figure 5.23. Average plan and profile view index of asymmetry for each evaluation.

This is the same pattern as is seen for the majority of the other measurements which can likely be explained by the decrease in additional practice and teaching hours between evaluations two to three compared with one to two. The profile view averages do not show this same pattern with similar index averages produced for each evaluation by the whole group.

Using the recommendations of the Fliptest creators a score of 4.00-4.99, which was the average for the first evaluation of the plan view of the handaxes, equates to a moderate level of handaxe symmetry (Hardaker & Dunn 2005). The average result for the second evaluation lies between 3.00 and 3.99 and according to the same document relates to a high level of symmetry representing skilled work. The average scores then return to the same moderate symmetry level in the third evaluation. The averages for the profile view of the handaxes all lie above 6.00 and represents a very low level of symmetry. This suggests that while skill was acquired in creating a symmetrical plan view of the handaxe in the group between the first and second evaluations, creating a symmetrical bifacial plane was not easy to achieve and was beyond the capabilities of most of the group.

When individual data are plotted against scores for connaissance and savoir-faire, a clearer understanding of the relationship between skill and symmetry seen in this project can be gained (Figs 5.24 & 5.25). From this it can be seen that while there appears to be, particularly in terms of savoir-faire score, some negative correlation between index of asymmetry for plan view of the handaxes there is no clear picture of correlation for the profile view. As

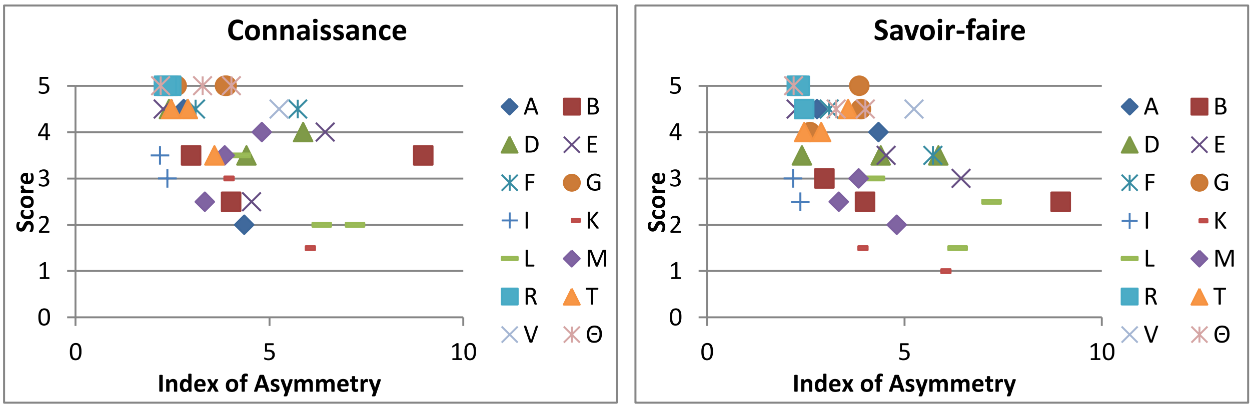
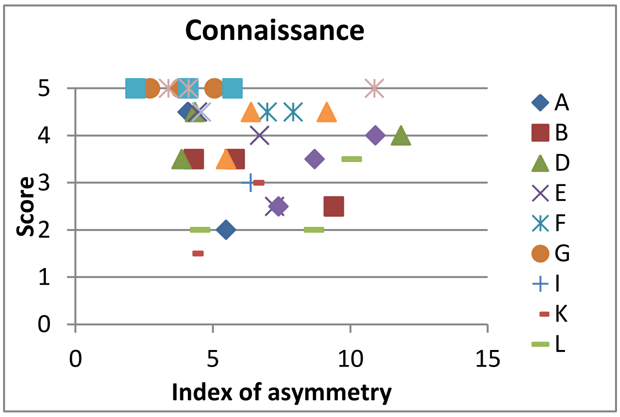


Figure 5.24. Plan view index of asymmetry plotted against scores received for connaissance and savoir-faire.



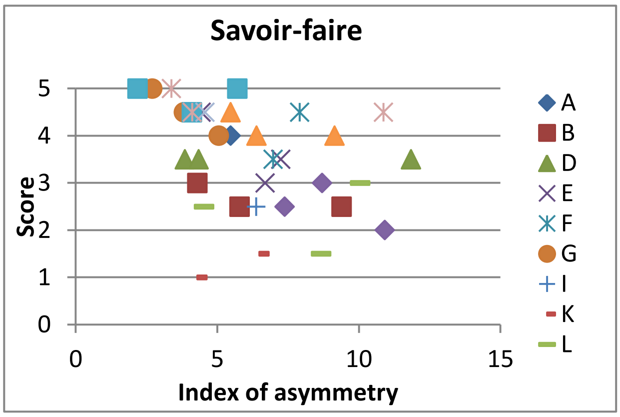


Figure 5.25. Profile view index of asymmetry plotted against scores received for connaissance and savoir-faire.

discussed above, the majority of the group were unable to achieve high levels of symmetry in plan view and from this it seems likely that this area of handaxe technology is one of the most difficult for knappers to master.

5.2.6 Debitage

As well as the handaxes produced, all debitage created during the evaluations was collected and every piece with a maximum dimension of more than 10mm was analysed. The results of this are presented below. In all instances, except for the mass of flakes all counts are of flakes above 10mm maximum dimension.

Mass and Number of Flakes:

The mass of flakes produced was considered for analysis together with the number of flakes produced as it was believed that this would give a measure of the efficiency of production seen and thus the skill of the knapper. All pieces that had an identifiable bulb of percussion were considered a flake. It was expected that highly skilled knappers would produce a lower number of flakes than a less skilled knapper producing the same mass of flakes due to the difficulty of producing large flakes, especially in bifacial reduction sequences. The average number of flakes per 100g was calculated for each evaluation to observe changes through the project (Fig. 5.26). This revealed that contrary to

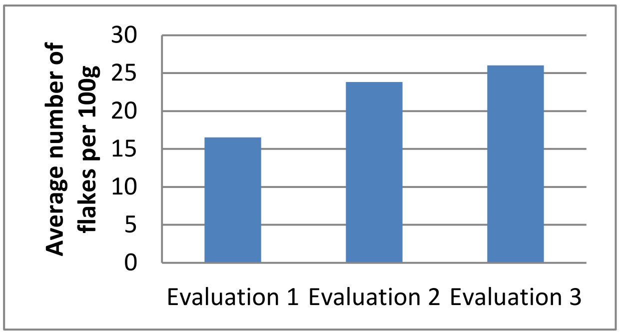


Figure 5.26. Average number of flakes produced per 100g of debitage for each evaluation.

expectations number of flakes per 100g increased for each evaluation. This is probably due to knappers being able to continue further with the technology as the project progressed and thus in the latter stages of manufacture have to deal with a small tool and so remove smaller flakes.

Number of flakes per 100g was plotted against individual skill scores for each knapper for each evaluation (Fig. 5.27). This showed no correlation, suggesting that this is not an effective indicator of skill in handaxe technology. As with the handaxe mass information discussed above, the results of this analysis suggest that measures of efficiency can not always be related to technological skill, with more skilled knappers choosing to spend more time and able to take more removals from handaxes than less skilled. This indicates care must be taken when trying to apply measures of efficiency to assessments of skill in handaxe manufacture.

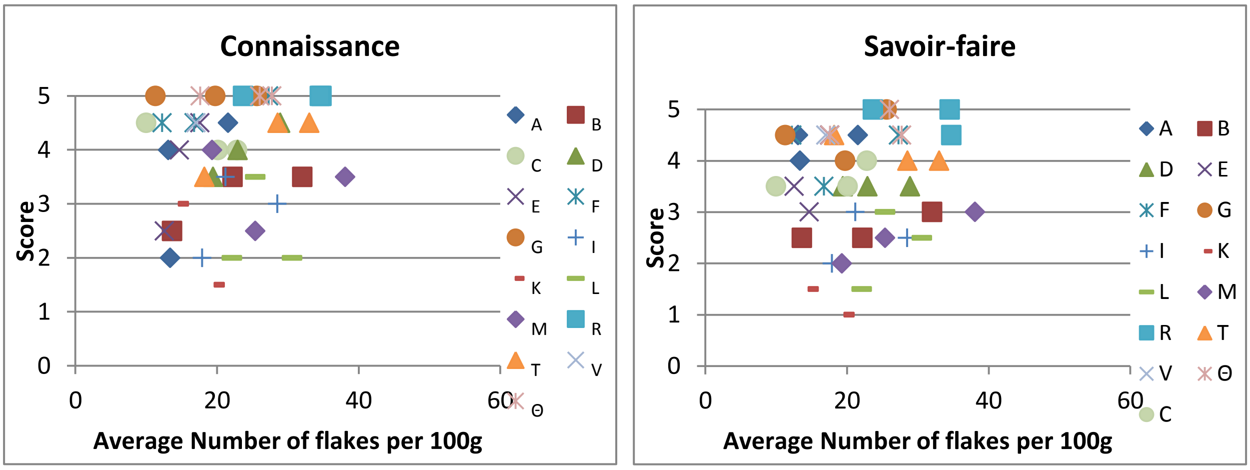


Figure 5.27. Average number of flakes per 100g debitage plotted against scores received for connaissance and savoir-faire.

Platform Type:

In addition to total number of flakes, platform types of flakes were counted. Three types of platform were identified: flat, faceted and undetermined. It was assumed that platform type would give information on skill

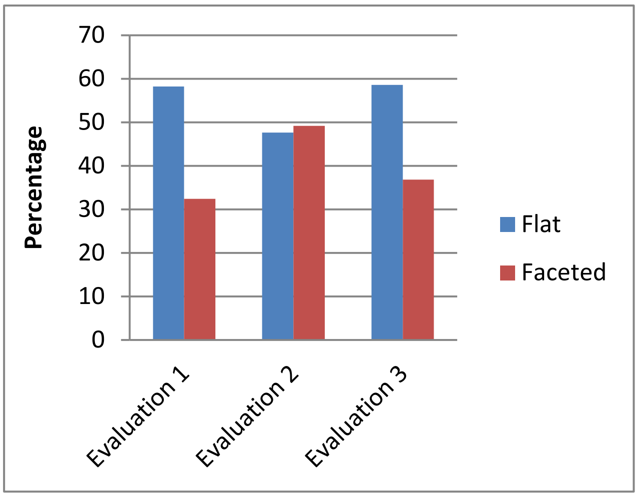


Figure 5.28. Percentage of flat and faceted platforms for each evaluation.

as faceted platforms can indicate that some platform preparation has taken place to adjust edge and platform angles. Platform preparation is a technique that novices are often unaware of or unable to correctly apply in knapping (Shelley 1990, 191–2). Average percentages of flat and faceted platforms were calculated for each evaluation to observe changes through the project (Fig. 5.28). This shows average percentages of around 60% for flat and 30% for faceted platforms for evaluations one and three and nearly 50% each for evaluation two. This increase in faceted platform percentage from evaluation one to two is an expected reaction to increase in skill as it should reflect an increase in amount of platform preparation used during handaxe manufacture. The results seen in the third evaluation, however, mark a return to the same figures seen in the first. Again as discussed above this is likely due to the reduction in additional practice hours seen between evaluation two and three, compared to evaluations one and two.

To observe in more detail the relationship between skill and platform type percentages, these were plotted against skill scores for connaissance and savoir-faire (Fig. 5.29). From this it can be seen that there appears to be some correlation between increasing percentage of flat platforms and decreasing skill score both for connaissance and savoir-faire. The percentages of faceted platforms potentially show a similar correlation, with higher percentages associated with higher skill level, however, the results of this are not as clear.

The results of the platform preparation type analysis indicate that while calculations of proportions of flat/faceted platform have some possibility of being a useful indicator of individual skill level in handaxe technology, the use of platform preparation is a complex issue and further work is necessary in order to get a full understanding of the reasons some knappers prepare platforms and others do not.

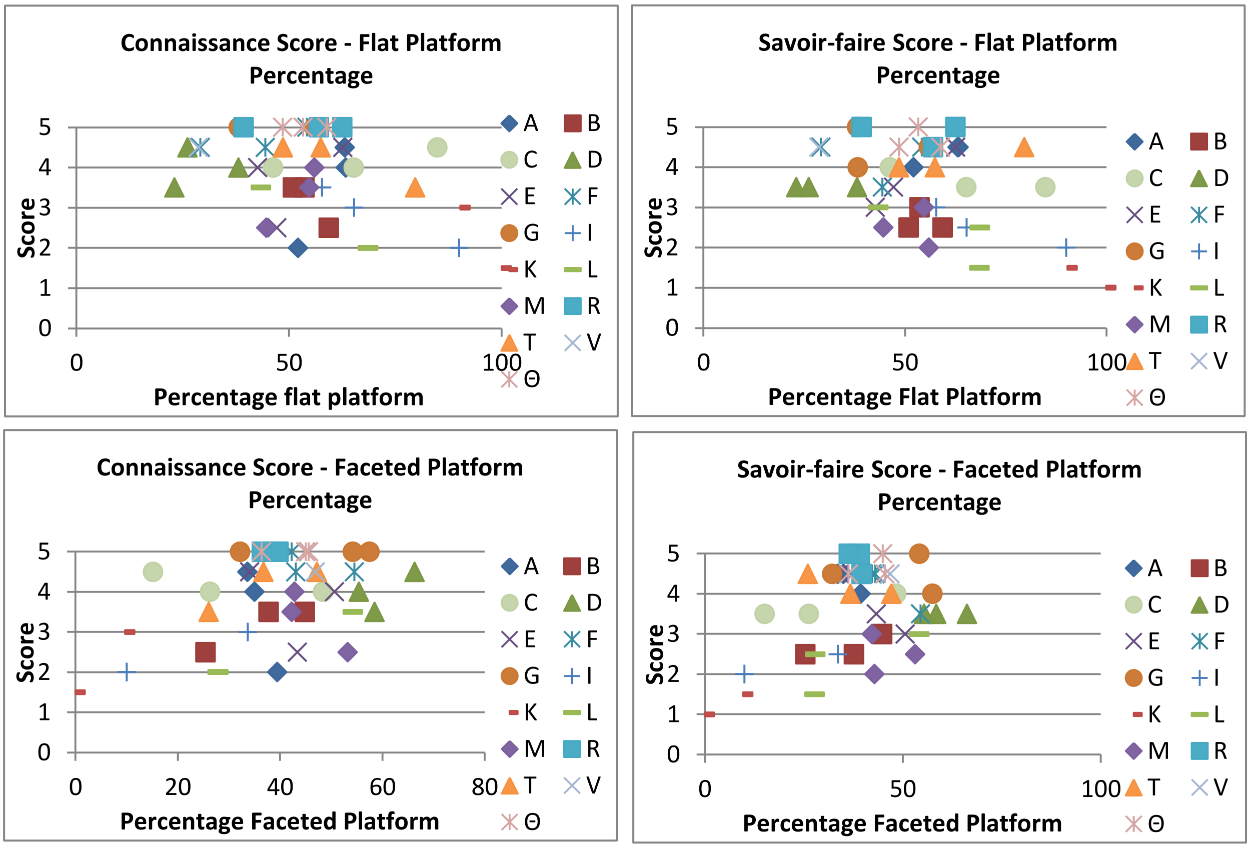


Figure 5.29. Percentages of flat and faceted platforms plotted against scores received for connaissance and savoir-faire.

Termination Type:

In addition to platform type, termination type was recorded. Types identified were feathered, hinge, step and undetermined. Hinge and step fractures are, in the majority of technologies, considered as knapping errors (Whittaker 1994, 106). It was therefore thought likely, that proportions of these terminations compared with feathered terminations might be indicative of knapper skill as highly skilled knappers would be less likely to make a high number of errors. Average percentages of hinge and step terminations compared with feathered were calculated for each evaluation to observe changes through the project (Fig. 5.30). This revealed that contrary to expectations the smallest percentage of hinge/step terminations

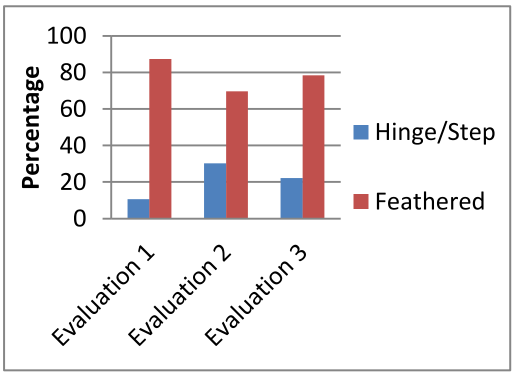


Figure 5.30. Average percentages of hinge/step and feathered terminations for each evaluation.

occurred in the first evaluation and the most in the second evaluation.

Percentages of hinge/step fractures were plotted against skill scores for connaissance and savoir-faire to observe if there was any correlation (Fig. 5.31). This showed no correlation between skill and percentage of hinge/step fractures produced. This suggests that, for handaxe technology, proportions of hinge and step fractures produced are not a good indicator of skill. The reasons for this are unclear.

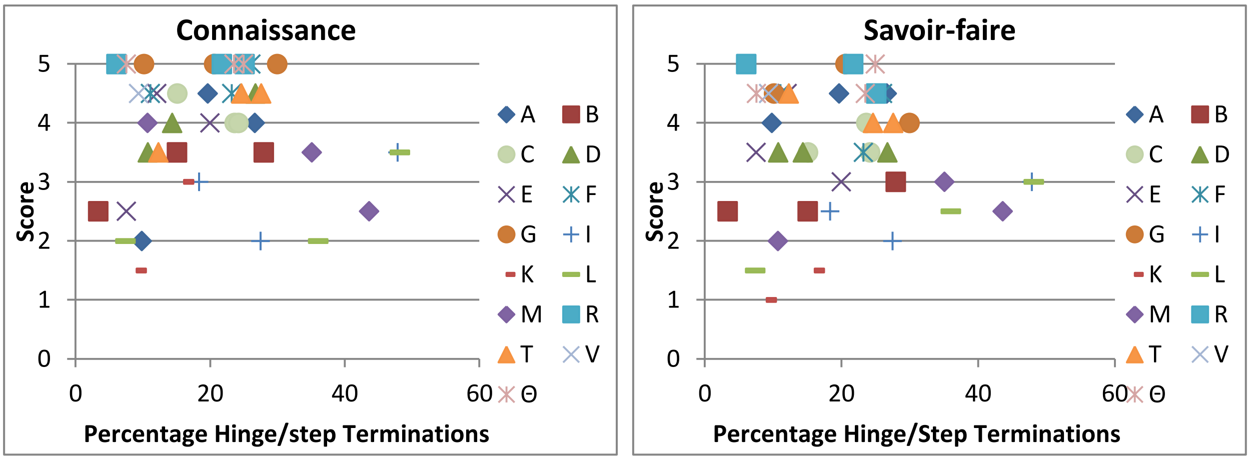


Figure 5.31. Percentage of hinge/step fractures for each evaluation plotted against scores received for connaissance and savoir-faire.

5.3 Discussion

The results of the analysis of the Acheulean handaxe evaluations reveal a very complex picture of learning and skill acquisition in this technology. One key area that this thesis focusses on is the relative importance of teaching and personal practice in determining skill level achieved in the assessed technologies. One of the most marked differences between handaxe and Oldowan technology appears to be that teaching makes more of an impact on skill achieved. This is only the case, however, if it is specifically in handaxe manufacture rather than generally in flaked stone technologies. In other respects some of the results suggested by the Oldowan evaluations are also seen here. For instance, in terms of handaxe manufacture, there is a large amount of evidence that supports the idea that continued as well as accrued practice is essential in ensuring that skill level remains high. Contrary to the results seen for the Oldowan evaluations, this appears to be the case in handaxe technology for both connaissance and savoir-faire aspects of skill. In addition to the results seen in the scores for each evaluation, the results of much of the analysis of the materials produced support this. In most cases a change seen from evaluations one to two was slightly reversed between evaluations two to three, reflecting a decrease in additional practice hours between evaluations one to two and two to three.

In addition to this, another area in which the results seen in handaxe technology support those seen in Oldowan technology evaluation analysis is in the fact that initial skill level is widely varied between individuals. In the first evaluation skill was widely varied regardless of number of taught hours or practice hours undertaken, however, practice and teaching beyond this point can be seen to have an influence on the scores achieved for skill. It appears that after around 50 hours of practice or six hours of technologically focussed teaching we begin to see a very strong influence on the scores achieved both for connaissance and savoir-faire (Figs 5.8 & 5.10). Similar to the results seen in the Oldowan chapter this shows that there is some level of natural aptitude that affects the degree of initial skill seen in flaked stone technologies. The areas of aptitude that are important for determining initial skill level in handaxe technology is discussed in more detail in the Aptitude chapter (Chapter Seven).

In terms of relative importance of teaching and practice in determining skill achieved, there does not appear to be support for one having priority over the other. The amount of teaching hours carried out by individuals in the group was, however, in general a significantly lower number than number of practice hours. If even at these low levels it is possible to see a correlation between skill score and number of hours in taught sessions, this suggests that teaching can have a very significant impact on a knapper’s ability to achieve a high level of skill. This means that, through teaching, those knappers who have low natural ability in the technology can achieve high scores after a certain number of hours have been spent in taught sessions. This has important implications for the kind of social interactions that would have allowed early hominins who practiced handaxe manufacture to achieve a high level of skill if their initial aptitude was low.

Unlike in Oldowan technology, the results of the handaxe technology do not show such a clear cut difference in the way connaissance and savoir-faire skills are acquired. Both connaissance and savoir-faire skill seem to be gained at fairly similar rates and both show some loss as well as gain in some individuals through the project. They also seem to be equally affected by teaching and practice hours and there are no strong areas of difference in the way different levels in each affect the different attributes analysed in the materials produced in the evaluations. The areas of error that were most apparent in the connaissance part of the evaluation were poor technological strategy, platform preparation errors and incorrect predictions. These are all errors that can be related to ability to plan ahead and strategize future removals. The most common savoir-faire errors were problems creating or maintaining a suitable bifacial plane, problems thinning the piece and errors in platform preparation. The bifacial plane and platform preparation errors can, as with the connaissance errors, be related to ability to plan ahead and visualise necessary future removals. This suggests that in this technology conceptual ability and physical ability to carry out removals are very strongly linked and may be hard to separate using the methods of the skill evaluations in this project. Without a degree of understanding of the concepts of bifacial strategy it may be impossible to make sufficient successful removals to achieve a high level of skill in savoir-faire. Likewise, without the physical ability to remove a sufficient number of successful bifacial flakes it may be impossible to develop a strong understanding of the full technological strategy involved in making a handaxe. These ideas can be linked to the theories of embodied skills that do not see a clear separation between cognitive and physical skill and abilities (Ingold 2000, 375). It may be for this reason that no strong differences are seen in the rates at which connaissance and savoir-faire skill are acquired in this technology.

Another area that this thesis focusses on is the assignment of skill levels to the performance and materials produced by knappers during evaluations. Skill levels are based on previous work performed by Lohse in this area (discussed in skill in Oldowan technology Chapter Four) and take into account levels of connaissance and savoir-faire seen in knappers performance (Lohse 2010, 159). From the results of the evaluations the same number of skill levels can be assigned to the knappers work for handaxes as was for Oldowan style flaking. These are beginner, novice natural, adept, crafter and experienced. The definitions and criteria for assignment for each of these stages are shown in Table 5.3.

Skill Level	Definition	Name	Scores
Level 1	Low connaissance and savoir-faire.	Beginners	2 or below connaissance and savoir-faire.
Level 2	Low-medium connaissance and high savoir-faire.	Novice Natural	2-3 connaissance, 4-5 savoir-faire.
Level 3	Medium connaissance and low-medium savoir-faire.	Adept	2.5-3.5 connaissance, 1.5-3.5 savoir-faire.
Level 4	High connaissance and medium savoir-faire	Crafters	4-5 connaissance, 2.5-3.5 savoir-faire
Level 5	High connaissance and savoir-faire.	Experienced	4-5 connaissance and savoir-faire.

Table 5.3. Skill level definitions.

Of these, two levels, beginner and novice natural, are only seen in the first evaluations, suggesting these represent the earliest levels of skill. The wider beginners group only managed to achieve, at best, adept level of skill throughout the project. Within the core group (knappers A-H) there was a wide range of skill seen with abilities ranging from adept to experienced in all three evaluations in the project. Each knapper’s progress in achieving skill levels can be seen in Table 5.4. The fact that only the wider group knappers showed the lowest skill levels at evaluation one suggests that core group knappers were assessed at a point too far from the period in which skills in handaxe manufacture were first taught to catch the earliest stages of ability in the analysis.

In order to apply these observations of skill level based on knapping performance to archaeological assemblages, the archaeological visibility of each must be assessed in order to address the likelihood of distinguishing this data. To do this the material markers that were shown to be most significant for having correlation with skill must be considered in terms of these skill levels. The most significant of these in terms of handaxe properties was maximum

Knapper	Skill Level Progress		
A	Novice Natural	Experienced	
B	Adept		
C	Crafter	Experienced	Crafter
D	Adept	Crafter	
E	Adept	Crafter	Experienced
F	Experienced	Crafter	Experienced
G	Experienced		
I	Beginner	Adept	
K	Beginner	Adept	
L	Beginner	Adept	
M	Adept		
R	Experienced		
T	Novice Natural	Experienced	
V	Experienced		
Θ	Experienced		

Table 5.4. Skill level progress for all knappers.

thickness, while maximum length, maximum width and mass also showed some correlation with skill. When maximum thickness measures are averaged for each skill level it can be seen that there appear to be three separate levels that can be identified. These can be described as beginner, adept and a group that comprises novice natural, crafter and experienced levels which has been deemed expert (Fig. 5.32). There is, however, a great deal of overlap seen in the scores produced by this group, suggesting that it is only through averaged measures of the results of an individual knapper that this can be distinguished reliably.

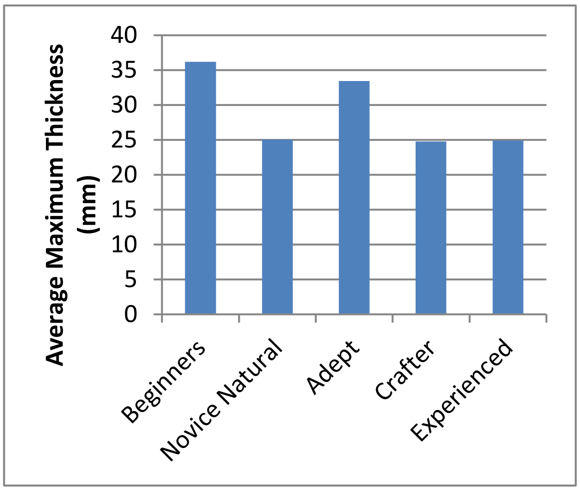


Figure 5.32. Average maximum thickness for each skill group.

Maximum length, width and mass were also analysed in this manner. This revealed that, in the case of maximum length, there is significant overlap in the range of measurements produced by each skill level, with only the beginner group appearing significantly separated from the other groups (Fig. 5.33). When this is looked at in more detail it is apparent that only the crafter and experienced group produced lengths less than 100mm suggesting that it was only possible for individuals of higher level experience to continue reducing the handaxe beyond this level.

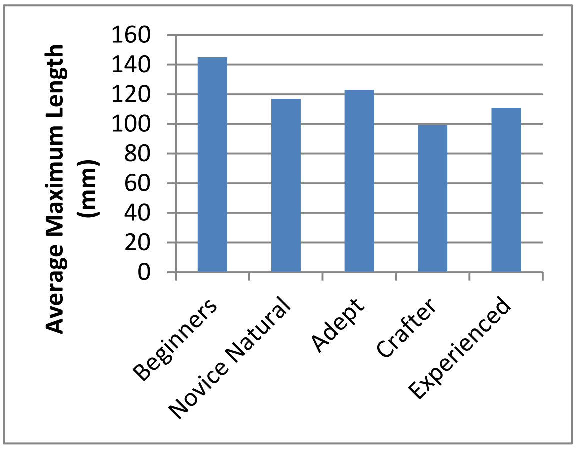


Figure 5.33. Average maximum handaxe length for each skill level

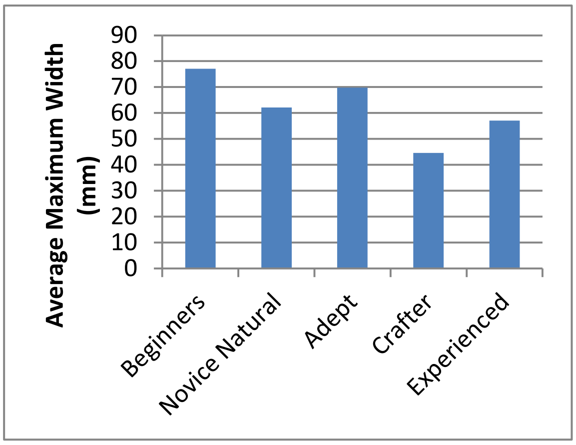


Figure 5.34. Average maximum handaxe width for each skill level

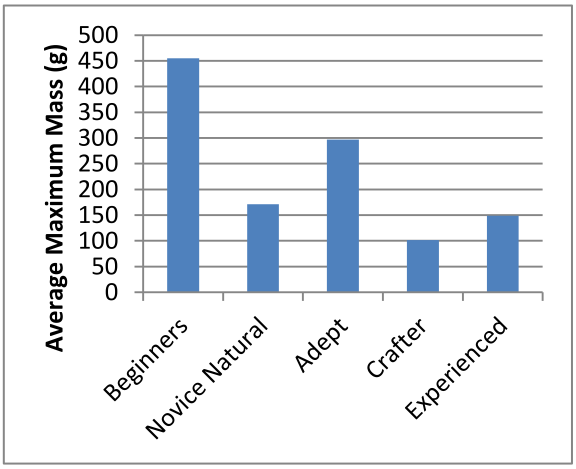


Figure 5.35. Average maximum handaxe mass for each skill level

From the results of this it seems likely that it would be difficult to identify skill level based on length of handaxe alone, however, if this was combined with a consideration of handaxe thickness it may be possible to assign three skill levels as discussed above for maximum thickness. The results of the maximum width skill level analysis show high overlap between the identified skill levels (Fig. 5.34). It is possible, however, that two different skill levels could be identified from analysis of maximum width, one comprising beginner, novice natural and adept groups and one the crafter and experienced groups. Only the first group showed measurements above 71mm and only the second showed them below 55mm. These figures could be used to give some indication of individual skill level represented by the handaxes produced in the skill assessments. The results of the handaxe mass skill level analysis show three clear groupings of results, one comprising the beginners, one the adepts and one the novice naturals, crafters and experienced groups (Fig. 5.35).

The results of the handaxe measurement skill level analysis suggests that, based on the use of standardised pre-cores, it is possible to identify three separate levels of skill from the materials produced in skill evaluations, the first representing beginner skill level, the second adept level skill level and the third experienced skill level which generally comprises the novice natural, crafter and experienced groups. This suggests that it may be difficult to distinguish the work of someone with limited practice time but a high level of natural ability from the work of someone who has practiced and been taught a great deal but has a lower level of natural ability, based on actual archaeological remains.

In many cases in the archaeological record finished intact tools are not found and the only evidence we have of knapping activities may be from debitage scatters. For this reason it is also important to assess the likelihood of identifying skill level from the debitage attributes analysed, as well as from the completed tool features. The results of the debitage analysis discussed above revealed that, of the attributes assessed, platform type was the most indicative of skill scores achieved for connaissance and savoir-faire. When averages for each skill level identified by performance are considered a clear distinction can be seen in the percentage of faceted platforms produced by the beginner level compared to the others (Fig. 5.36). This suggests that this measure may be the most useful for distinguishing the lowest skilled category from the others. The novice natural group are similarly separated with a low percentage of faceted platforms produced. This suggests that platform type may be a suitable measure for distinguishing the work of knappers with little experience but high levels of ability from experienced knappers with less natural ability. The adept, crafter and experienced group all show similar average figures for percentage of faceted platforms produced suggesting it may only be possible to distinguish three levels of ability based on this measure.

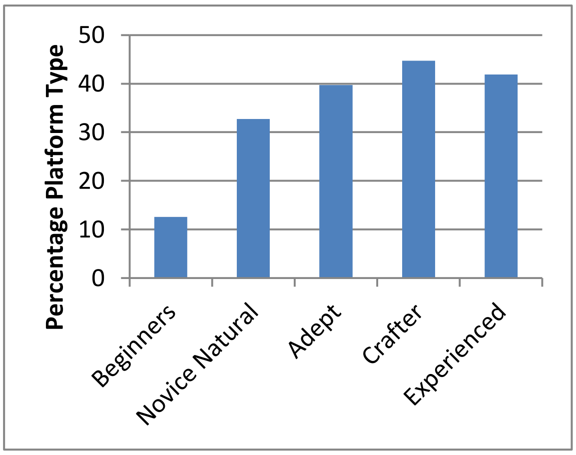


Figure 5.36. Average percentage of faceted platforms for each skill level.

The results of the skill level analysis suggest that, at best, it would only be reasonable to identify three skill levels based on an examination of the features of the tools and debitage produced during handaxe manufacture. While it may be difficult to distinguish the work of a naturally talented knapper with little experience from the work of an experienced knapper with little natural talent based on the tools produced, the evidence of platform type from the debitage analysis suggests that percentage of faceted platforms may indicate this. For instance, if a reduction sequence that resulted in an handaxe that showed signs of experienced level performance included a low percentage of faceted platform types it could be suggested that this was the work of an individual with natural ability but a low level of experience in knapping. The features that best correlate with the identified skill levels are maximum thickness of handaxe, handaxe mass and platform type for debitage. Through analysis of a combination of these features it seems likely that it would be possible to gain an understanding of an individual's skill level in this technology.

A lot of previous work has investigated the cognitive implications of the ability to produce handaxe technology (e.g. Ambrose 2001; Holloway 1969; Mithen 1998; Noble & Davidson 1996; Winton 2005; Wynn 1995). Work has focussed on the identification of handaxes as symbols or the representations of mental templates (Holloway 1969, 405–6) and the implications this has for the cognitive capacity for language (Ambrose 2001). While it is not possible to address the importance of language or imposed symmetry or mental templates on handaxe technology using this group, as all members have modern human brains and were taught this technology by modern humans using language, there are some areas of the project data that can give information on the necessary cognitive abilities to produce high levels of skill. The results of the analysis of the skill evaluations for handaxes from this project have revealed that thinning and platform preparation are the two most difficult areas of this technology for knappers to learn. Together with the results from the error analysis discussed above (Fig. 5.5) this suggests that to gain the highest level of skill in this technology a good understanding of technological strategy, the ability to plan ahead represented by the understanding of the need to prepare platforms to ensure the success of future removals and the ability to visualise shapes in three dimensions to allow for effective piece thinning are needed.

This suggests the necessary cognitive abilities for handaxe manufacture far surpass those necessary for simple flaking. Work involving brain scans of knappers who have performed handaxe technology has shown activations in areas associated with visuospatial representations and complex action regulation of hierarchically structured action sequences (Stout et al. 2008). The results of the handaxe evaluations support this. A good understanding of spatial properties is necessary to allow biface thinning and the ability to understand how to appropriately apply the necessary technological strategies to a changing object while keeping in mind the overall task goal is essential in allowing a handaxe to be made. These findings give indications of the areas of cognitive ability that would have been important in allowing handaxe technology to be possible for the hominins who first made them and are discussed in more detail in the aptitude chapter (Chapter Seven).

This study has also identified issues with some of the accepted measures of skill when applied to handaxe technology. In some studies measures of efficiency are used to indicate skill levels (Bamforth & Finlay 2008, 6). If such efficiency measures were applied to the material produced in this study we would expect to see more skilled individuals producing longer and wider handaxes out of the pre-cores by removing fewer larger flakes. The results of the analysis show the opposite of this, with more skilled knappers producing shorter, less wide and thinner handaxes using a greater number of smaller flakes. This appears to be due to the less experienced knappers abandoning pieces at an early stage of manufacture as a result of the creation of edge angles that make it impossible for them to take further removals. More experienced knappers were able to maintain suitable edge angles or alter unsuitable ones to continue to take removals past the point that was possible for inexperienced knappers. It may be that none of the knappers in the project gained a high enough level of skill to efficiently produce handaxes or it is possible that efficiency measures are not indicative of skill in this technology. Further work is necessary in this area to gain a more complete understanding.

5.4 Conclusion

It is possible to conclude, based on the results of the handaxe skill evaluation analyses, that handaxe technology is far more complex than Oldowan, both in terms of the cognitive abilities needed to master it and the methods which may be used to understand skill levels. It is clear from the results that simple measures such as identification of hinge and step fractures as errors, consideration of breakage as a low skilled occurrence and the simple equation of long tools with skilled work are not useful if a clear understanding of knapper skill is to be gained. In addition, measures of efficiency were shown not to be useful indicators of skill based on the materials produced during this experiment. Measures that have been shown to be good indicators of skill level include platform type of debitage and handaxe maximum thickness. These perhaps provide a means to identify knapper skill based either on the tools or debitage produced.

The long term nature of this project has allowed the effect of teaching and practice on handaxe technology to be more clearly understood than has been possible with experimental studies that took place over a period of single knapping episode or a couple of weeks. While both practice and teaching clearly have an effect on the skill level achieved by knappers, neither factor can be said to have shown a more significant influence. Interestingly, reflecting the more complex nature of this technology compared to earlier technologies, to have a significant effect on the handaxe skill level teaching had to be technologically focussed, contrary to the results seen for Oldowan. While it is not possible to say from this that teaching is necessary to achieve a high level of skill in this technology it is clear that it significantly sped up the learning process for some individuals, especially after six hours of teaching had been received. It is clear that teaching and practice had a much greater impact on the work of the knappers for handaxe than for simple flaking (Fig. 5.37). This implies that forms of social learning may have been important in this technology, having implications for hominin behaviour, although much further work is needed in this area to make more definitive statements. It is also clear that, as for Oldowan, a level of natural aptitude plays a role in determining skill level, particularly in the early stages of skill acquisition. The areas that are most connected to this are discussed in more detail in later chapters.

Figure 5.37. Comparison of the products produced in the final evaluation for a knapper who performed 150 hours knapping in the project (top) and one who performed 20 (bottom).

5.5 Summary of Results

- In general, connaissance skill shows a sharp increase between evaluations one and two with skill maintained at this level between two and three.
- Savoir-faire skill does not show this pattern, some knappers steadily gained skill, some maintained the same skill level, some lost as well as gained skill.
- Areas of most common error were those involving technological strategy and biface thinning.
- Hours spent in handaxe/biface taught sessions affected skill level achieved.
- Hours spent practicing affected skill level achieved.

- Maximum thickness of handaxe most strongly correlated with skill scores.
- Platform type of debitage most strongly correlated with skill scores.
- Three levels of skill are likely to be identifiable based on these results, with maximum thickness of handaxe, handaxe mass and percentage platform type of debitage most indicative of skill level.

6. Skill in Levallois Technology

6.1 Introduction

The introduction of the Levallois technique at around 300,000 years BP has been described as the "most important innovation of the Middle Palaeolithic" (Stringer & Andrews 2011, 210). The use of prepared cores allowed greater control of flake production and thus the shape and size of tools produced. This, together with the change in focus from the production of core tools such as handaxes to the use of flakes as tools, is widely considered as a significant stage in technological evolution (Wynn & Coolidge 2011, 84). It therefore seems likely that the cognitive capacities of the manufacturers of Levallois technology were more advanced than the first handaxe manufacturers. For these reasons Levallois technology was considered as a potentially interesting technology type for investigation with experiments in skill and learning, as it represents a clear shift from bifacial handaxe technologies. It seemed likely that different areas of aptitude would precondition someone to achieve high levels of skill in these two technologies. Skill in Levallois technology has been the focus of previous experiments (Eren 2008; M. Eren I. et al. 2011) but none have involved a large sample of participants or study over a period of more than a year.

The Levallois technique of tool manufacture was introduced at the beginning of the Middle Palaeolithic, c. 300,000 years ago and has been found across Africa, western Asia and Europe (Eren & Lycett 2012, 1). Levallois technology has predominantly been attributed to Neanderthals. While Neanderthals are the best known of our hominin ancestors, there is still much dispute over their cognitive capacities. This debate has focused on their use of language, their treatment of the dead and their capacity to produce symbolic or cultural artefacts (e.g. Kuhn & Stiner 1998; Mithen 1996, 160–1; Noble & Davidson 1996, 83; Stringer & Andrews 2011, 210–1; Wynn & Coolidge 2011). Much of the evidence used to discuss these points is derived from brain size and shape and from the complexity of their technological productions such as the Levallois technique.

Levallois technology in general relies on the careful preparation of a core to allow for the controlled removal of a flake or a succession of flakes to a size and shape predetermined by the tool maker. Five technological criteria have been defined as means of identifying Levallois technology: (1) The core has two surfaces that meet at a plane of intersection; (2) the two surfaces are hierarchically related – one is the platform face, the other the production face; (3) the production face predetermines the morphology of products; (4) the fracture plane is subparallel to the plane of intersection; (5) the striking platform allows the removal of predetermined flakes from the production surface, requiring it and the flaking surface to be perpendicular to the flaking axis of the predetermined flakes (Chazan 1997, 724). The Levallois technique was applied in a number of ways. As well as the best known tortoise core technology, Levallois blades and points were also manufactured using similar prepared core techniques (Schlanger 1996, 237–8).

This study focussed on the experimental replication of Levallois tortoise core technology also known as preferential Levallois. This technology involves the manufacture of an oval, tortoise shaped core which has been worked on two surfaces (Butler 2005, 66–8). Unlike handaxe technology, however, these two faces are treated differently. The lower surface (referred to as dorsal in this thesis) is worked all around the circumference, generally with little or no platform preparation, creating a series of negative flake scars and ridges around the edge. The upper surface (referred to as ventral) is worked using the ridges created on the dorsal surface as platforms (Eren & Lycett 2012, 4). These are sometimes faceted to adjust the angle, but no platform reduction is used (Bradley 1977). The aim of the ventral removals is to create a domed surface, so flakes are not intended to travel further than to the centre of the surface and often have very thick platforms, tapering to a thin termination. Once a suitable dome has been created a platform for a preferential flake removal that removes most of the dome, without overshooting the edges, can be set up. This involves creating a platform below the bifacial plane, isolating it by taking a flake removal on either side and faceting to adjust the angle if necessary (Mithen 1996, 134). A final blow can then detach a Levallois flake with a large cutting edge and thick platform end (Wynn & Coolidge 2011, 90). This useful flake was then often retouched into a variety of tools of different forms (Butler 2005, 66–68).

While this technology is the latest technology of those evaluated in the project, it was introduced to members of the core and wider experienced groups of knappers before handaxe technology. This was because it was felt that as a flake technology the skills needed would link better with the simple Oldowan technology first introduced to the group, rather than the bifacial thinning and shaping techniques needed for successful handaxe manufacture. It also allowed the group to have more time to practice and learn the skills needed for this technology through the project's time period. As the most complex technology to be taught to the group it was thought that it would likely take individuals longer to achieve high skill levels in this technology compared to Oldowan style flaking and Acheulean handaxe technology. The dates and participants of taught Levallois sessions are listed in Table 6.1. The technology was introduced to the wider beginners group at a much later date because their skills in flaking were felt to be insufficient to allow them to achieve success in this technology at an earlier point in the project. Levallois technology was not much practiced by the group as a whole and in the wider group especially. The majority of knappers found it difficult to master and did not enjoy their attempts at producing it.

Date	Knappers	Time
22/01/2011	ABCDEF	3
09/02/2011	ABCDEFΓ	1.5
16/03/2011	RSTVΓΘΞ	3
16/04/2011	BCDEFGHΘ	1
14/09/2011	ACDEFGH	0.5
09/11/2011	T	2
19/11/2011	L	2
23/02/2012	IM	2
04/07/2012	L	0.5

Table 6.1. Dates of taught Levallois sessions for all knappers.

Skill in Levallois technology was assessed three times for the core group and twice for the wider group. This was due to the much later introduction of the technology to the wider group and the low skill level evident in their attempts to reproduce it. The first evaluation for the core group took place in October 2011, nine months after their first introduction to the technology. The second core group evaluation took place in June and July 2012 and coincided with the first evaluation for the wider group. The final evaluation for the core group and second for the wider group took place in October-November 2012 at the end of the nearly two year project. The results of these evaluations are detailed below.

6.2 Results

6.2.1 Skill Evaluations

The scores that knappers received in the skill evaluations in the project are listed in Table 6.2. Core group and wider group data are presented separately as the wider group only performed two skill evaluations for this technology.

	Evaluation 1 - 11/10/11-28/10/12		Evaluation 2 - 1/06/12-10/7/12		Evaluation 3 - 16/10/12-28/11/12	
Knapper	Connaissance Score	Savoir-faire Score	Connaissance Score	Savoir-faire Score	Connaissance Score	Savoir-faire Score
A	4.5	3	4	4	3.5	4.5
B	2	2	2.5	3	4	3
C	4.5	3.5	5	3.5	5	4
D	4.5	3.5	5	4	5	4
E	4.5	4	4	4.5	4.5	4.5
F	4	3	3.5	3.5	4.5	3.5
G	5	4	3.5	4	4	3
H	3	4.5	4		4.5	
I			3	2.5	2.5	2.5
L			3	2	1.5	1.5
M			3	2	3.5	3
R			3.5	3	4.5	3.5
T			3.5	3	4.5	2.5
Θ			3	2.5	3.5	3

Table 6.2. Scores received by knappers for connaissance and savoir-faire for each evaluation (grey= not evaluated at this point, orange= unable to knap for health reasons).

When scores for connaissance and savoir-faire are considered separately some clear differences can be seen in the gain and loss of skill in this technology compared to Acheulean and Oldowan style flaking (Fig. 6.1). While for the earlier technologies connaissance skill increased sharply between the first and second evaluations and remained fairly stable after this point, in the case of Levallois technology no such pattern is seen. Scores show loss of skill as well as gain throughout the three evaluations for the core and wider groups. This suggests that the theoretical concepts that underlie Levallois technology were more complex and difficult to understand for the volunteer knappers compared to those of handaxe and simple flaking. The principles of Levallois technology also seem more difficult for knappers to retain, signified by the loss of skill seen in some individuals. The scores for savoir-faire show a different picture. While there is some loss of skill the majority of knappers show an increase from evaluation one to two and, for the core group, half of the knappers show stability at this level between evaluations two and three. While this suggests that the physical skills needed to achieve success in Levallois technology are easier to acquire than knowledge of the concepts that lie behind

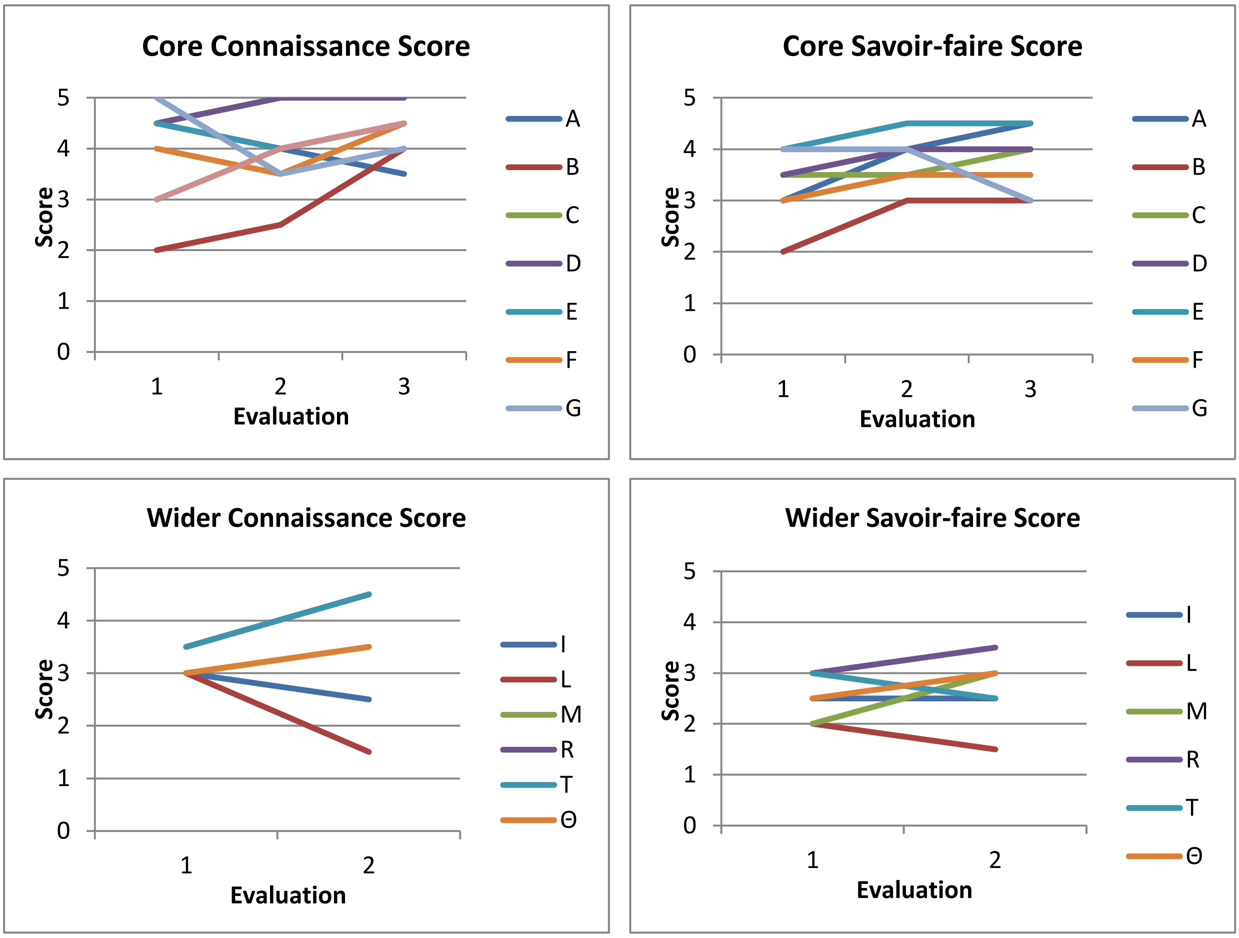


Figure 6.1. Skill scores received for the core and wider groups for connaissance and savoir-faire in each evaluation through the project.

it, none of the knappers received a score higher than 4.5 suggesting none truly mastered this area of skill.

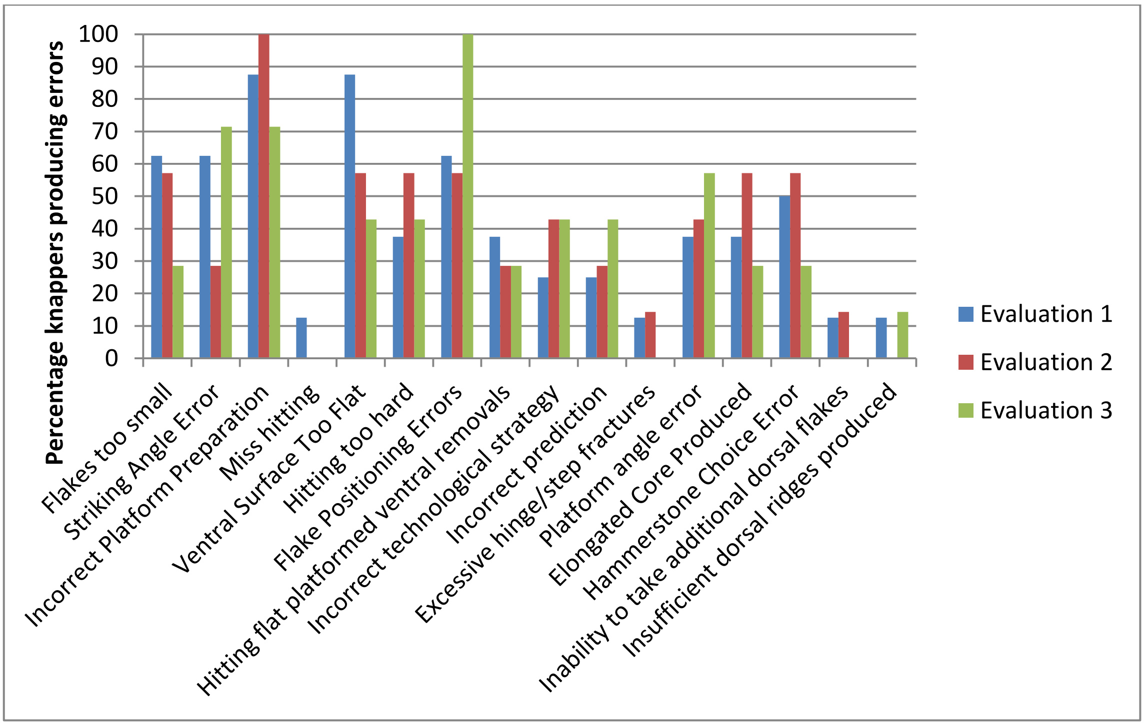
To look at this issue in more detail, the errors recorded during the skill evaluations were considered. Errors identified in the connaissance and savoir-faire evaluations included:

- Production of dorsal flakes that were too small;
- Striking angle errors;
- Incorrect or missing platform preparation;
- Miss hits;
- Creation of a flat ventral surface;
- Striking too hard;
- Flake positioning errors;
- Hitting flat rather than ridged platforms for ventral flakes;

- Incorrect strategy for technology;
- Incorrect predictions (connaissance);
- Excessive hinge/step fractures produced;
- Platform angle errors;
- Creating an elongated core;
- Hammerstone choice errors;
- Inability to make additional dorsal removals once ventral surface has been worked;
- Insufficient dorsal ridges produced;

An analysis of the errors produced by each individual for each evaluation revealed no clear pattern of decreasing errors across the successive skill evaluations in the project for either the core or the wider groups (Fig. 6.2). For the core group only two error areas show a reduction with each evaluation – the production of excessively small dorsal removals and the production of a flat ventral surface. This suggests these areas were the most straightforward for knappers in the group to master. The other error areas show both increase and decrease in percentage occurrence across the evaluations or increase in prevalence through the project. Errors that show consistently high occurrence include platform preparation errors and flake positioning errors, as well as the creation of a flat ventral surface. These areas are all interconnected as without correct spacing of removals and suitable platform preparation it would be extremely difficult to create a suitably domed ventral surface. This suggests that spatial visualisation and strategic planning of removals to prepare for future removals are the areas of this technology that are most difficult for knappers to master.

As well as knapping errors the time taken to complete the savoir-faire part of the evaluations was recorded. It was assumed that more skilled knappers would be able to successfully take a preferential flake removal more quickly than less skilled knappers. Time proved not to be associated with skill in the handaxe evaluations and the Levallois evaluations show similar results. The average times taken for each evaluation for the core and wider groups are shown in Figure 6.3. This shows that, similar to the handaxe evaluations, there appears to be no significant change in average time taken across the three evaluations for either the core or wider group. There appears also to be a



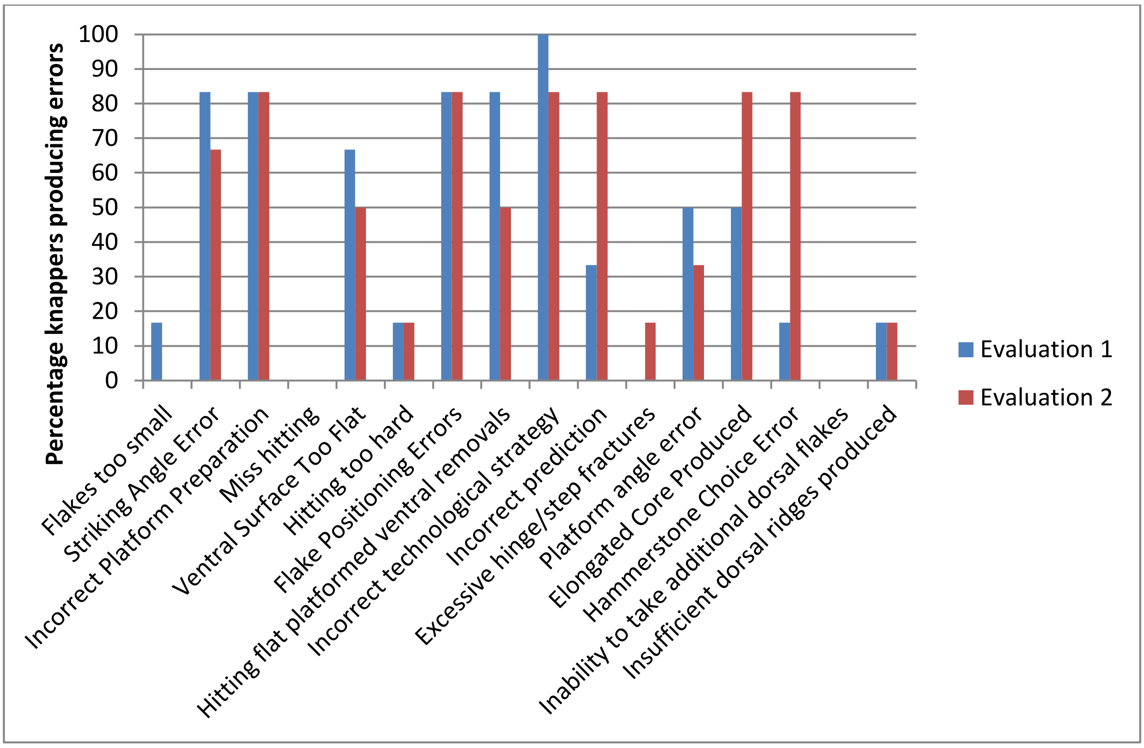


Figure 6.2. Percentage of knappers committing errors in each evaluation for core group (top) and wider group.

strong pattern of individual knappers producing similar times for each evaluation while there is a lot of variability between knappers. To investigate whether this variability was associated with individual skill level, scores for connaissance and savoir-faire were plotted against time taken (Fig. 6.4). This showed no correlation between time taken and skill score received for the technology.

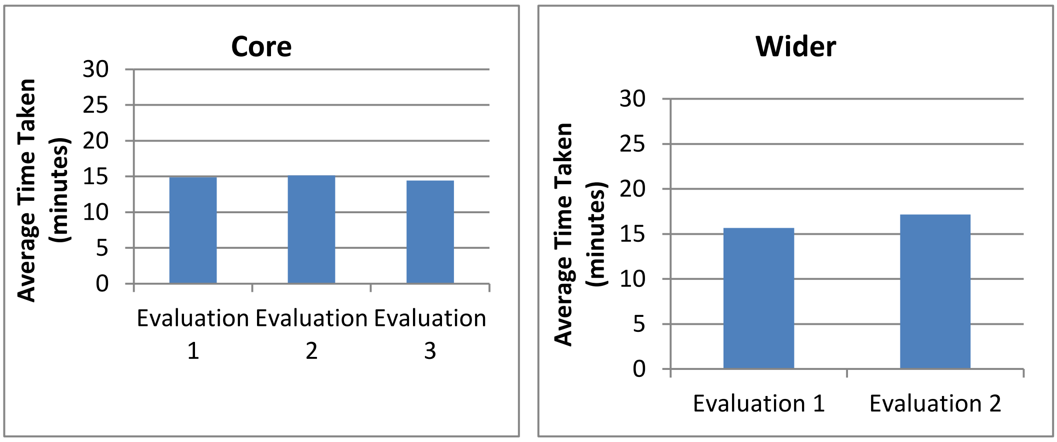


Figure 6.3. Average times taken for each savoir-faire evaluation for the core and wider groups

This suggests that, as was seen in the handaxe results, time taken is due to individual knapper choice rather than skill or experience.

Factors that were considered as likely for influencing the level of skill shown by the knappers include number of hours spent in taught sessions, number of hours spent practicing and natural aptitude of knappers in a number of areas. Results for teaching and practice are presented below, while aptitude results are presented in Chapter Seven.

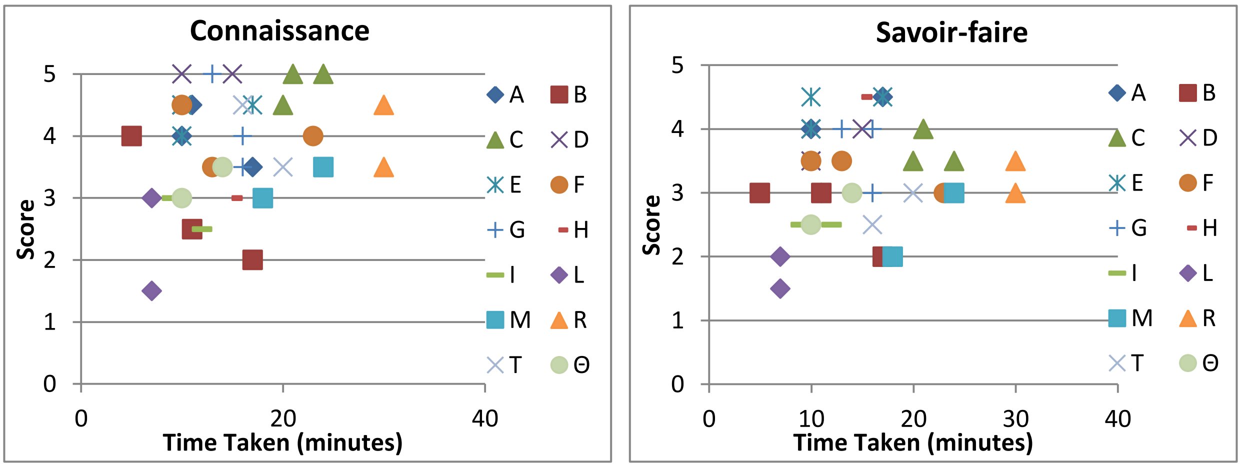
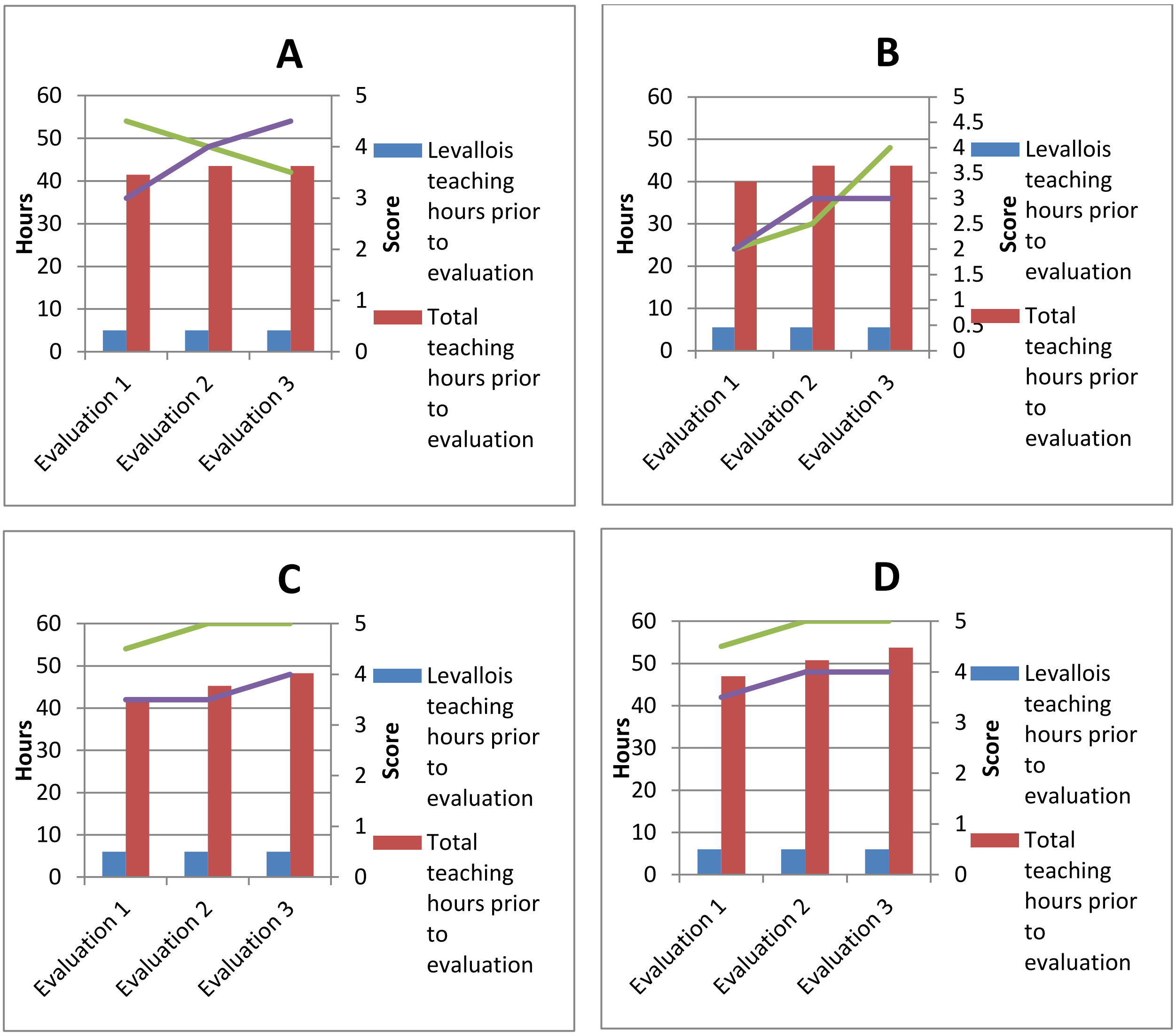
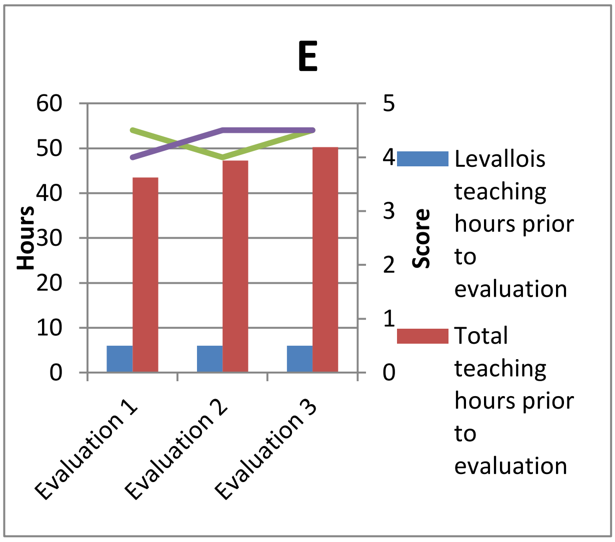


Figure 6.4. Time taken for Levallois manufacture plotted against scores received for connaissance and savoir-faire.

6.2.2 Teaching

The Levallois technique was the second technology introduced to the core group and wider experienced group of knappers and the third to members of the wider beginners group. Table 6.1 shows the dates and participants of taught Levallois sessions. This shows that the core group received a larger number of taught sessions in this technology than the wider group. Hours spent in taught sessions prior to the skill evaluations were plotted against scores received for connaissance and savoir-faire for each knapper to see the effect of teaching on skill acquisition (Fig. 6.5). This reveals that, for the majority of the core group (knappers A-H), there is some correlation between increase in savoir-faire score and increase in total knapping teaching time between evaluations. Interestingly the same pattern is not seen in the connaissance scores, which is the area of skill one might expect to be most affected by direct teaching. The same pattern can not be seen in the wider group due to the lack of additional teaching hours for these knappers between the first and second evaluations.

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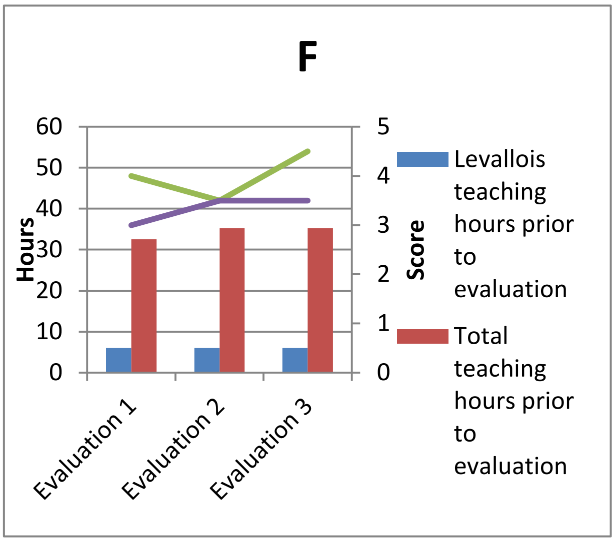
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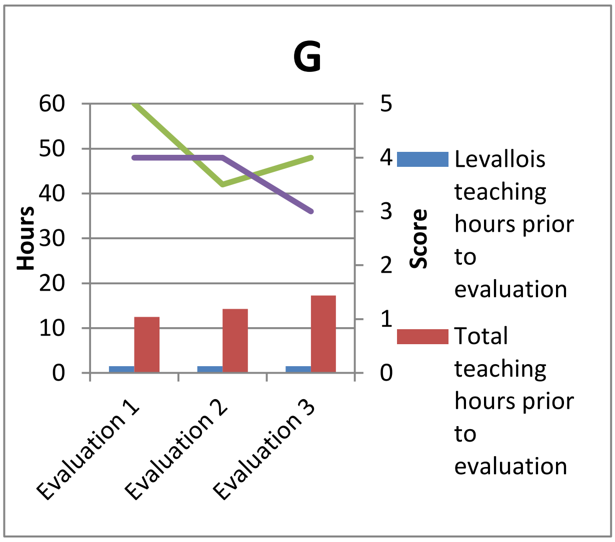
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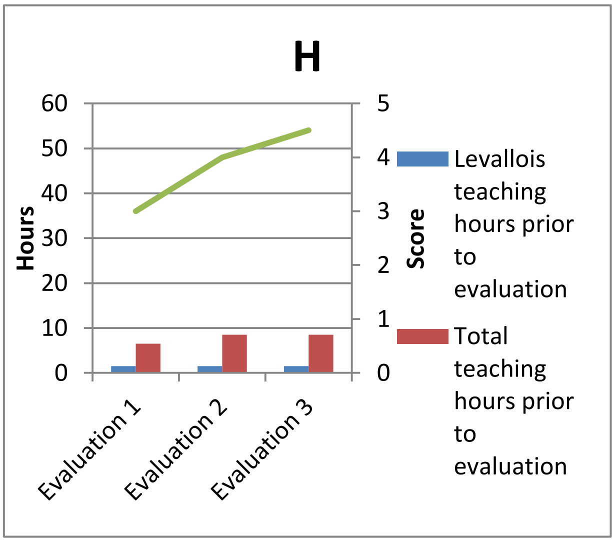
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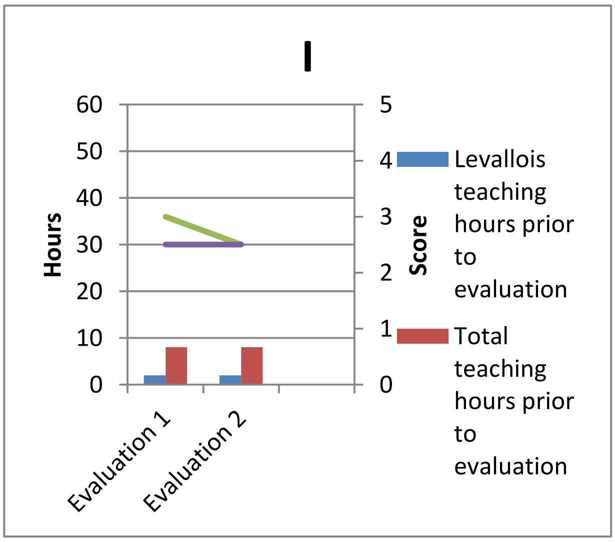
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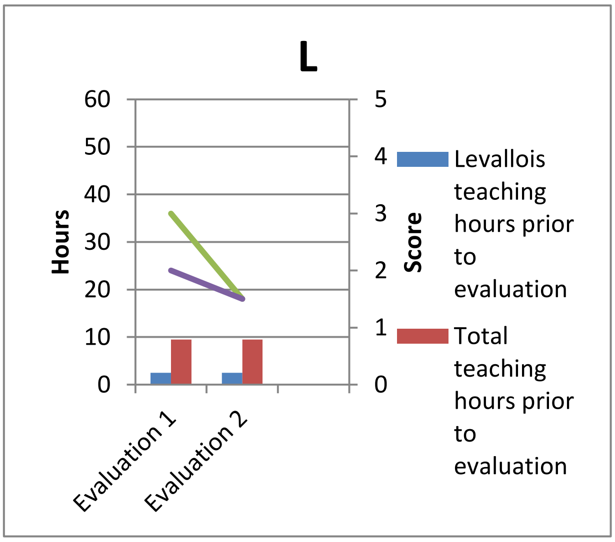
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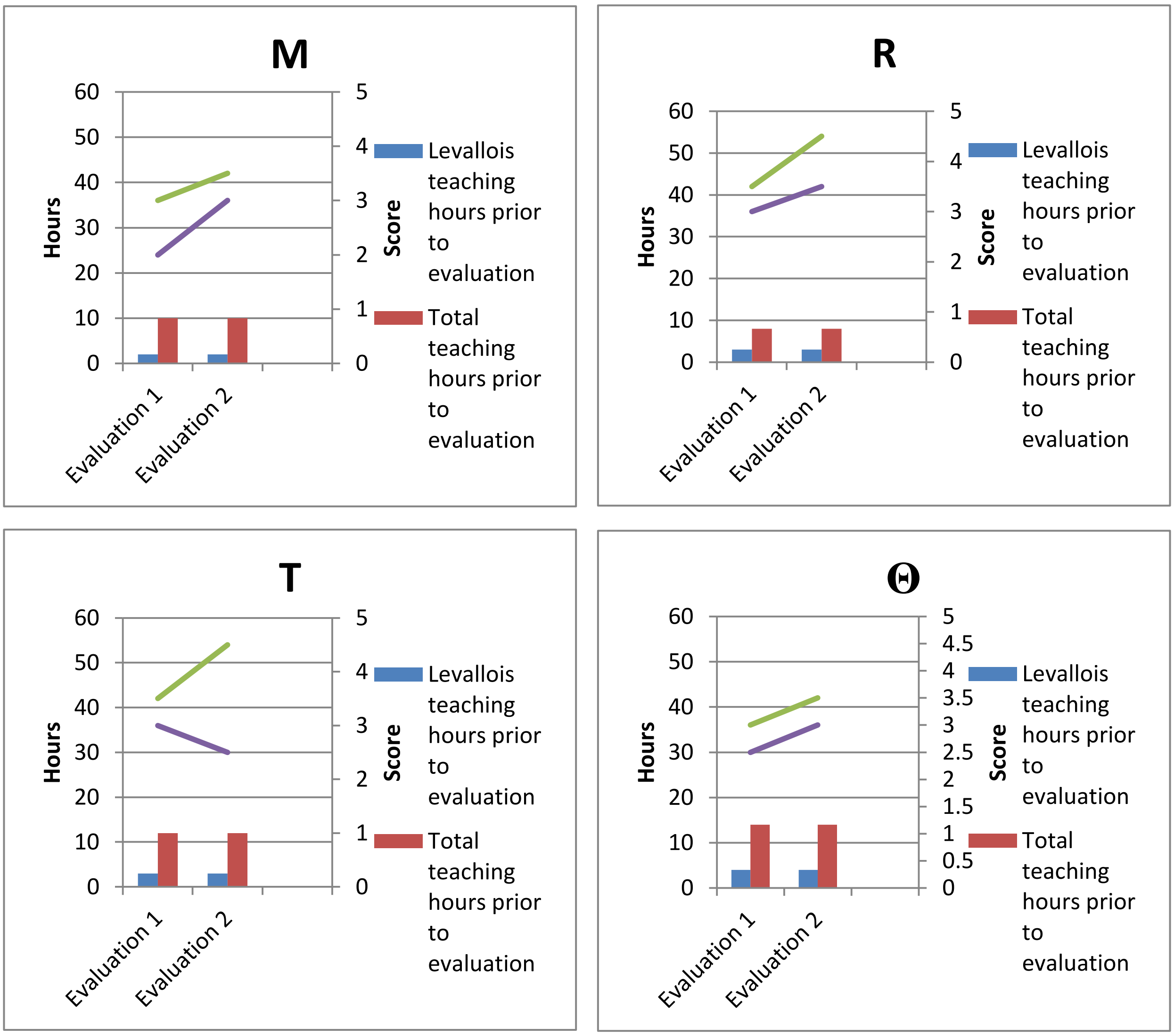


Figure 6.5. Individual knapper skill scores for connaissance (green) and savoir-faire (purple) and teaching hours prior to evaluation

In order to observe in more detail the relationship between skill and time spent in taught sessions, scores for savoir-faire and connaissance for each evaluation were plotted against hours spent in taught session prior to the evaluation (Fig. 6.6). This reveals some correlation between savoir-faire score and hours spent in taught Levallois sessions and to a lesser extent all taught sessions. The connaissance scores do not show this pattern suggesting that for this technology teaching has a stronger impact on physical ability to carry out the technology than understanding of it. This may be due to the fact that there were relatively few specifically Levallois technology taught sessions in the project and the fact that the concepts that lie behind the Levallois technique are complex in comparison to the other two technologies that the project focusses on. It may be that there were insufficient taught sessions in the project to allow

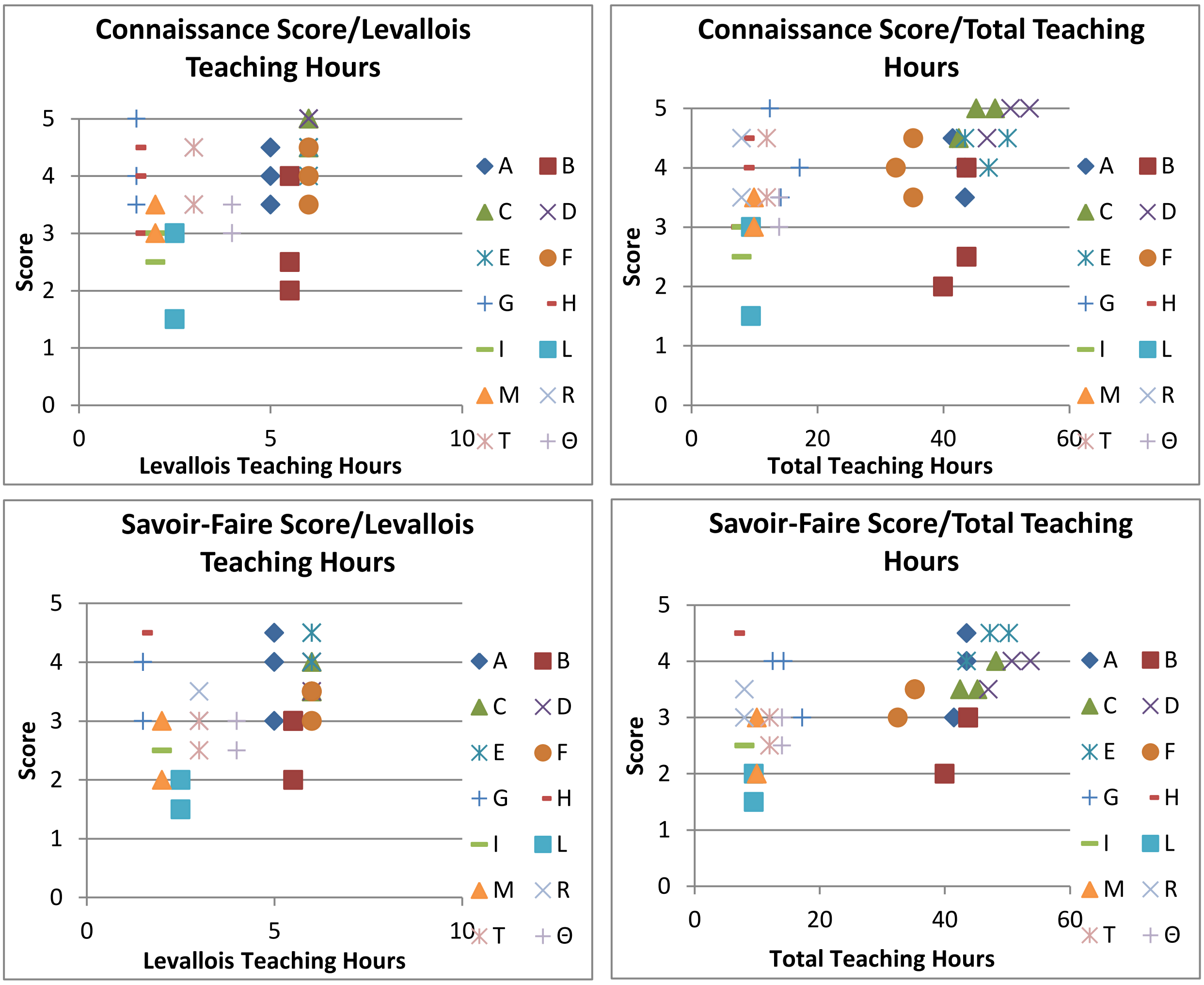
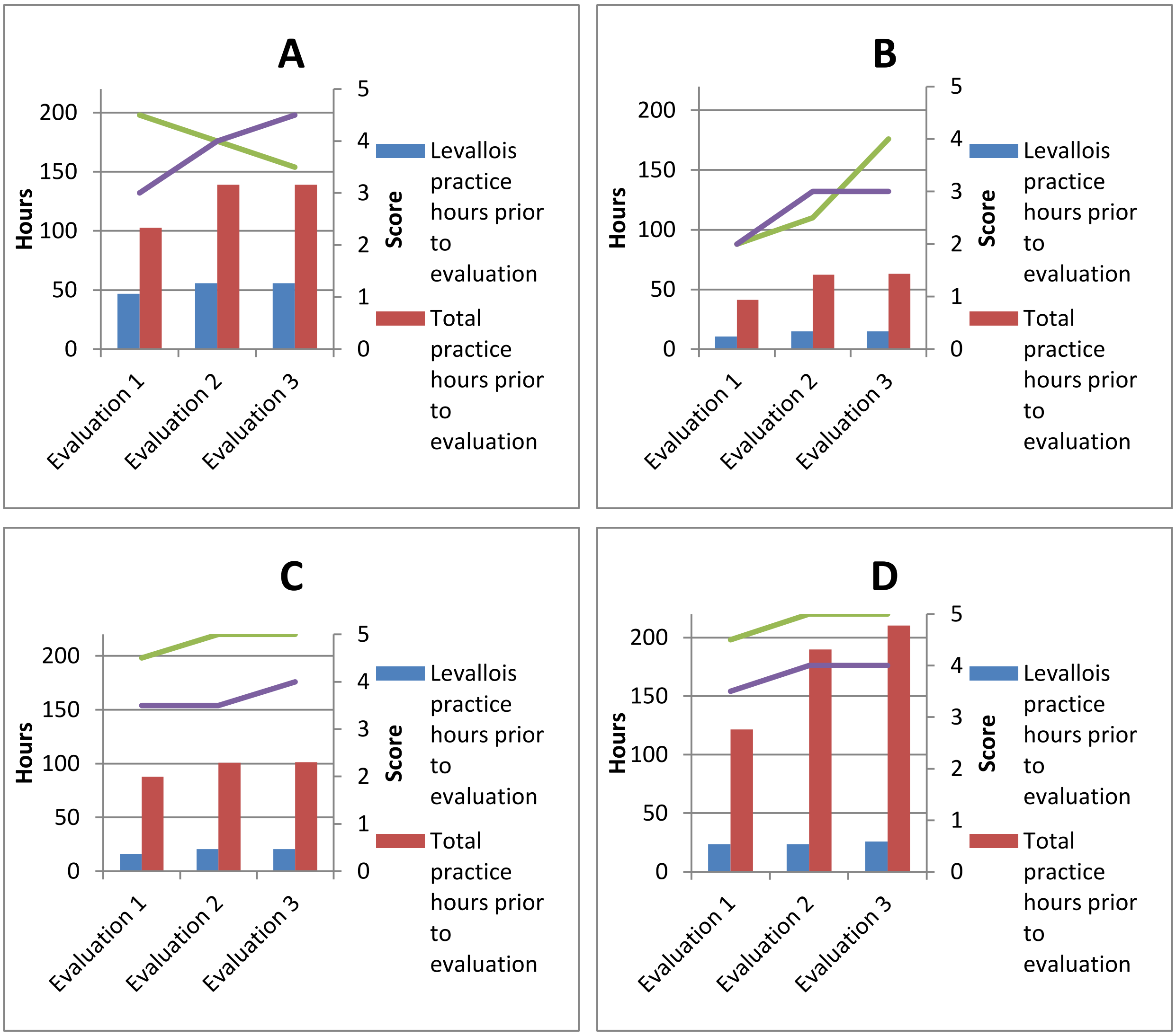


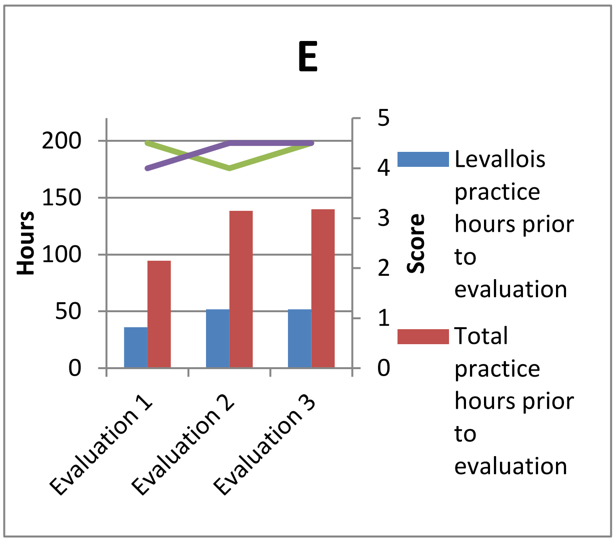
Figure 6.6. Scores for connaissance and savoir-faire plotted against hours spent in taught sessions.

knappers to gain a full understanding of this technology, while the physical skills necessary to complete this technology are also utilised in flaking and handaxe technologies. This illustrates the more complex nature of this technology and thus the advanced cognition that would have been necessary for the Neanderthals who first practiced it.

6.2.3 Practice

As well as hours spent in taught sessions, time spent practicing flintknapping was logged during the project to investigate the impact this had on the skill levels achieved in the evaluations. The results of this analysis for each knapper are shown in Figure 6.7. This demonstrates that for the core group, as was seen for the taught hours, savoir-faire skill appears most affected by practice hours with most knappers in this group showing increases in skill that coincide with increases in additional practice hours between evaluations. Connaissance skill does not show a similar pattern with loss as well as gains in ability being seen even in cases when additional practice hours have been carried out by knappers. The very low practice hours for the wider group, with most knappers carrying out no Levallois practice, make it difficult to see patterns in this data. This means that the skill level achieved by these knappers was most likely affected by the teaching they received and their own natural aptitudes.

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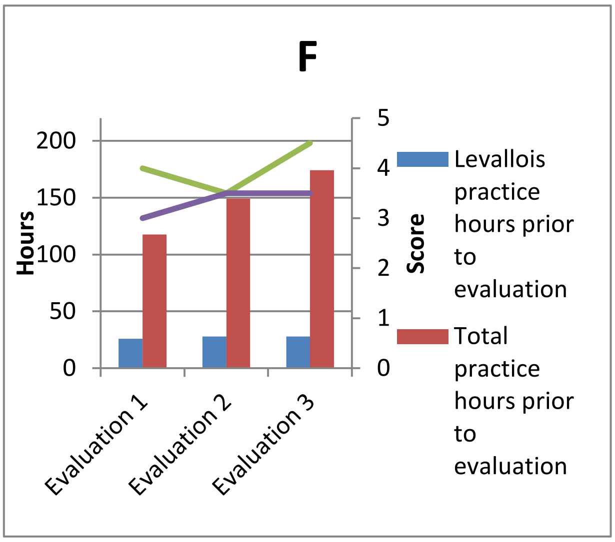
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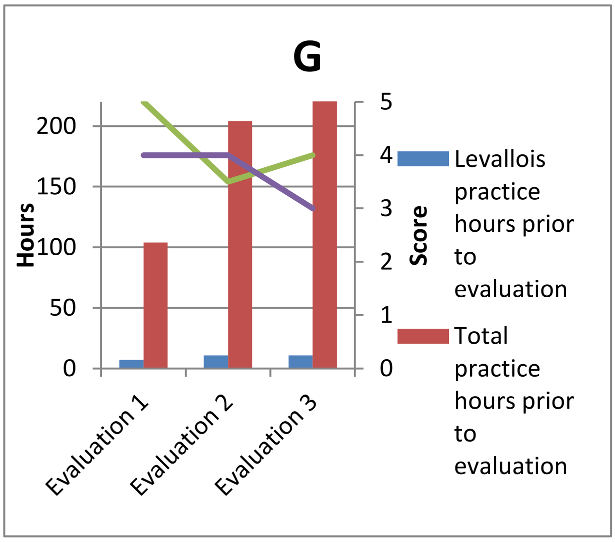
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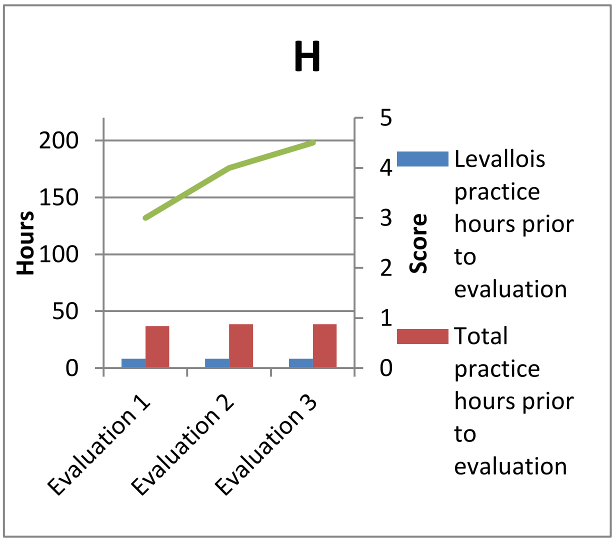
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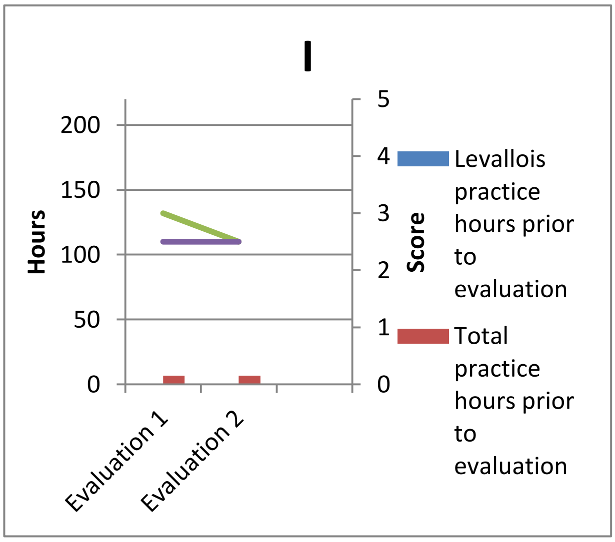
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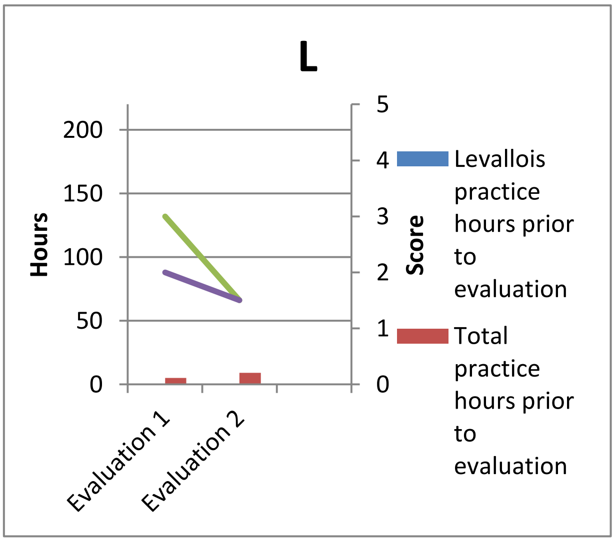
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Levallois practice hours prior to evaluation
Total practice hours prior to evaluation

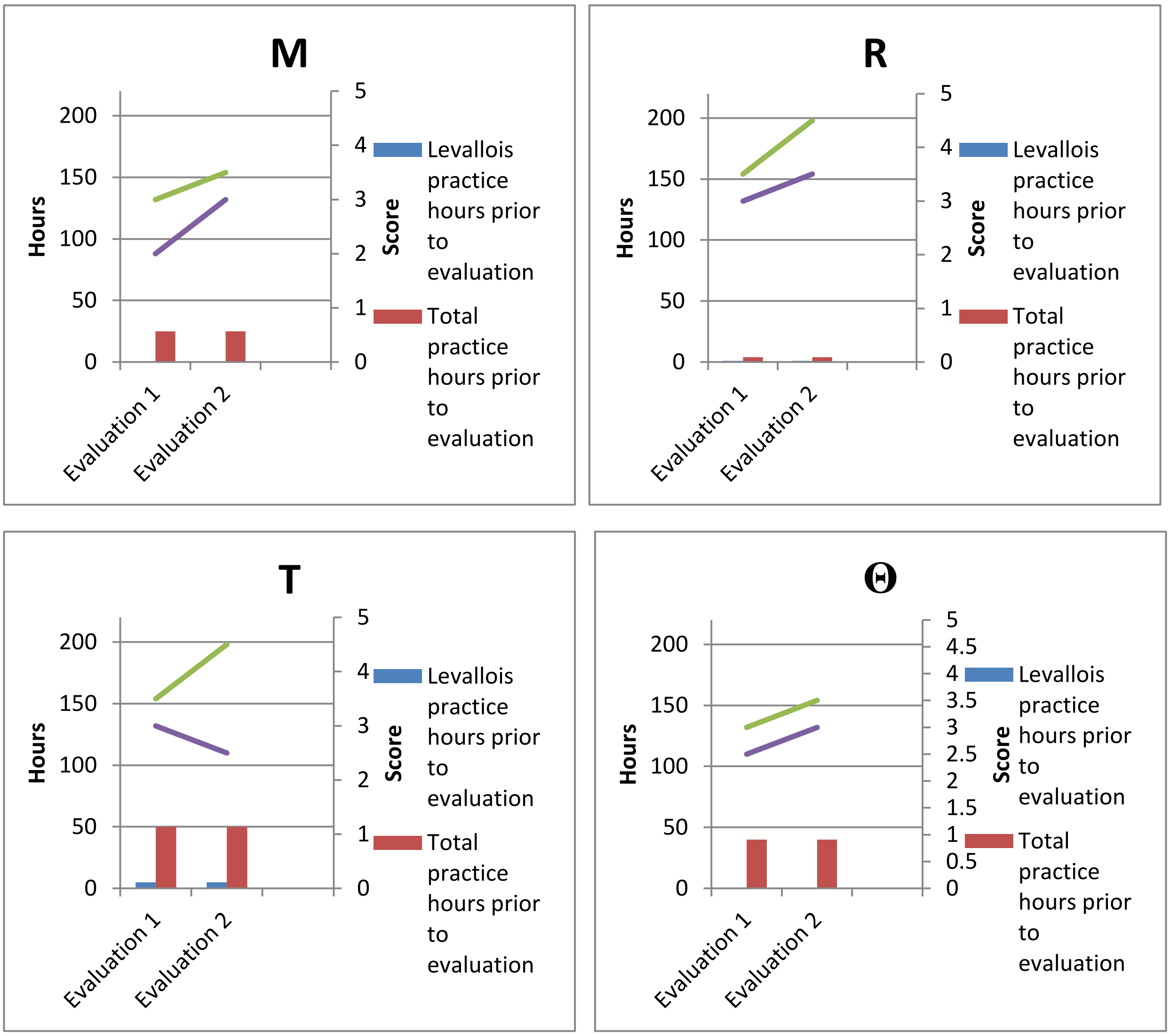


Figure 6.7. Individual knapper scores for connaissance (green) and savoir-faire (purple) and practice hours prior to evaluation.

In order to observe in more detail the effect of technologically focussed and general knapping practice on the skill level achieved, the number of practice hours was plotted against scores received for connaissance and savoir-faire in all evaluations (Fig. 6.8). This shows a good correlation between savoir-faire score and total practice hours as well as specifically Levallois practice hours but a less strong correlation for connaissance scores. This suggests that a full understanding of the concepts that lie behind Levallois technology can not be gained simply by practicing the technology. A greater level of teaching than was given during this project would be necessary to achieve the highest levels in this area of skill. This has implications for the social interactions of the Neanderthals who first practiced Levallois technology. Teaching is often reliant on a level of social intercourse and in this case may require vocalisation of concepts, having implications for the language abilities of Neanderthals, an issue that has been much debated (Eren & Lycett 2012, 2). Levallois concepts were difficult for the knappers in the group, with modern human brains and receiving direct spoken teaching, to grasp. Without language this would likely have been more difficult for the Neanderthals to master. These issues are discussed in more detail in the discussion section below.

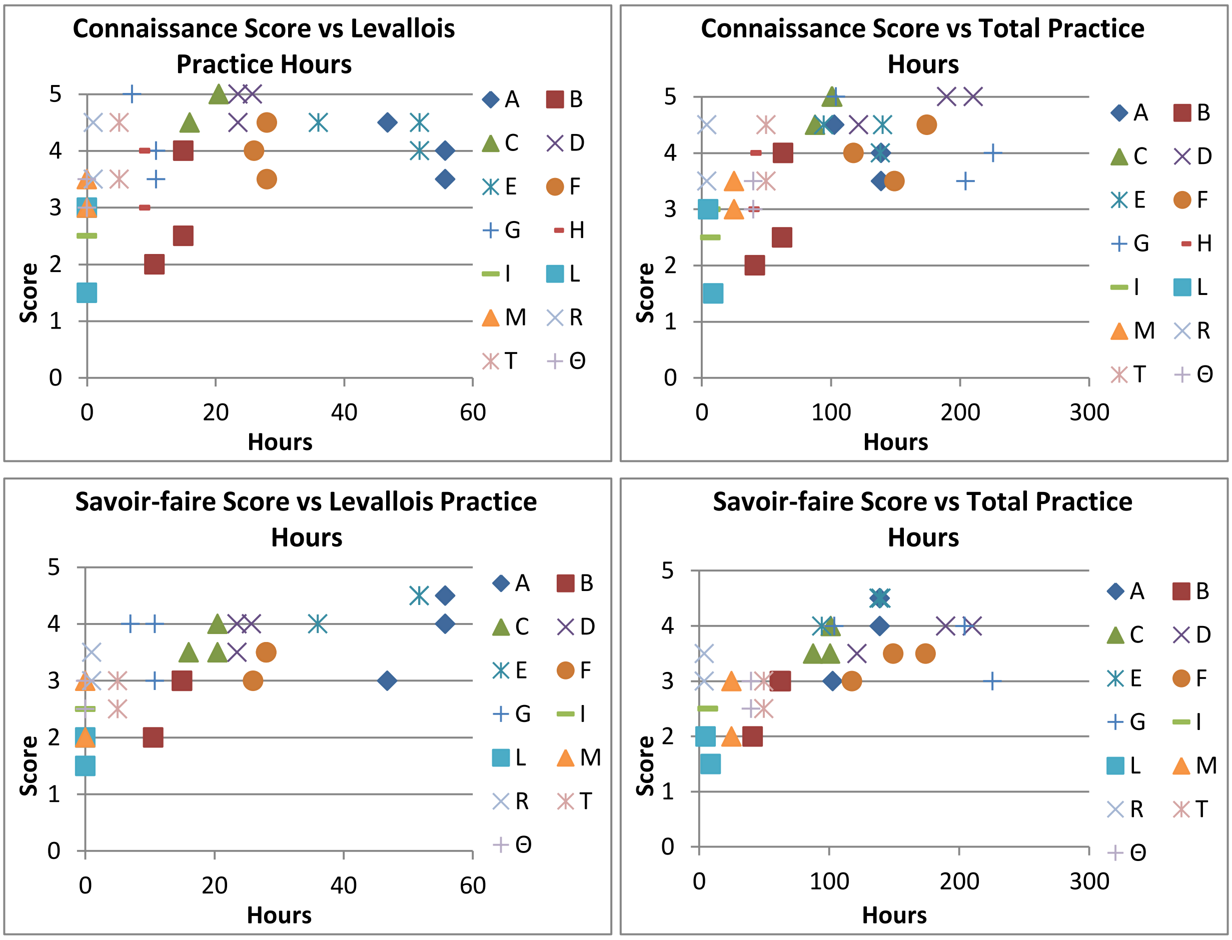


Figure 6.8. Skill scores for connaissance and savoir-faire plotted against practice hours.

6.2.4 Material Skill Markers

In order to relate the skill results based on an assessment of performance with the archaeological record, the materials produced during the evaluations were collected and analysed with the expectation that the scores produced would correlate with some of the features seen in the materials. Attributes of the cores, preferential flakes and debitage produced were analysed. Core attributes considered were:

Production of preferential flake;

- Maximum length;
- Maximum width;

- Maximum thickness;
- Mass.

Flake attributes considered were:

- Maximum length;
- Maximum width;
- Maximum thickness;
- Platform thickness;
- Termination type;
- Mass;
- Coverage of surface area of the core.

For the debitage the following attributes were analysed:

- Mass and number of flakes;
- Termination type;
- Counts of dorsal and ventral flakes;
- Platform Type.

Each of these attributes has been assessed in terms of their relationship to knapper skill and the significance of each attribute in displaying knapper skill where this is most appropriate.

6.2.5 Core

Presence of preferential flake:

The ability of knappers to produce a preferential Levallois flake was considered to be one of the most likely indicators of skill in this technology. For each evaluation knappers were asked to continue knapping until they had made one successful Levallois removal or until they felt there was nothing more they could do to achieve this aim. Percentages of Levallois flakes produced for each evaluation were calculated with the expectation that percentages would increase for each evaluation (Fig. 6.9). Both the core group and the wider group results do show an increase through the evaluations with an improvement from 50% to 100% of knappers producing a flake for the core group from evaluation one to two and from 0% to 33% for the wider group. This suggests that the ability to produce a flake is associated with increased skill in the knappers, as was the expectation.

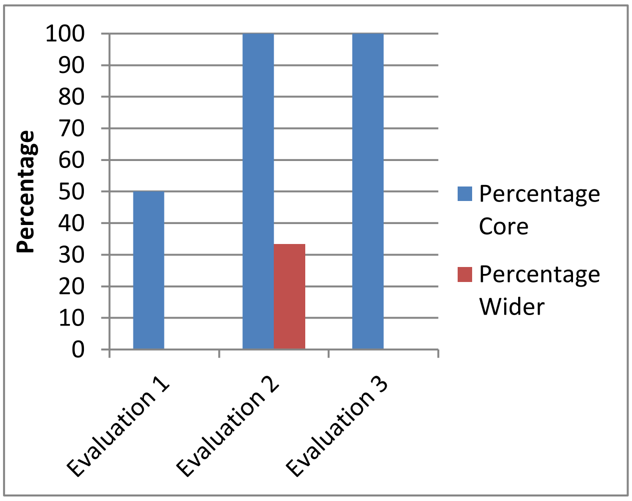


Figure 6.9. Percentage of knappers producing a preferential flake for each evaluation.

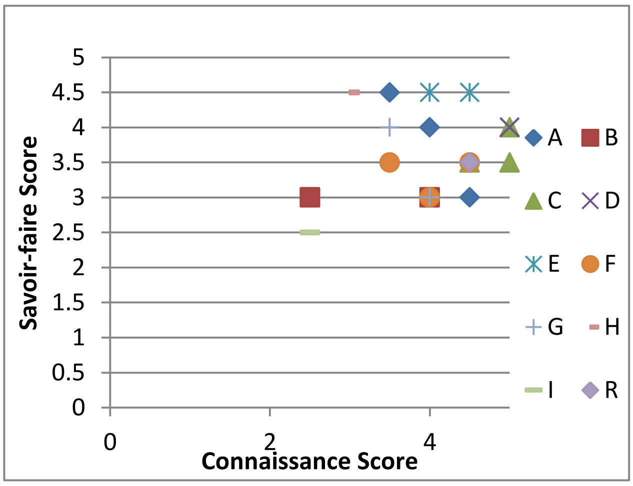


Figure 6.10. Skill scores for knappers who produced a preferential flake.

To look in more detail at how this correlates with the scores received for skill, the connaissance and savoir-faire scores for knappers who achieved a flake were plotted (Fig. 6.10). This revealed that to be able to produce a preferential Levallois flake knappers had to receive a score of 2.5 or above for connaissance and savoir-faire and that the majority of knappers who produced flakes scored 3 or above for both areas of skill. This suggests that to be able to perform what is generally assumed to be the primary aim for this technology, (Butler 2005, 66; but see also Noble & Davidson 1996, 200), a certain amount of skill acquisition is necessary, which is likely beyond what can be gained from natural aptitude without teaching or knapping practice (see Chapter Seven).

Maximum Length:

Measurements of the core produced during the skill evaluations were taken with the assumption that more highly skilled knappers would be able to produce a preferential flake sooner in the reduction sequence as their knapping would be more efficient. Previous studies have indicated that higher levels of skill allowed knappers to produce preferential flakes by removing less mass of debitage from dorsal and ventral surfaces (Eren et al. 2011, 242–2). For this reason it was expected that larger cores would be associated with more skilled knappers. The average maximum core length for each evaluation was calculated (Fig. 6.11). This revealed that the opposite pattern to the expected

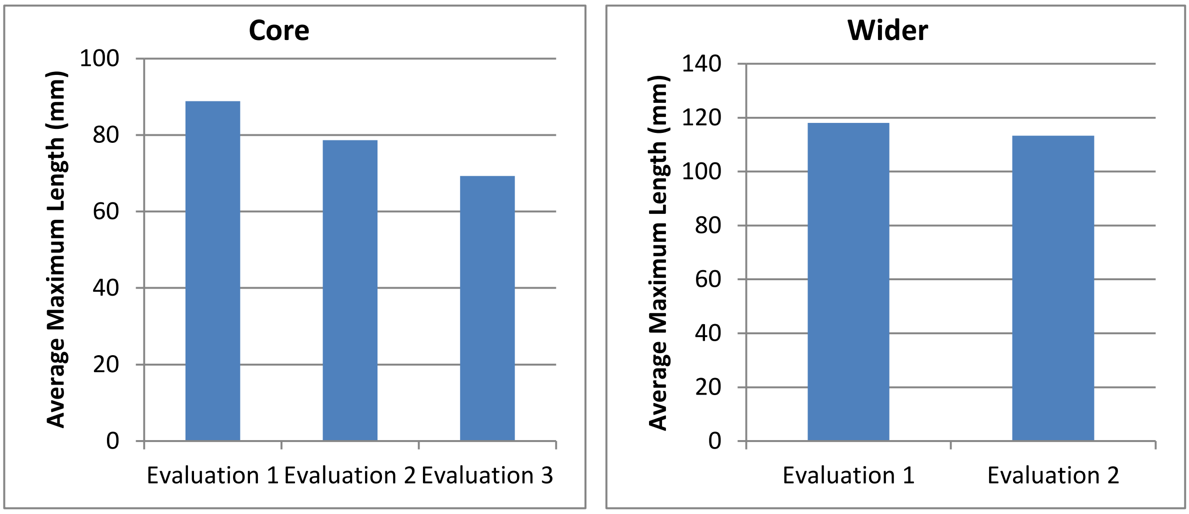


Figure 6.11. Average maximum core length for core and wider group in each evaluation.

was seen with shorter cores produced as the project progressed for the core group and, to a lesser extent, the wider group.

To investigate in more detail how this relates to individual knapper skill, maximum lengths for each knapper for each evaluation were plotted against scores for connaissance and savoir-faire (Fig. 6.12). This showed some negative correlation between maximum length and scores for savoir-faire and, to a lesser extent, for connaissance. This is similar to the results seen for the handaxe evaluations which showed shorter handaxes correlated with higher skill levels. These results are likely due to more skilled knappers being able to continue further with the technology and correct any errors they may have created during the reduction sequence. Knappers with less skill were likely to give up at an early stage if they created errors, as they were unable to clear

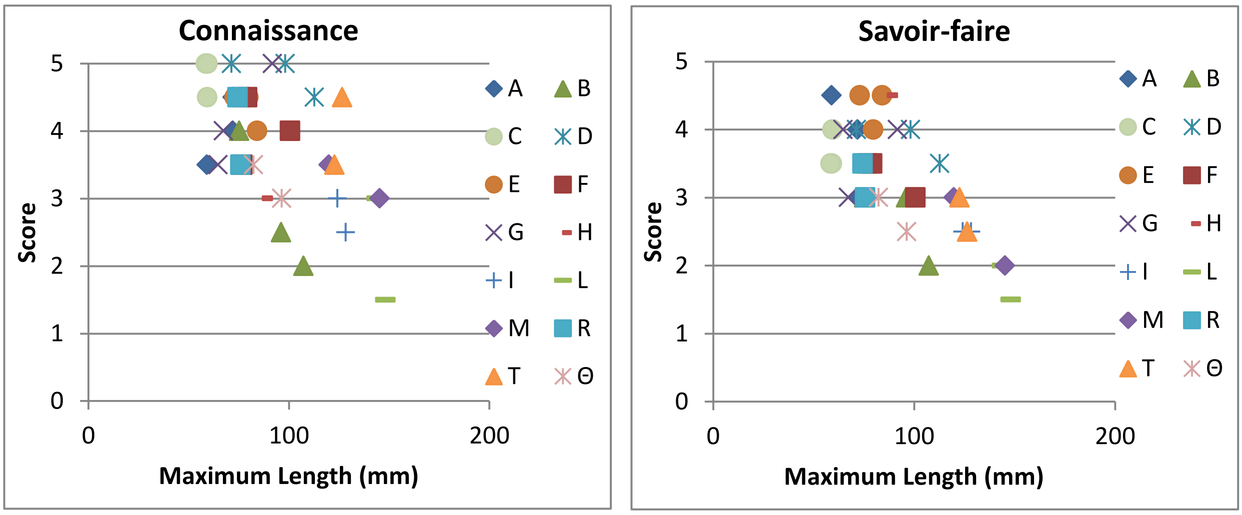


Figure 6.12. Maximum core lengths plotted against scores for connaissance and savoir-faire.

stacked hinge or step fractures and adjust edge angles. As with the handaxe results this suggests that in the earliest stages of learning it may be hard to see skill through efficiency measures.

Maximum Width:

As well as maximum length, maximum width measurements were taken of Levallois cores produced during the evaluations to observe any correlation between this measure and knapper skill level. The average maximum width for each evaluation is shown in Figure 6.13. The results show a slight decrease in width with each successive evaluation for both the core and wider groups, mirroring the results seen for length and suggesting that as skill was gained in the project less wide Levallois cores were being produced.

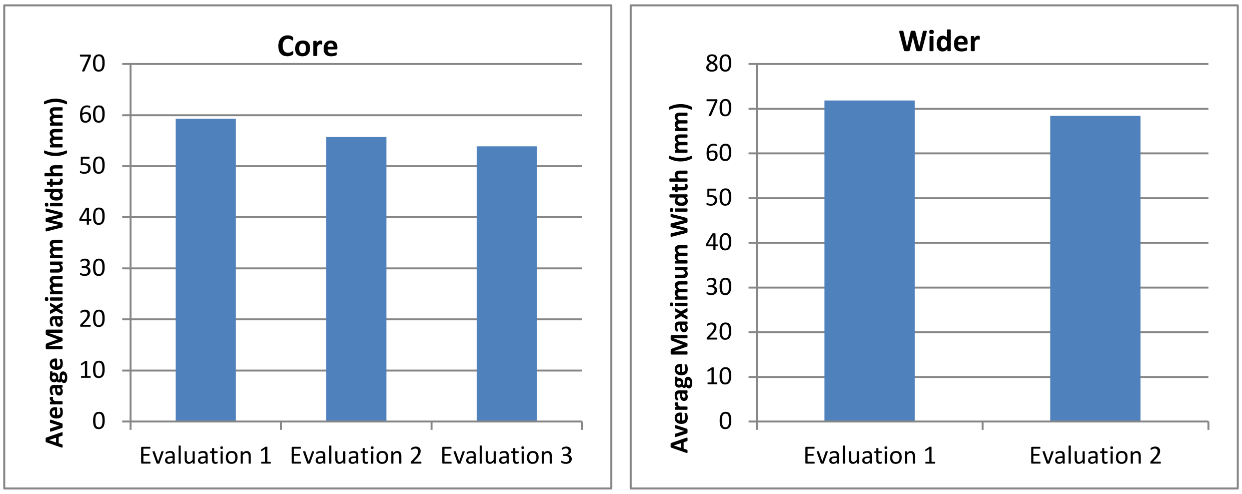


Figure 6.13. Average maximum core widths for core and wider groups for each evaluation.

The width results were plotted against scores for connaissance and savoir-faire for each knapper to observe in more detail the effect of skill on Levallois core width (Fig. 6.14). The results of this show no observable pattern of correlation for connaissance or savoir-faire with width suggesting that this is not a measurement that can be used to indicate skill in this technology. The changes seen in the averages for each evaluation were too small to be statistically significant given the small sample size of knappers. A paired t tests comparing the means of evaluations one and two and two and three revealed p values of 0.549 and 0.815 respectively ($\alpha=0.05$).

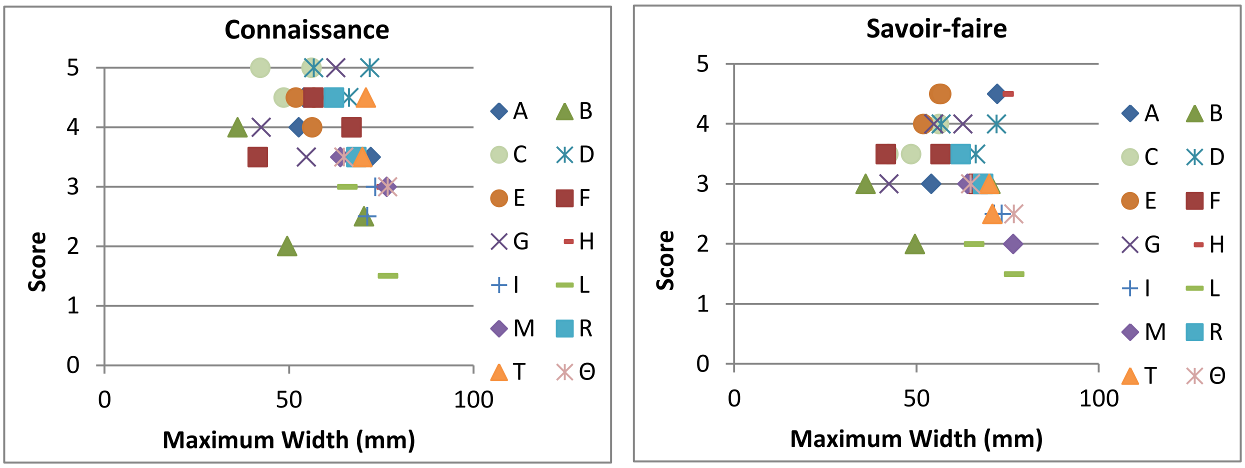


Figure 6.14. Core maximum width plotted against scores received for connaissance and savoir-faire.

Maximum Thickness:

The final dimensional measurement taken was maximum thickness. Thickness of produced tool in biface technology has been shown to be related to knapper skill (Apel 2008, 103). Although Levallois technology does not involve bifacial thinning, Levallois cores are worked on both the dorsal and ventral face making thinness of core a suitable attribute for consideration when assessing effect of knapper skill on core dimensions. The average maximum core thickness for each evaluation was calculated (Fig. 6.15). For the core group this showed an increase in thickness between evaluations one and two followed by a decrease between evaluations two and three, while the wider group showed a slight decrease between evaluations two and three. This suggests that maximum core thickness may not be a good measure of skill in this technology.

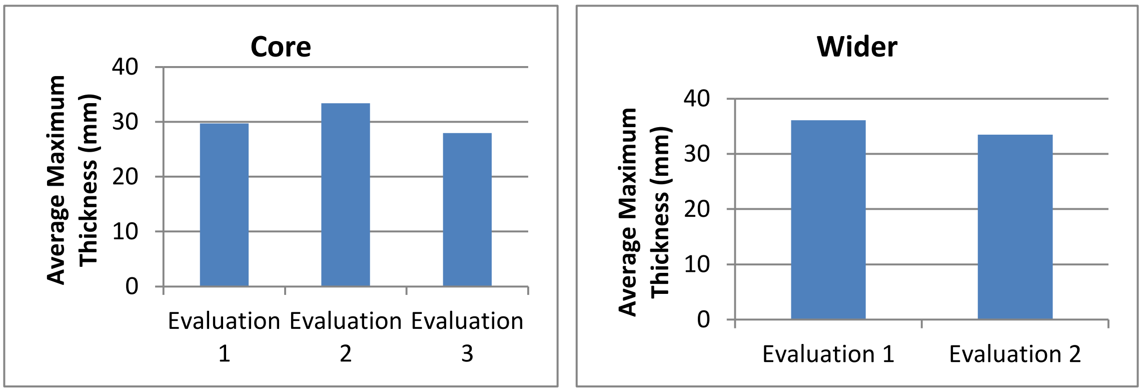


Figure 6.15. Average core maximum thickness for core and wider group in each evaluation.

To look in more detail at how this relates to scores received thickness was plotted against skill scores for connaissance and savoir-faire (Fig. 6.16).

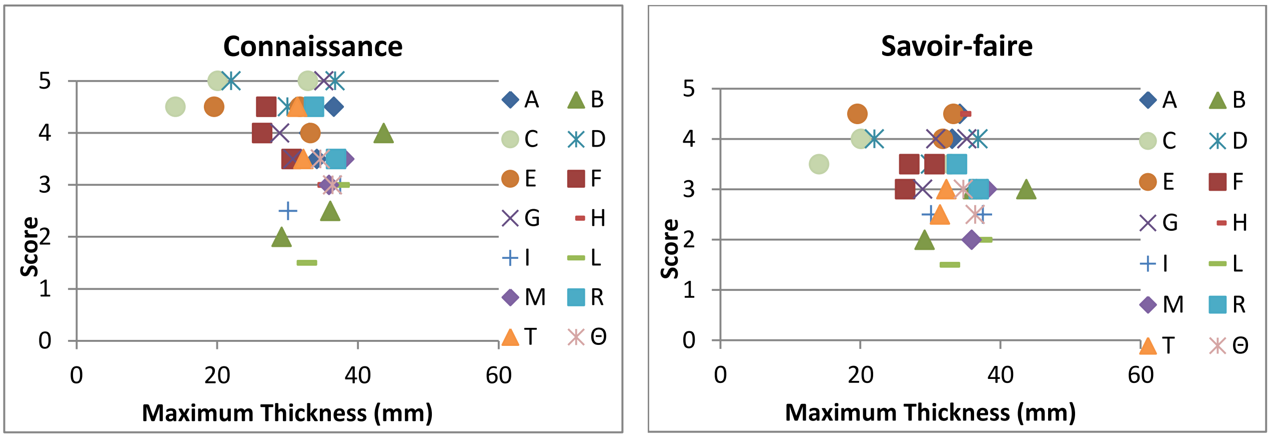


Figure 6.16. Maximum core thickness plotted against scores received for connaissance and savoir-faire.

This showed no strong correlation between skill and maximum core thickness for Levallois technology. This is likely due to knappers being unconcerned with thinning in this technology and, for the most part, retaining much of the original thickness of the pre-core used in the evaluations (average 38mm). It might be expected that a successful preferential flake removal would thin the piece significantly and thus thinner pieces would represent higher skilled performance. This was shown not to be the case, likely due to the high numbers of knappers producing preferential flakes by the second evaluation meaning there was not enough variation to show significant differences in thinness.

Mass (with and without flake):

The final attribute assessed for the Levallois cores produced during the evaluations was mass both with and without the final preferential flake. This was done in the expectation that more skilled knappers would be able to produce a flake at an earlier stage in reduction and thus produce cores with more mass. The average results for each evaluation are shown in Figure 6.17. The results

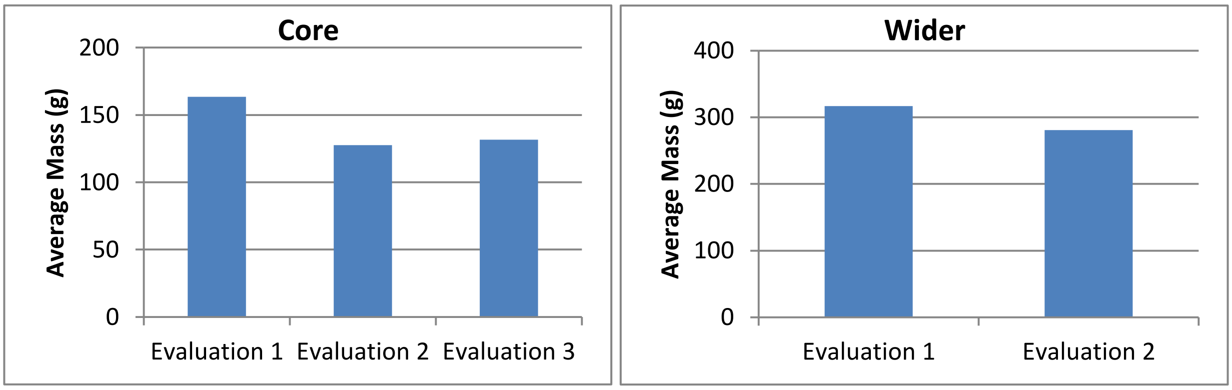


Figure 6.17. Average core mass for each evaluation for core and wider groups.

excluding the final flake mass reveal a sharp drop in core mass from evaluations one to two for the core group, but similar figures for evaluations two and three. The results for the wider group show a slight drop between evaluations one and two. It seemed likely that these results could be explained by the increase in preferential flakes produced by knappers between evaluations one and two – from 50% to 100% for the core group. For this reason the mass including the final flake was considered for those knappers who had produced one (Fig. 6.18). The averages for each evaluation now show a less significant decrease in mass between evaluations one and two, followed by an increase between two and three for the core group.

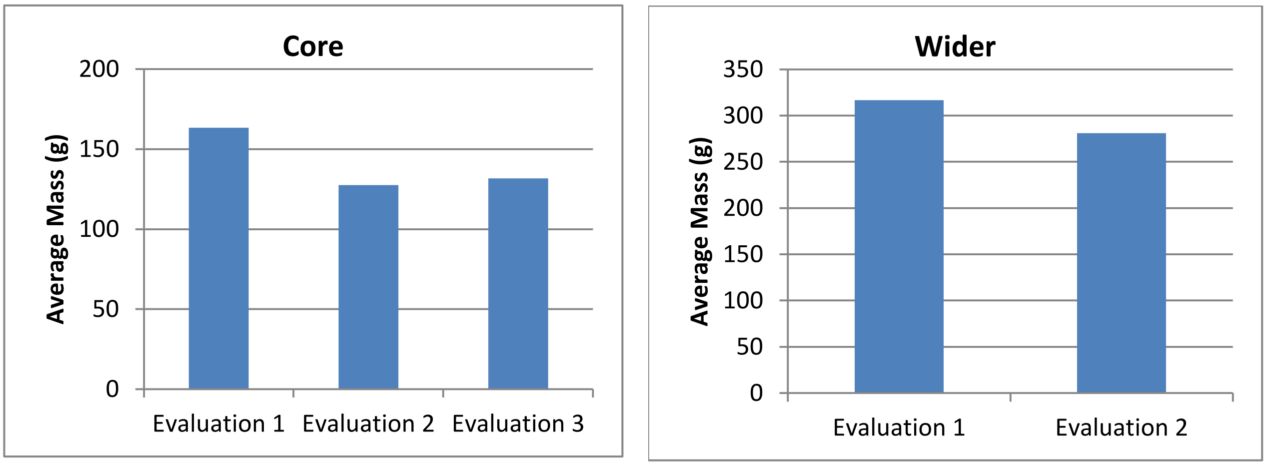


Figure 6.18. Average core mass including preferential flake for core and wider group knappers for each evaluation.

To investigate in more detail how these results relate to the skill level of the knappers, mass including and excluding preferential flake was plotted against scores received for connaissance and savoir-faire (Fig. 6.19). This showed that there is some negative correlation between mass and the scores received for savoir-faire and that this can be seen most clearly when the mass including the final flake is considered. There is no clear pattern of correlation for connaissance score and mass although the knapper who received the lowest score for this area of skill also produced the core with the highest mass. This indicates that knappers with the greatest ability in performing Levallois technology were producing smaller, lighter cores than those with lesser abilities in this area. This is likely due to the more skilled individuals' ability to continue further with the technology and correct errors they had made in the piece rather than simply abandoning it if errors were made at an early stage.

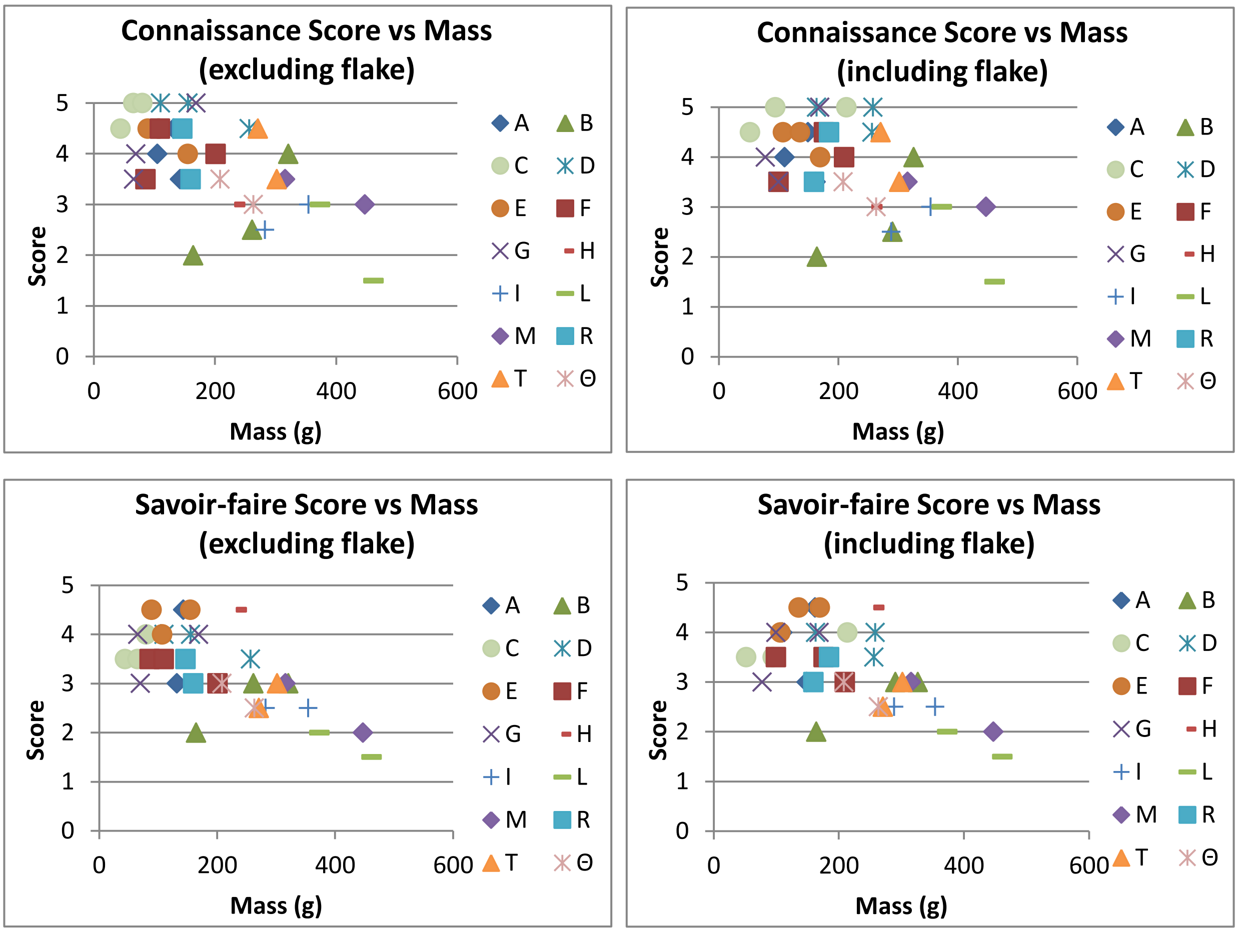


Figure 6.19. Core mass including and excluding preferential flake plotted against scores received for connaissance and savoir-faire.

<u>6.2.6 Flake</u>

Attributes of the preferential flake produced were also analysed. As very few knappers in the wider group succeeded in producing flakes (see presence of preferential flake section above) their results are not considered in this analysis. A large enough number of the core group knappers managed to produce flakes (50% in evaluation one and 100% in evaluations two and three) to allow their data to be analysed.

Maximum Length:

As with the Levallois cores measurements were taken of the preferential flake to observe the effect of skill on certain attributes. It was expected that the more highly skilled knappers would be able to produce longer and wider flakes that covered more of the surface area of the upper surface of the core (ventral) than those produced by less skilled knappers. The average maximum flake length for each evaluation is shown in Figure 6.20. This indicates that there is an increase in average length between evaluations one and two, while the

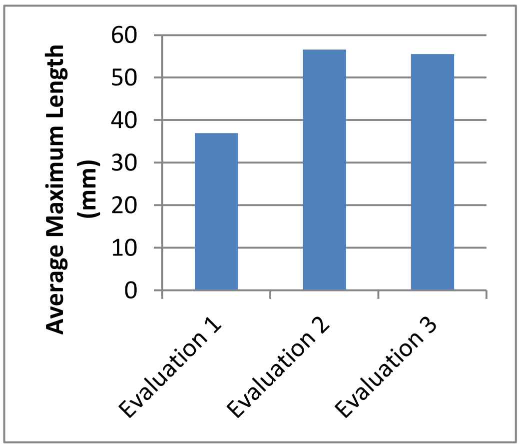


Figure 6.20. Average preferential flake length for each evaluation.

average length for evaluation three is close to the figure for evaluation two. This suggests that flake length is associated with skill with longer flakes produced towards the latter stages of the project.

To investigate in more detail how these figures relate to skill, scores for connaissance and savoir-faire were plotted against maximum flake length for each knapper in each evaluation (Fig. 6.21). The results of this do not suggest a simple picture of increasing flake length with increasing skill. This suggests that other factors may have had an influence on the increased flake length seen between evaluations one and two. This could be due to more practice in other technologies giving knappers the ability to remove larger flakes but doing this by using inappropriate techniques for Levallois, such as platform reduction.

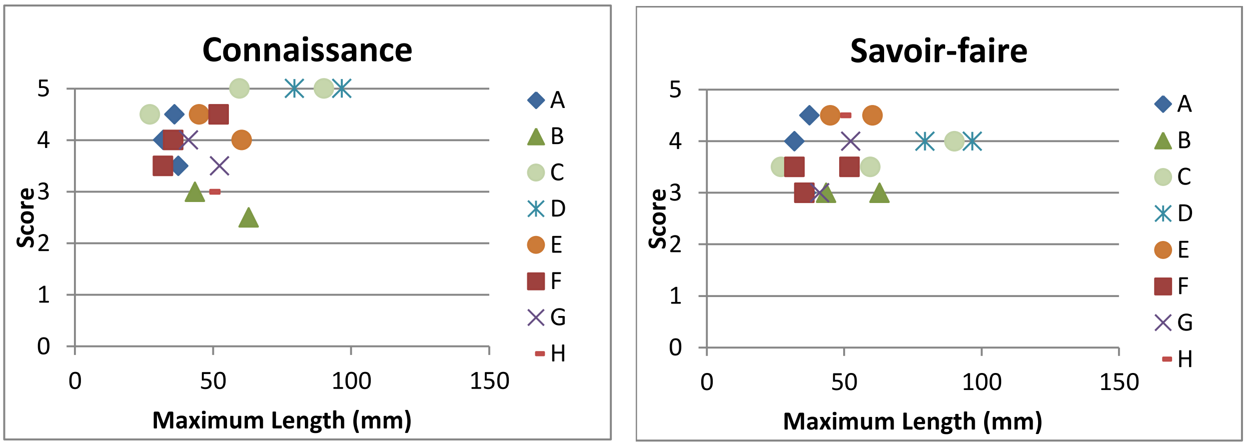


Figure 6.21. Maximum preferential flake length plotted against scores received for connaissance and savoir-faire.

Maximum Width:

As well as maximum length, maximum width measures were taken of preferential Levallois flakes, with the expectation that more skilled knappers would be able to produce wider flakes than less skilled. The average results for each evaluation show similar figures for each evaluation (Fig. 6.22). The slight decrease seen from evaluation one to three is not statistically significant

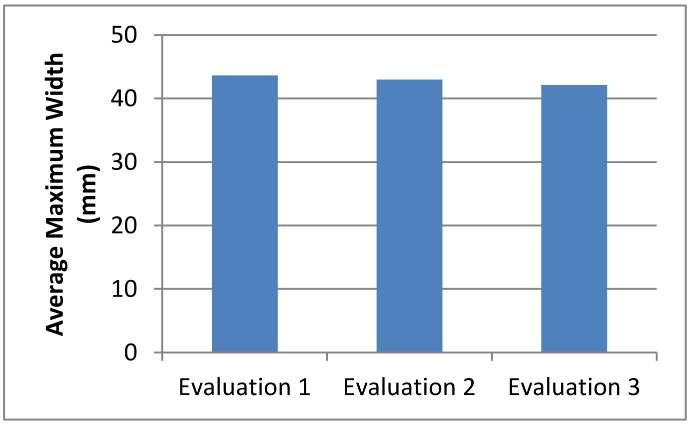


Figure 6.22. Average maximum preferential flake width for each evaluation.

(p=0.405) and this suggests that flake width is not determined by knapper skill. This was also seen in the flaking evaluations. For this reason no further analysis was carried out on maximum width measures

Maximum Thickness:

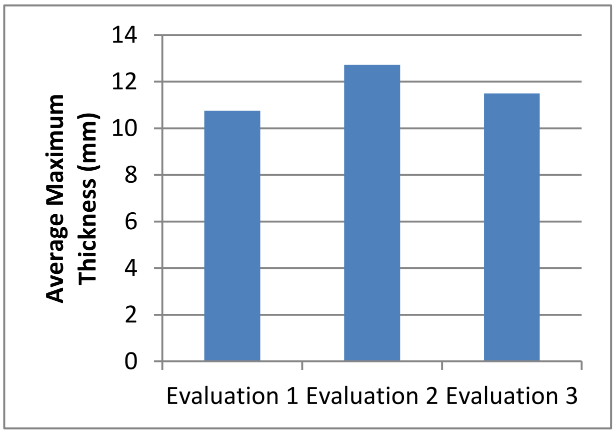


Figure 6.23. Average maximum preferential flake thickness for each evaluation.

Maximum thickness measures were also taken of preferential flakes produced in skill evaluations. The average results for each evaluation were calculated (Fig. 6.23). This revealed an increase in average thickness between evaluations one and two, followed by a decrease between evaluations two and three. This indicates that it is unlikely that preferential flake thickness is an indicator of skill in this technology.

To investigate the relation between flake thickness and skill in more detail, scores for connaissance and savoir-faire were plotted against maximum flake thickness (Fig. 6.24). This suggested some negative correlation between connaissance score and thickness, although with some significant outliers. This indicates that greater understanding of the technology allowed knappers to produce thinner preferential flakes. The outliers seen are overshot flakes that would generally have a thicker profile than flakes with other termination types. There appears to be no similar correlation with savoir-faire score, representing physical ability to carry out the technology.

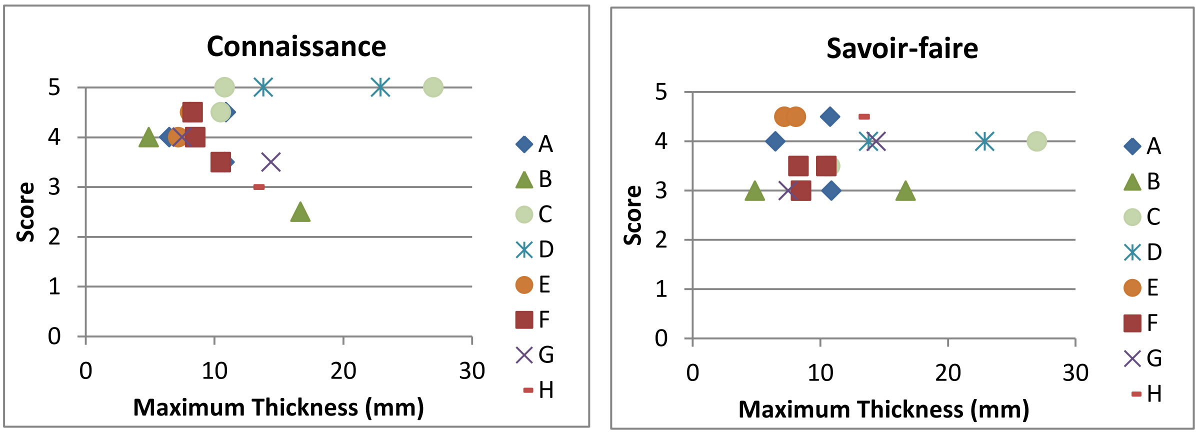


Figure 6.24. Maximum preferential flake thickness plotted against scores received for connaissance and savoir-faire.

Platform Thickness:

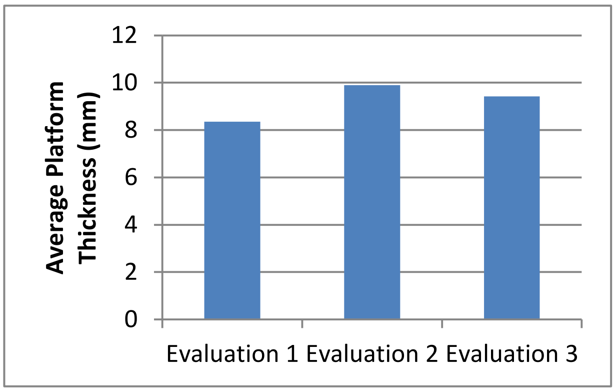
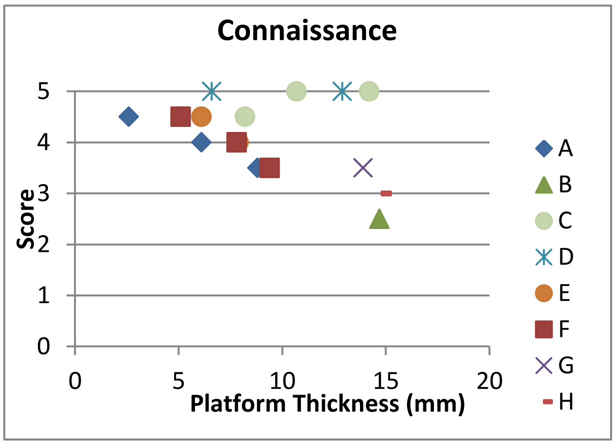


Figure 6.25. Average preferential flake platform thickness for each evaluation.

As well as maximum thickness, platform thickness measurements were taken. This was due to the importance of final platform preparation in this technology (Mithen 1996, 134). As a result of this it was likely that platform shape and form would be an indicator of knapper skill. Average platform thickness for each evaluation was calculated (Fig. 6.25). This showed an increase in thickness between evaluations one and two, followed by a slight decrease between evaluations two and three. This suggests that knapper skill may have some effect on platform thickness.

To look at this in more detail platform thickness measures were plotted against skill scores for connaissance and savoir-faire (Fig. 6.26). The results of this suggest some negative correlation between platform thickness and connaissance score, similar to that seen for maximum thickness discussed above and with the same overshot outliers. Again, similar to the results for maximum thickness there is no corresponding correlation with savoir-faire score. This suggests that the maximum flake thickness and platform thickness are strongly linked and, in part, determined by the skill of the knapper in understanding the concepts of Levallois technology.



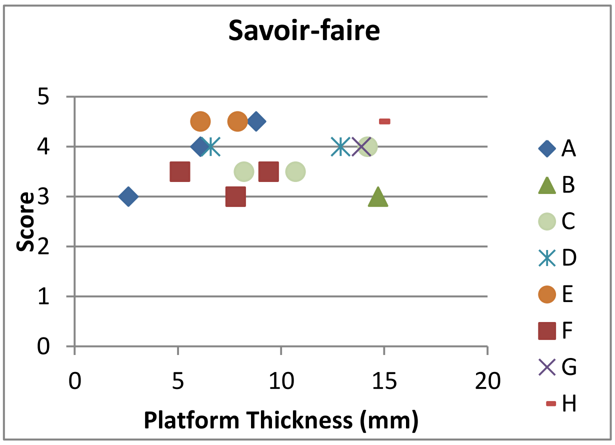


Figure 6.26. Preferential flake platform thickness plotted against scores received for connaissance and savoir-faire.

Termination Type:

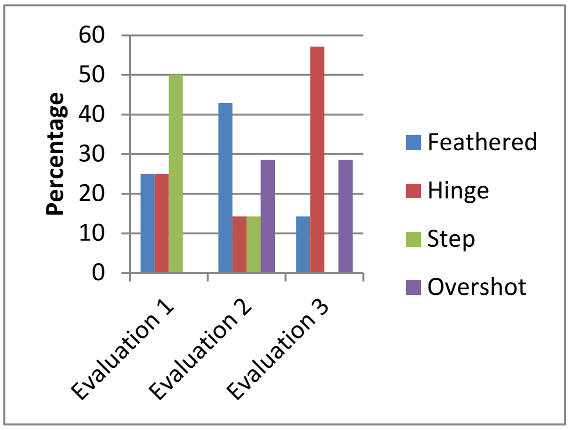


Figure 6.27. Percentage preferential flake termination types for each evaluaton.

Termination type has, in previous work, been strongly linked to knapper skill as hinge, step and overshot terminations are often considered flintknapping errors (Whittaker 1994, 106). In Levallois technology it was considered likely that the termination seen on the preferential Levallois flake would be a product of knapper skill. In this technology a feathered termination is the best outcome for allowing continued removals from the core and in producing a sharp edge all around the distal end of the flake. While an overshot termination would produce a larger flake, it does not have the benefit of this sharp cutting edge all around the surface, a factor that is seen as one of the aims of Levallois reduction(Copeland 1983, 18). For this reason it seemed likely that more highly skilled knappers would produce flakes with feathered terminations. The percentage of feathered, hinge, step and overshot terminations for each evaluation are shown in Figure 6.27. This shows no clear pattern of increasing percentage of feathered terminations, or decreasing percentage of hinge, step and overshot fractures through the project, with only step fractures showing a steady decrease through the three evaluations.

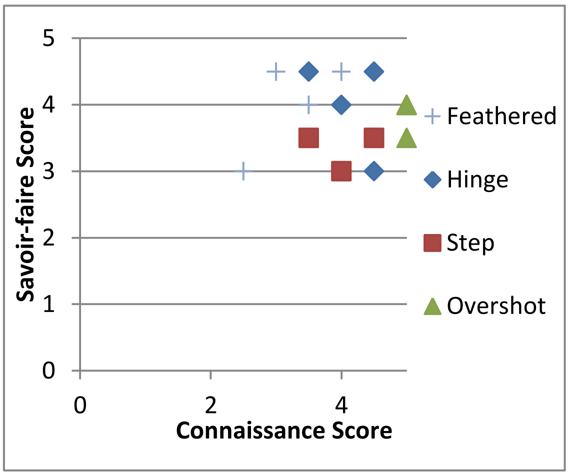


Figure 6.28. Skill scores for each termination type.

In order to observe in greater detail the impact of knapper skill on the termination types produced, the skill scores for connaissance and savoir-faire were plotted for each termination type produced by knappers (Fig. 6.28). This shows no clear pattern of more or less skilled knappers producing any particular termination type. This suggests that either termination type of preferential Levallois flake is not a good indicator of skill in this technology, or none of the knappers reached a level of skill at which they were able to control the termination type they produced in the preferential flake.

Mass:

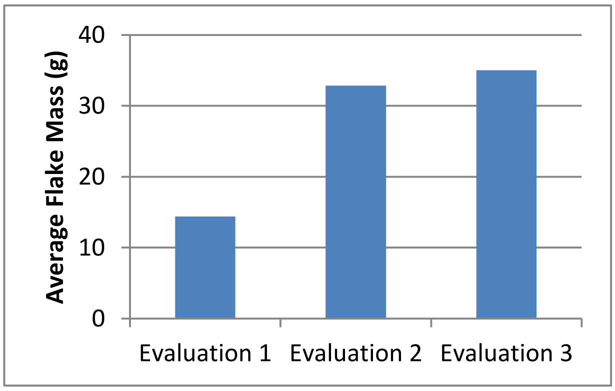


Figure 6.29. Average preferential flake mass for each evaluation.

Mass of preferential flakes was measured as a figure that would give an idea of the size of piece removed. It was expected that, excluding overshot examples, higher skill would be more associated with flakes with larger mass. The average flake mass for each evaluation was calculated (Fig. 6.29). The results of this show an average increase in mass for each evaluation, suggesting that as knappers gained more skills during the project they were producing larger, heavier flakes.

To look at the effect of individual knapper skill on this measure scores for connaissance and savoir-faire were plotted against flake mass (Fig. 6.30). This showed some negative correlation between score for connaissance and mass, if outliers caused by overshot flakes are removed. This suggests the opposite to

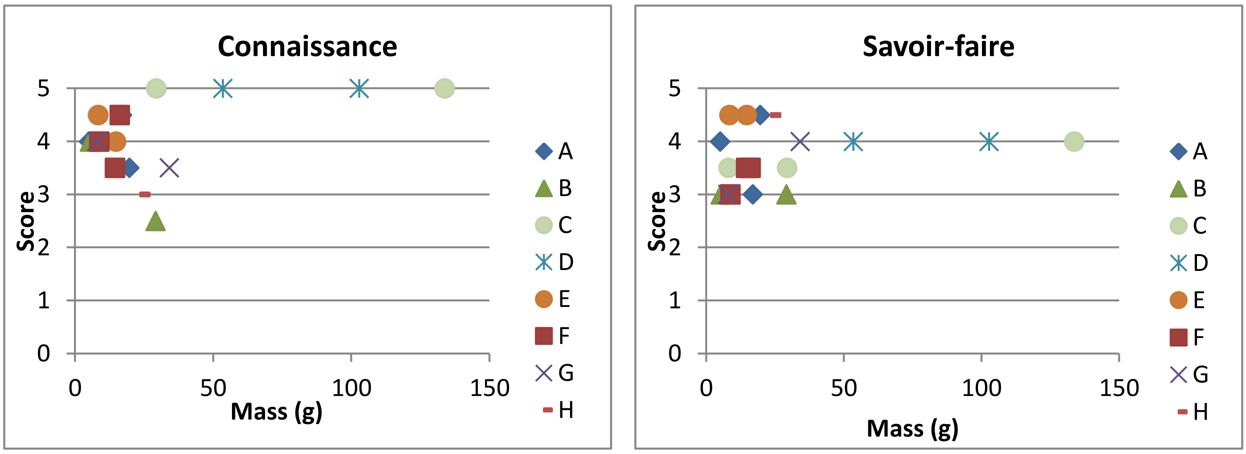


Figure 6.30. Preferential flake mass plotted against scores for connaissance and savoir-faire.

the expected result – knappers with greater understanding of the concepts of Levallois were producing smaller, lighter flakes. The scores for savoir-faire do not show the same correlation.

An explanation for these results could be that knappers with greater understanding of Levallois technology were more focussed on correctly setting up the dome for the final removal and created rounded cores, rather than elongated pieces (Fig. 6.31). A rounded core would likely result in a smaller flake than an elongated one, resulting in the patterns seen in the mass measurements.

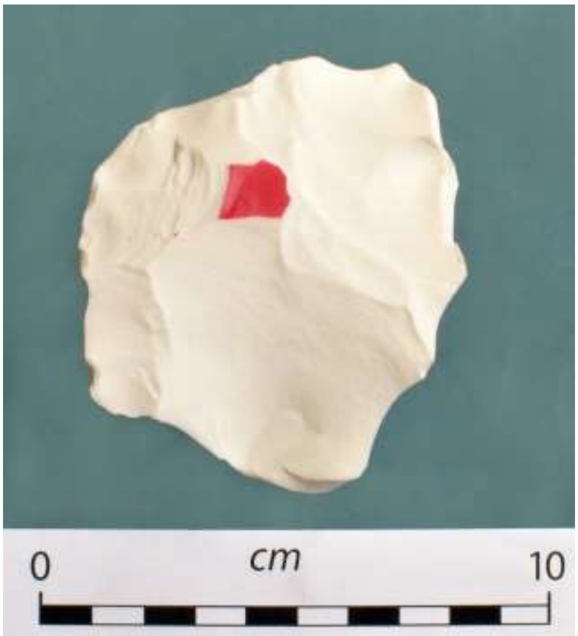


Figure 6.31. An elongated core produced by a less skilled knapper (left) and a rounded core produced by a knapper with a greater level of skill (right). (Photos: Whitlock 2013)

Surface Area of Core Covered:

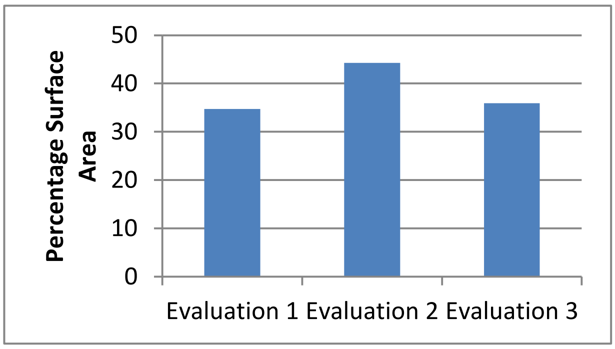
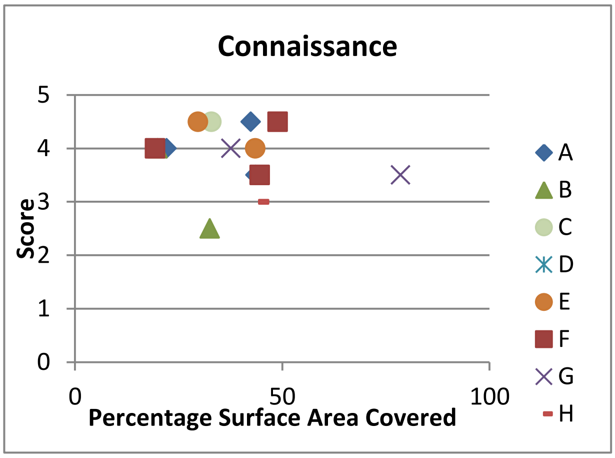


Figure 6.32. Average percentage of surface area of core covered by preferential flake for each evaluation.

While the intentions of the original Levallois manufacturers are unknown, one aim that has often been hypothesised as significant is the creation of a flake that covers as much of the surface area of the original core as possible without overshooting at any point (Eren et al. 2011, 231). For this reason the percentage of the original core surface that the Levallois flake covered was calculated. The expectation was that, as skill increased, knappers would be able to remove flakes that covered a greater percentage of the original core surface area. The average percentage for each evaluation, excluding overshot flakes, is shown in Figure 6.32. This shows an increase in surface area covered between evaluations one and two, followed by a decrease between evaluations two and three. This suggests that the increased skill of knappers between evaluations one and two may have been responsible for an increase in surface area covered by preferential flake, but a lack of additional practice hours between evaluations two and three for the majority of knappers may have caused loss of ability reflected by less surface area coverage.

To look in more detail at the effect of individual knapper skill, scores for connaissance and savoir-faire were plotted against surface area of core covered by preferential Levallois flake (Fig. 6.33). This shows no clear pattern of correlation between knapper skill and percentage surface area covered. This suggests that the relationship between this measure and skill is more complicated than initially thought and factors other than skill contribute to it, such as the aims of the knapper or the influence of practice of other technologies.



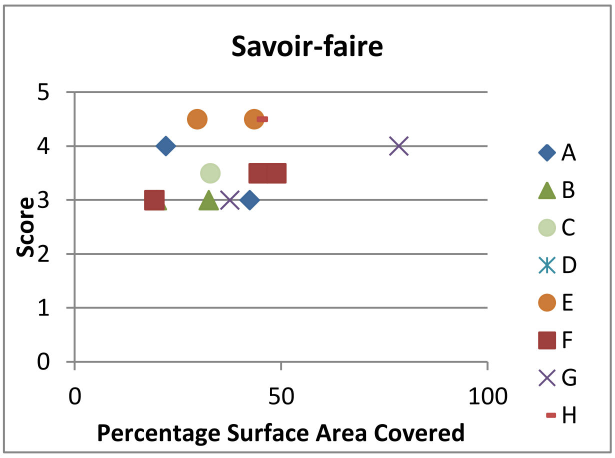


Figure 6.33. Percentage of core surface area covered by preferential flake plotted against scores received for connaissance and savoir-faire.

6.2.7 Debitage

As well as core and flake measures debitage attributes were analysed to observe the effect of skill. In many cases debitage would be the only evidence of Levallois technology as debitage forms the majority of lithic material found in archaeological contexts (Odell 2003, 118). For this reason, to be able to usefully apply skill measures seen in this experimental work to the archaeological record, it is necessary to identify debitage features that can indicate skill level.

Mass and Number of Flakes:

As mentioned in the handaxe chapter, efficiency measures are sometimes used to indicate knapper skill level. If these measures are applicable to Levallois technology you would expect to see more skilled knappers producing successful Levallois flakes by taking fewer, larger flakes than less skilled knappers. To investigate whether this measure could indicate knapper skill in Levallois technology the number of flakes produced per 100g of debitage for each knapper was calculated. The average results for each evaluation are shown in Figure 6.34. This shows an increase in number of flakes per 100g of debitage for the core group between evaluations one and two, followed by a decrease between evaluations two and three suggesting that this measure cannot be looked at simply in terms of improvement through time. The wider group in contrast show a clear decrease from evaluation one to two and a higher number of flakes per 100g than the core group for both evaluations, suggesting that the increased training and practice performed by the core group did have an effect on number of flakes produced.

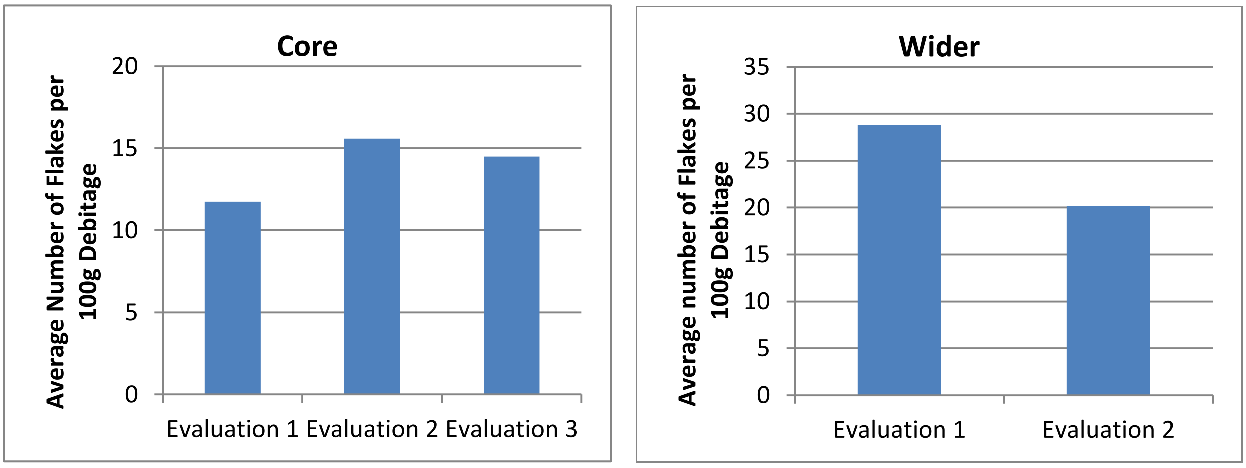


Figure 6.34. Average number of flakes per 100g debitage for core and wider groups for each evaluation.

To look in greater detail at the effect of individual knapper skill on this measure, scores for connaissance and savoir-faire were plotted against number of flakes per 100g (Fig. 6.35). This showed better correlation for savoir-faire score than for connaissance score, with high savoir-faire scores more associated with smaller numbers of flakes per 100g of debitage. This suggests that physical ability determines the efficiency of reduction in this technology, while understanding of the concepts does not.

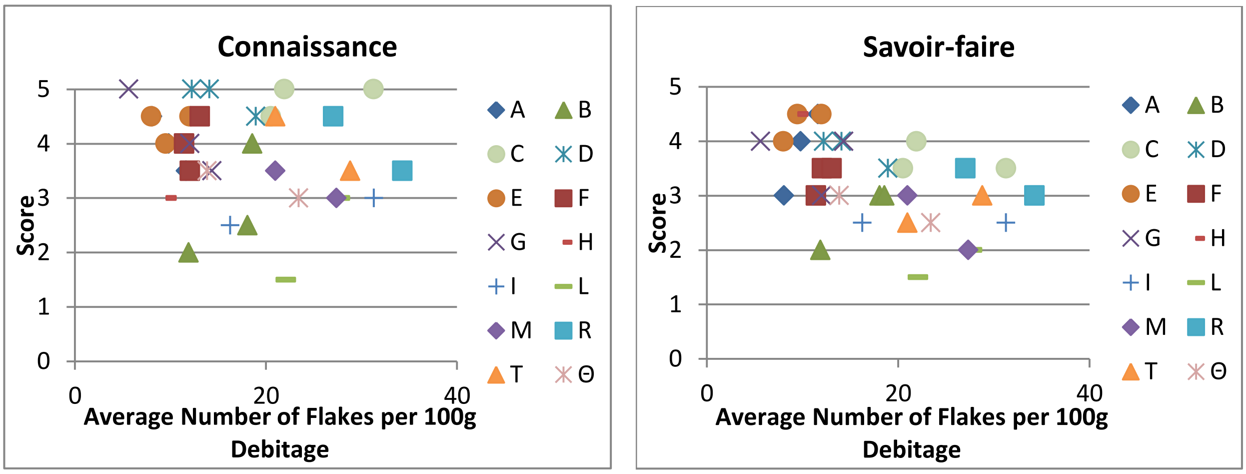


Figure 6.35. Number of flakes per 100g debitage plotted against scores received for connaissance and savoir-faire.

Termination Type:

Along with efficiency measures, termination type has often been used to indicate knapper skill, with hinge, step and overshot terminations associated with knapper error (Bamforth & Finlay 2008, 6). Average percentages of each termination type were calculated for each Levallois evaluation (Fig. 6.36). This revealed that, for the wider group, the percentage of feathered flakes compared with hinge/step terminations increased in the second evaluation, as would be

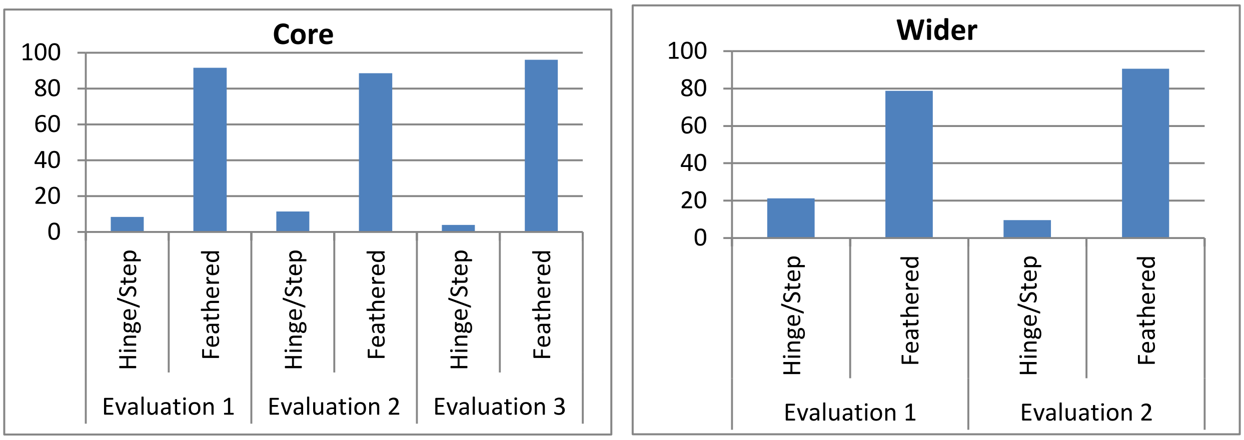


Figure 6.36. Average percentages of termination types for each evaluation.

expected if skill increase reduced knapping errors. The picture for the core group is slightly different, with a similar but a slightly lower percentage of feathered terminations for the second evaluation compared with the first, followed by a higher percentage for the final evaluation. This suggests that percentage of feathered flakes may be increased with increasing skill although skill in the core group in specifically Levallois technology did not increase dramatically between evaluations one and two.

To look at this factor in more detail percentage of feathered and hinge/step fractures were plotted against scores received for connaissance and savoir-faire (Fig. 6.37). This revealed no clear pattern of correlation with connaissance score but some correlation with savoir-faire skill. This suggests that percentage of feathered flakes produced can be related to knapper skill level and the area of skill that this falls under is physical ability in Levallois technology. It is not possible, however, to simply equate a flake with a hinge or step termination with the work of an unskilled knapper. All knappers produced at

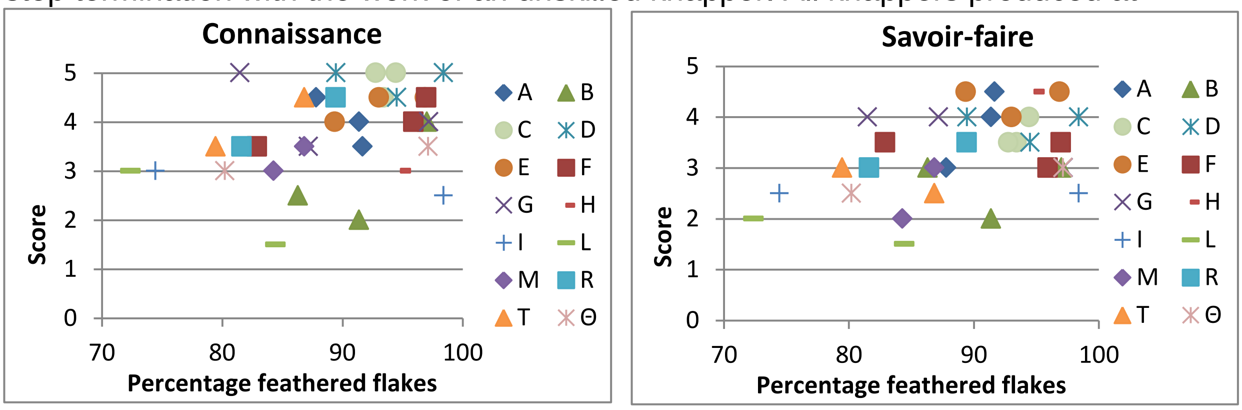


Figure 6.37. Percentage of flakes with feathered terminations plotted against scores received for connaissance and savoir-faire.

least one hinge or step fracture in each evaluation they performed. This highlights the importance of analysing complete reduction sequences in the archaeological record, in cases where this is possible, as it was comparisons of numbers of feathered to hinge and step fractures that gave indications of skill level.

Dorsal/Ventral Counts:

Levallois technology involves the working of the dorsal and ventral surface of a core. While both sides are flaked, they are also treated differently, with flakes from the dorsal surface taken to prepare ridges to take doming removals from the ventral surface. This different treatment causes different numbers and mass of dorsal and ventral removals to be taken and counts of dorsal and ventral flakes have been shown to relate to knapper skill level (Eren et al. 2011, 242–4). In the analysis of evaluation materials dorsal and ventral flakes were identified by presence of the coloured outer surface of the pre-core on the flake's dorsal face. Average percentage of each type for each evaluation is shown in Figure 6.38. This shows a clear distinction between the results seen for the core and wider groups. The core group show similar percentages for dorsal and ventral flakes in the first and third evaluations (around 65% dorsal and 25% ventral), with a slightly lower percentage of both for the second evaluation (and thus a higher percentage of unidentified flakes). The wider group, on the other hand, show a higher percentage of ventral than dorsal flakes in both evaluations and a higher percentage of both types in the second compared to the first evaluations (and thus a lower percentage of unidentified flakes). Since the core group consistently received higher skill scores than the

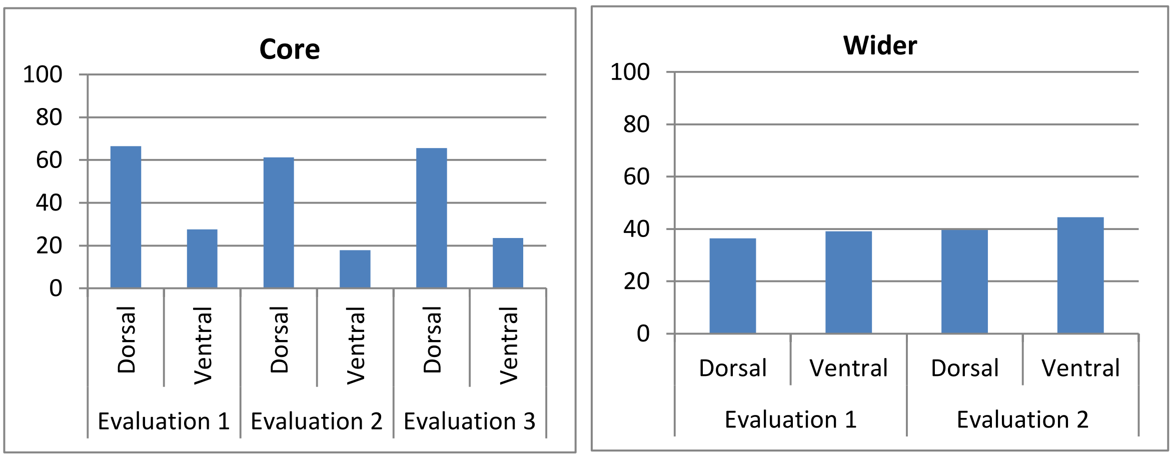


Figure 6.38. Average percentage of dorsal and ventral flakes for core and wider groups for each evaluation.

wider group, partially as a result of a greater number of taught and practice hours, this suggests that a lower percentage of ventral flakes compared with dorsal is representative of greater skill in this technology.

To observe how well this result is reflected in individual scores, percentages of dorsal and ventral flakes were plotted against skill scores for connaissance and savoir-faire (Fig. 6.39). This revealed that there was some correlation between skill and percentage of dorsal flakes produced and some negative correlation between skill and percentage of ventral flakes. The area of skill that shows the strongest correlation is savoir-faire, suggesting that high physical ability in this technology allows a knapper to produce a successful dome with fewer ventral removals compared with the number of dorsal removals. It also seems likely that the association of larger percentage of dorsal removals with higher skill reflects the need to create ridges all the way around the core to allow the successful creation of a dome without excessive flaking from the ventral surface. Again, as with termination type analysis, this indicator of skill could only be identified by analysing the results of a reduction sequence, rather than individual flakes. Eren et al. (2011) carried out similar analysis looking at the ratio of the mass of dorsal and ventral removals, finding some

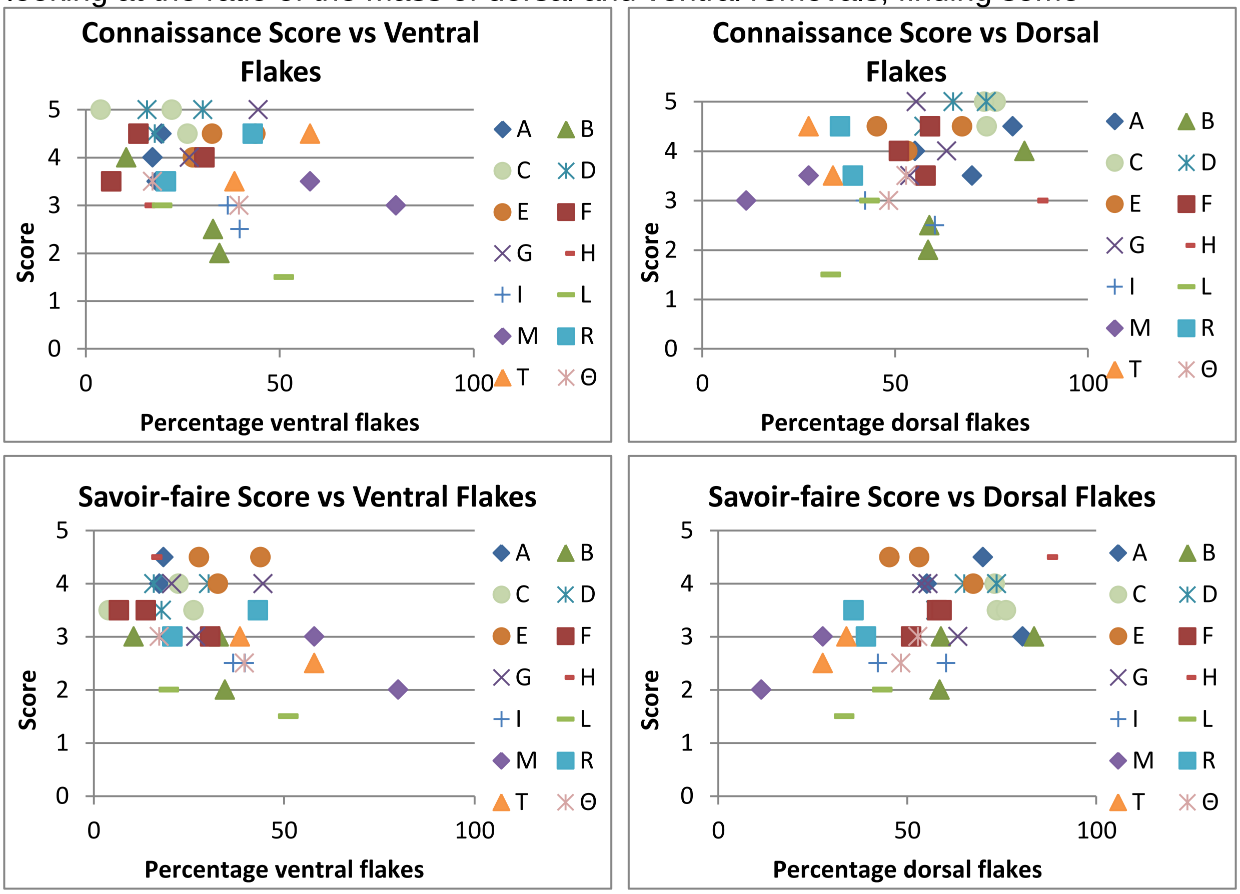


Figure 6.39. Percentage of dorsal and ventral flakes plotted against scores received for connaissance and savoir-faire.

indications that less mass of dorsal removals was produced with greater skill levels while mass of ventral removals rose. The flake percentages in this analysis suggest the opposite picture with fewer ventral and more dorsal removals with higher skill levels.

Platform Type:

The final flake attribute that was analysed was platform type. The ability to adjust platform angles by preparation has been identified as a technique that novices are often unaware of, especially as concerns discerning the situations in which preparation is appropriate (see Skill in Acheulean Handaxe, Chapter Five). As platform preparation errors were some of the most commonly produced during the skill evaluations it was thought likely that amount of platform preparation would be a good indicator of skill in this technology. One way to identify platform preparation from debitage is the type of platform seen in flakes. Flakes were assigned three platform types flat, facetted and undetermined (which included missing platforms).

In Levallois technology platforms for dorsal and ventral removals are treated differently. Dorsal removals often need no preparation whereas ventral flake platforms may need faceting to adjust to a suitable angle to create a domed flake. For this reason platform types were considered for dorsal and ventral flakes separately to observe any differences in occurrence that could be related to skill. The averages for each type for each evaluation are shown in Figure 6.40. This shows for the dorsal flakes, similar figures for each of the evaluations for the core group but, as with the dorsal/ventral flake counts, a clear distinction from the percentages seen for the wider group. The core group produced on average over 90% flat platform dorsal flakes for each evaluation, whereas for the wider group the figure was closer to 50% for both evaluations. Ventral flakes show a similar difference between core and wider group figures, although with less separation, with the core group producing over 80% faceted flakes for each evaluation and the wider group below 70%. This suggests that platform type may be a strong indicator of skill in this technology as the wider group consistently received lower skill scores for Levallois.

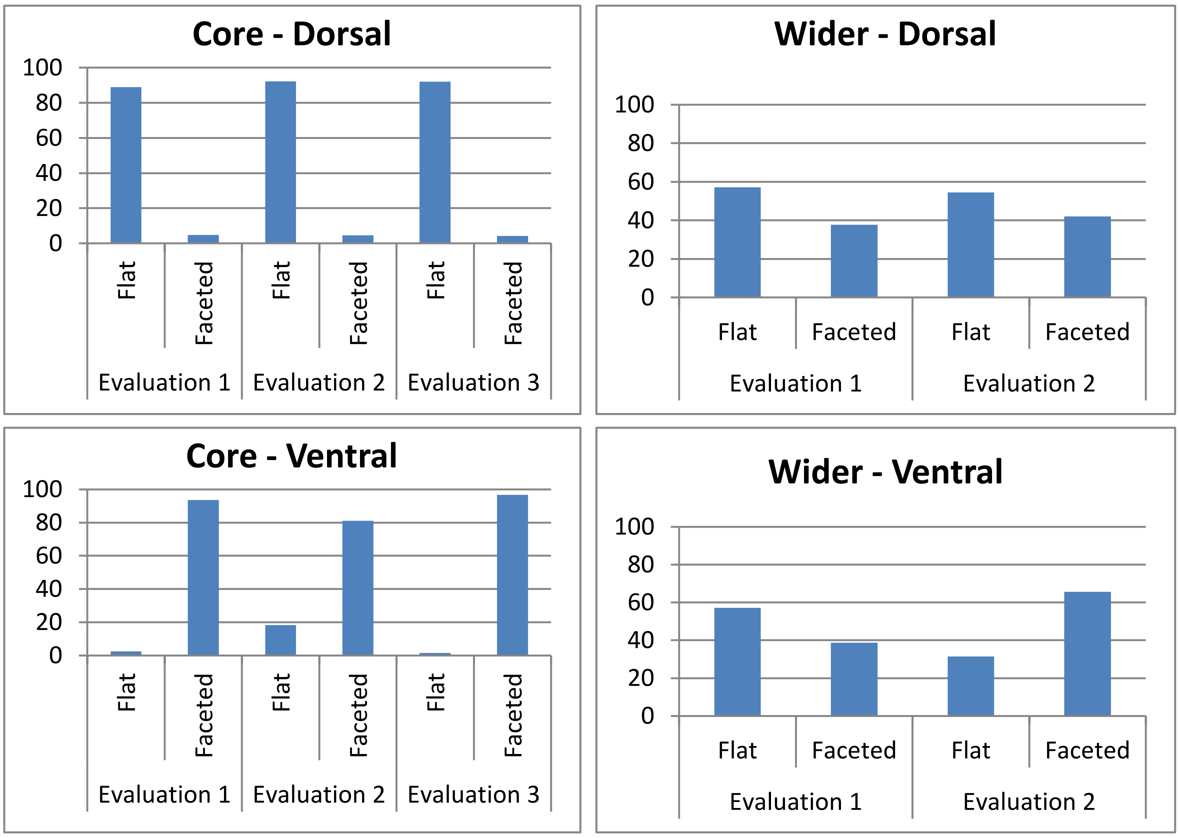


Figure 6.40. Percentages of flat and faceted platforms for dorsal and ventral flakes for each evaluation.

To investigate in more detail the links between skill and platform type, percentage types for dorsal and ventral flakes were plotted against scores for skill (Fig. 6.41). This showed that for both dorsal and ventral flakes there is some correlation with skill. In both cases this is most apparent with savoir-faire skill scores. This suggests that it was knappers' physical ability in Levallois technology that determined whether or not they prepared platforms, more than their understanding of the technology. Percentages of different platform type are good indicators of knapper skill. However, this is only a useful measure of skill if flakes can be assigned to the original surface they were removed from as a high percentage of flat platform dorsal flakes are an indicator, whereas a low percentage of flat platform flakes show this for ventral flakes. As with the termination and dorsal-ventral count data this can also only be applied if complete reduction sequences are considered rather than individual flakes.

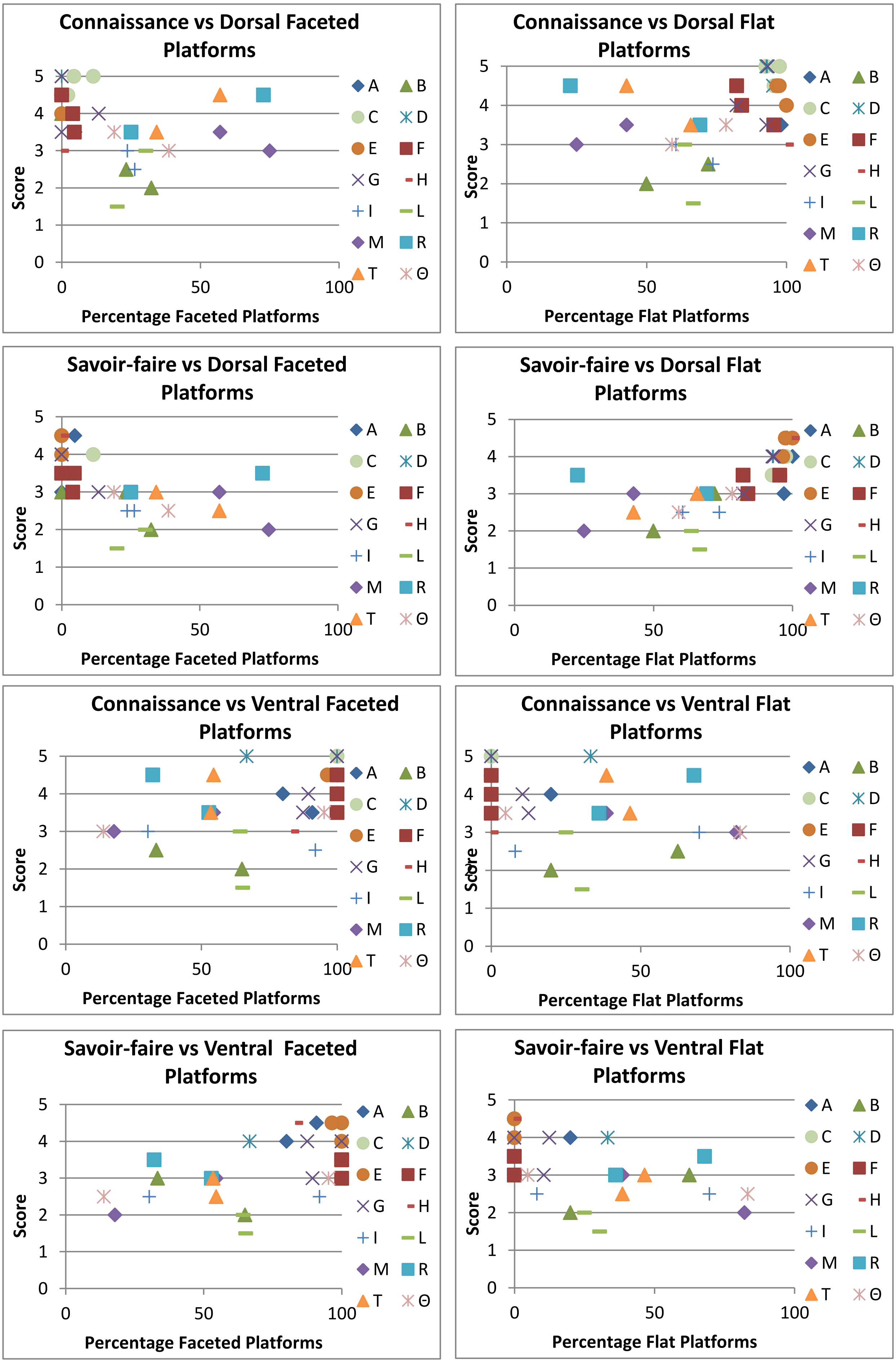


Figure 6.41. Percentages of dorsal and ventral flat and faceted platforms plotted against connaissance and savoir-faire scores.

6.3 Discussion

The results of the Levallois evaluation analysis reveal a more complex picture than was seen in the handaxe or flaking evaluations. This may in part be due to a lower level of attendance of taught sessions and fewer practice hours carried out by knappers. The fact that none of the knappers, even those who performed a reasonable level of practice, achieved a score of five for savoir-faire highlights the fact that this technology was not mastered by the group in the same way as simple flaking and, to a lesser extent, handaxe technology were. This gives an indication of the possible importance of teaching and practice in allowing a high level of skill in Levallois production to be achieved, suggesting that the training provided in the project was not enough to allow knappers to achieve a high level of skill. In this technology it does not appear to be as important as for handaxe that teaching be technologically focussed, although this does have an affect (Fig. 6.6). Practice, on the other hand, did not show any better results for savoir-faire if only Levallois results were considered compared with all technology types (Fig. 6.8). This suggests that the physical abilities needed for Levallois can be gained by practicing any knapping techniques, the concepts that lie behind it, however, appear more difficult to master. One area in which Levallois is similar to the previously discussed technologies is in the fact that initial skill level varies extremely between individuals. Skill scores in the first evaluation varied widely, even among those individuals who had similar practice and teaching times. This suggests that natural aptitude plays a part in determining initial skill in this technology, discussed in more detail in the Chapter Seven.

One way this technology differs from the Oldowan and handaxe technologies is the ways in which connaissance and savoir-faire areas of skill were acquired during the project. In simple flaking and handaxe evaluations skill in connaissance generally increased sharply between evaluations one and two and remained stable after this point, while savoir-faire skill was more variable with loss as well as gain of ability through the three evaluations. In Levallois technology these results are, to some extent, reversed with savoir-faire scores showing fairly consistent increases through the three evaluations, while connaissance scores vary quite widely, with one knapper (A) steadily losing ability in this area through the three evaluations (Fig. 6.1). It is likely that this result stems from the more complex nature of this technology compared to the other techniques. In flaking and handaxe technologies it was the physical skills that knappers had most difficulty mastering. In Levallois it was the complex scheme of removals that required different treatment for the dorsal and ventral surfaces and careful platform preparation for the final flake removal. This picture is backed up by the results of the error analysis that show platform preparation errors and flake positioning among the most common of those performed by knappers, areas that can be linked with strategic planning of removals. The limits on the connaissance skill the knappers achieved must also have an impact on the savoir-faire levels reached by knappers. Unlike in handaxe and Oldowan style flaking, no knapper in the project achieved a score higher than 4.5 for physical ability. Lack of full understanding of the concepts that lie behind Levallois technology likely prevented knappers from achieving their full potential in this technology, highlighting the links between connaissance and savoir-faire abilities.

In the material analysis for the Levallois evaluations it also became clear that different areas of skill were represented by different features of the cores flakes and debitage. Flake maximum thickness and platform thickness most strongly correlated with connaissance skill (Figs. 6.24 & 6.26) while core mass, maximum length and debitage platform type most strongly correlated with savoir-faire skill (Figs 6.12, 6.19 & 6.41). This suggests that the form and platform type of the preferential Levallois flake is most reliant on a knapper's understanding of how to carry out this particular technology, whereas the form of the core and debitage can be achieved based on knowledge of principles of knapping but without specific Levallois knowledge. This is useful as it offers a way to distinguish a knappers' ability in connaissance from savoir-faire. Achieving this can be difficult based on material evidence alone.

One of the aims of this research was to identify different skill levels based on the performance of knappers and the materials they produced during skill evaluations. Skill levels are based on the work of Lohse in this area (discussed in skill in Oldowan technology chapter) and take into account levels of connaissance and savoir-faire seen in knappers performance (Lohse 2010, 159). Five different skill levels were identified from the knapping performance for Oldowan style flaking and Acheulean handaxe evaluations (see previous

Chapters Four and Five). For Levallois flaking the same five levels could be identified in the scores the knappers received, but two knappers received scores that were not covered by the previously identified categories as they received moderate scores for connaissance and high scores for savoir-faire. This was not seen in earlier technologies and for this reason a new category was assigned to this occurrence – adept naturals. This level represents knappers who have high physical knapping skills but only a medium level of understanding of the specific technology. Individual knapper progression through these skill levels varied widely (Table 6.3).

Knapper	Skill Level Progress		
A	Crafter	Experienced	Adept Natural
B	Beginner	Adept	Crafter
C	Crafter	Experienced	
D	Crafter	Experienced	
E	Experienced		
F	Crafter	Adept	
G	Experienced	Adept Natural	Crafter
H	Novice Natural		
I	Adept	Beginner	
L	Adept	Beginner	
M	Adept		
R	Adept	Crafter	
T	Adept	Crafter	
Θ	Adept		

Table 6.3. Individual knapper progression through different skill levels.

Levallois technology appears to be more sensitive to loss of ability than the previously analysed technologies with a number of knappers receiving lower skill levels in the latter evaluations than they had received in earlier evaluations. This probably is a result of decreased time practicing the technology and spent in taught Levallois sessions.

In order to apply this information to the archaeological record the visibility of the identified skill levels in physical aspects of the material produced during knapping must be evaluated. For the Levallois cores and flakes produced during evaluations the material attributes that were shown to be most influenced by knapper skill were core maximum length, core mass including the preferential flake, flake maximum thickness and platform thickness. When core

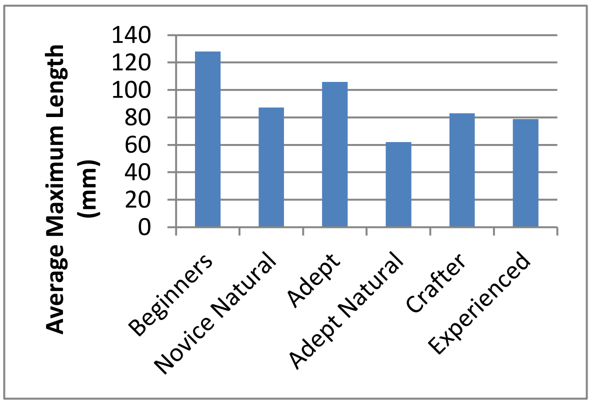


Figure 6.42. Average maximum core length for each skill level.

maximum length averages for each level are considered it can be seen that for each successive level, with the exception of the natural categories, the average length decreases (Fig. 6.42). The results of this suggest that maximum length is a suitable indicator of skill but it is likely that it is possible to identify only three categories: beginners; adepts; and a skilled knapper category that covers crafter and experienced levels and those with natural knapping ability. There is, however, significant overlap between the groups and it may be that it would only be possible to identify skill level from this measure by looking at a range of an individual knapper's work and taking average measurements. This type of measurement is also very sensitive to the initial size and shape of raw material used by a knapper. Core mass is also linked to initial raw material shape and size. The average results for each skill level of this measure show a similar decrease with each successive skill level if natural ability groups are excluded (Fig. 6.43). Based on this measure, however, it seems likely that only two skill groups would be identifiable due to the high level of overlap seen in the results and the small differences in averages, one comprising beginners, novice natural and adept groups and the other adept natural, crafter and experienced groups.

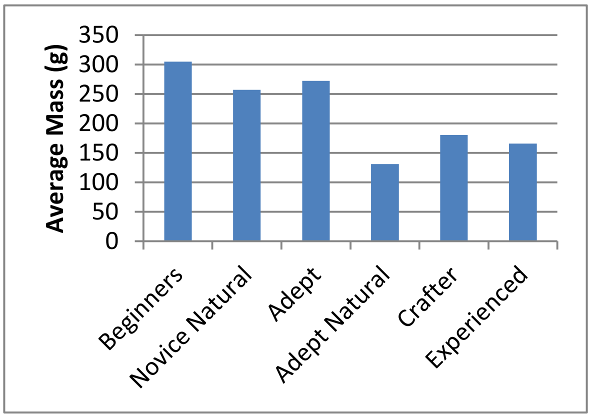


Figure 6.43. Average core mass for each skill level.

The measures of the preferential Levallois flake that show the most significance for identification of skill are flake thickness and platform thickness. These factors are less directly affected by initial raw material size and shape than core maximum length and mass and so may be more useful indicators of skill level. The average results for flake maximum thickness for each skill level

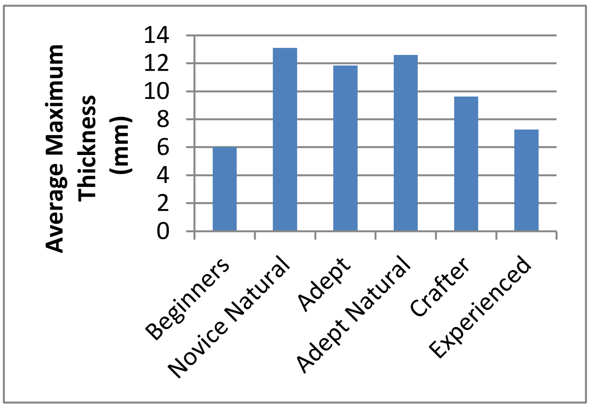


Figure 6.44. Average maximum preferential flake thickness for each skill level.

(excluding overshot flakes) are hampered by the low sample size due to low production levels of Levallois flakes in the wider group. The results, however, show some distinction between individual skill levels (Fig. 6.44). If beginner and novice natural groups are discounted (due to each category including only one result) it seems likely from these results that three skill groups can be identified based on flake maximum thickness – adept (comprising adept and adept natural), crafter and experienced. A flake attribute that was shown to be a good indicator of skill was platform thickness. The average results for each group show, if natural ability categories are excluded, a steady decrease in average platform thickness with each successive skill level (Fig. 6.45). This suggests that platform thickness is a good indicator of skill level. It seems likely from these results that three skill levels can be identified: beginners (comprising beginners and novice naturals), adepts (comprising adepts and adept naturals) and skilled (comprising crafters and experienced groups). As with the previous skill markers there is overlap in the results of the preferential flake material attributes between each group so assessment based on a range of a knapper's work would more successfully identify skill than assignment based on a single flake.

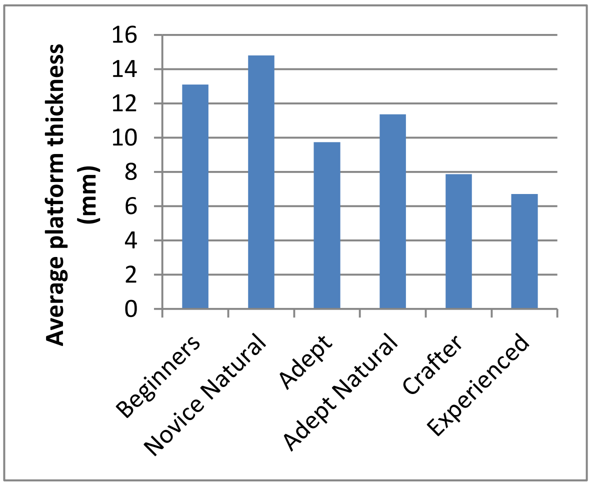


Figure 6.45. Average preferential flake platform thickness for each skill level.

As well as identifying markers on finished flakes and cores that can identify skill level it is also important that debitage attributes be considered, as debitage forms the majority of flaked stone assemblages (Odell 2003, 118). The debitage attributes that showed the influence of skill most clearly were (1) percentages of dorsal and ventral flakes and (2) flake platform type for dorsal

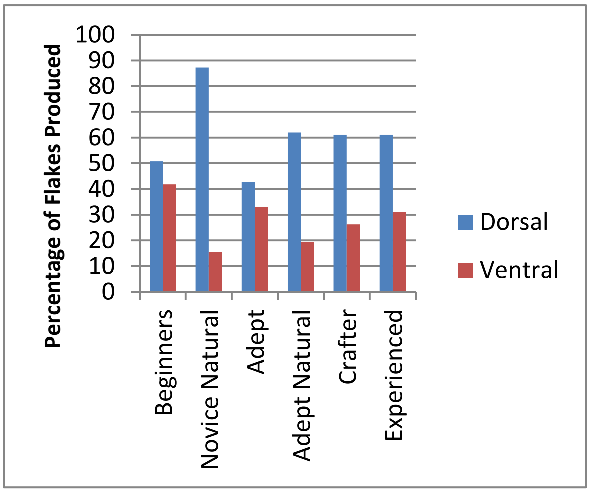


Figure 6.46. Percentages of dorsal and ventral flakes for each skill level.

flakes (Figs 6.39 & 6.41). Average percentages of dorsal and ventral flakes for each skill level show different results for each type of flake (Fig. 6.46). The information from the dorsal removals suggests that two skill groups may be discernible based on the average percentages seen for each skill level: one representing beginners (comprising beginner and adept levels) and one skilled knappers (comprising those with natural ability and crafter and experienced groups). Only knappers in the skilled group produced dorsal flake percentages greater than 60%, suggesting that a Levallois reduction sequence that shows this level of dorsal removals can be attributable to a skilled knapper. The ventral removals do not so clearly reflect the results seen in the skill analysis, which showed lower percentages of ventral removals associated with higher skill levels. While there are distinct differences in the average percentages of knappers with natural knapping abilities (novice natural and adept natural) and beginner knappers, the results of the other groups are very similar and not statistically significant. This suggests that this measure is unsuitable for identifying different skill levels. As well as the simple counts of dorsal to ventral flakes, the platform type of dorsal flakes was shown to be a good indicator of knapper skill level. When the average percentages of both flat and faceted platforms for each skill level are considered, the percentage of

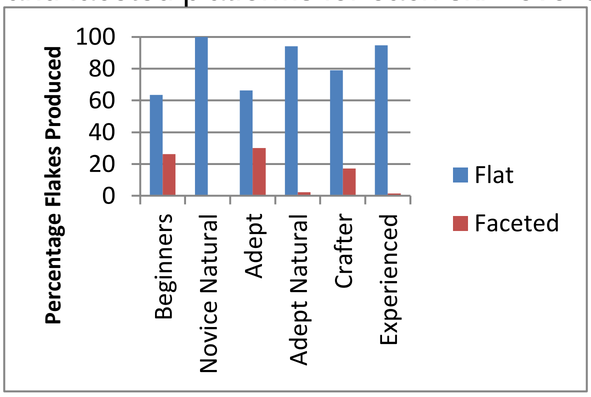


Figure 6.47. Percentage of flat and faceted dorsal flake platforms for each skill level.

faceted platforms for dorsal flakes appears to be a good indicator of knapper skill level with lower percentages indicating higher skilled groups (Fig. 6.47). The results allowed the identification of three different levels: beginners (comprising beginner and adept groups), moderate skilled (comprising crafter level) and skilled (comprising novice natural, adept natural and experienced groups). From this measure, however, it is not possible to distinguish the work of those with natural knapping ability from those with extensive understanding of Levallois technology based on practice and teaching. For this reason to gain a full understanding of the skill level of an individual analysis of a combination of different skill markers should be undertaken. It should also be noted that identification of dorsal and ventral flakes may only be possible if refitting studies are carried out on Levallois materials, highlighting the importance of such studies to gaining a comprehensive understanding of knapping skill.

The results of the skill level evaluation of material attributes of the Levallois core, preferential flake and debitage suggest that, at best, it may be possible to identify three separate skill levels based on material attributes. There are difficulties, however, separating the work of those with natural ability from those who have a full understanding of the Levallois technique, from some of these attributes. It seems likely that analysing a combination of features of the cores, flakes and debitage will enable this to be achieved, allowing a fuller understanding of the areas of ability that the knapper possesses.

Another area which this thesis focuses on is the cognitive implications of the results of skill evaluations for the hominins that first practiced these early technologies. Understanding the cognitive abilities of Neanderthals and comparing these to our own has been the focus of many previous works (e.g Mithen 1996, 164; Schlanger 1996; Wynn & Coolidge 2004; Wynn & Coolidge 2011). Those studies that focus on the stone tool evidence have often investigated the complexity of the technology, examined the need for planning abilities and discussed implications that this could have for Neanderthal language abilities (Eren & Lycett 2012, 2). The need for teaching in this technology is also an important consideration as this could give information on the social structures that underlay Neanderthal society and social interactions between Neanderthal individuals. The results of the skill evaluations from this experiment have highlighted the complexity of this technology when compared with simple flaking and handaxe technologies.

The results of the error type analysis demonstrated the importance of a good understanding of and physical ability to carry out platform preparation and correct flake positioning in allowing a high level of success to be achieved in this technology. These are both areas that involve strategic planning and good visualisation of possible flake outcomes. Interestingly, in this technology it was connaissance ability that proved most variable with some knappers unable to retain understanding of it. Savoir-faire skills in this technology seemed to be more straightforward for knappers to attain, suggesting that knappers could utilise physical skills gained in other technologies to gain success in this area, even without extensive technologically focussed practice. It was conceptual understanding in this technology that restricted the skill level achieved by knappers. It is also interesting that no-one received the highest scores possible in this technology, while some knappers achieved this for handaxe and flaking evaluations. Hours spent in taught sessions and practicing were low in this technology, however, and the fact that no-one achieved full mastery of the technique in the nearly two year project period highlights the importance of high levels of teaching and practice in this technology. Successful teaching requires a high level of social interaction, which has implications for the social life of Neanderthal flintknappers. This backs up the work of previous researchers who have highlighted the high degree of technical difficulty embodied by the Levallois technique, noting that very few modern knappers achieve a high level of skill in this technology (Mithen 1996, 134; Wynn & Coolidge 2011, 89).

As well as giving indications of Neanderthal cognitive abilities the results of the Levallois skill evaluations have identified issues with applying some standard measures of skill to this technology. As with the handaxe evaluations efficiency measures, when simply applied, were shown not to be useful measures of knapper skill. More skilled knappers in this technology tended to produce shorter, less wide, lighter Levallois cores than less skilled due to their ability to recover from mistakes and so not abandon the core at an early stage of reduction. The results of the debitage analysis, however, suggest that there was some tendency for more skilled knappers to produce a smaller number of flakes per 100g of debitage, indicating fewer, larger flakes were removed to successfully produce a core (Fig. 6.35). This suggests that on these terms efficiency measures can be applied to Levallois debitage. Other widely accepted measures include the identification of hinge, step and overshot fractures as knapping errors and thus indicative of lower skill levels. While this was upheld, to a certain extent, by the results from the debitage analysis, it was not shown to be the case for the preferential Levallois flake with knappers who produced overshot terminations, for example, showing the highest score possible for connaissance. Measures of thickness were shown in handaxe technology to be a good indicator of skill, in Levallois technology, however, no similar pattern was seen in the core maximum thickness results. This highlights the importance of applying appropriate measures of skill to individual technologies. Knapping skill does not manifest itself equally in each technology and, because of this, different measures of skill should be analysed as is appropriate for each.

6.4 Conclusion

The results of the skill evaluations in Levallois technology aptly demonstrate its conceptual complexity compared with Lower Palaeolithic Oldowan and Acheulean technologies. Even with modern human brains, language and teaching, knappers in the project had difficulty understanding Levallois strategy and techniques. While many clearly possessed the physical abilities necessary for Levallois removals this lack of understanding prevented most knappers from fully mastering this technology. This is contrary to the results seen in the Acheulean and Oldowan evaluations with knappers in these cases limited by their physical abilities to carry out the technology more than their understanding of the knapping concepts. This highlights the advanced cognitive abilities of Neanderthals compared with their predecessors and supports the work of researchers who have identified strategic planning as an essential component of Levallois mastery, for instance Wynn and Coolidge (2011, 100) in their analysis of “Marjorie’s core”, a refitted Levallois reduction sequence. The material analysis for Levallois has provided information that has been useful in indicating ways to identify skill in this technology. Focussed work identifying the reasons that these areas display skill while others do not could build on this to provide a fuller understanding of this complex technique.

6.5 Summary of Results

- Connaissance scores are variable with loss as well as gain through the three evaluations.
- Savoir-faire scores in general increase sharply between evaluations one and two and then remain stable.
- Most commonly occurring errors were those of flake positioning and platform preparation.
- Taught hours had a greater effect on savoir-faire scores than connaissance scores.
- Practice hours had a greater effect on savoir-faire scores than connaissance scores.
- For cores maximum length and mass including preferential flake were the best indicators of knapper skill.
- For preferential flakes maximum thickness and platform thickness were the best indicators of knapper skill.
- For debitage dorsal and ventral flake percentages and dorsal flake platform type percentages were the best indicators of knapper skill.
- A maximum of three skill levels are likely to be identifiable based on material evidence.

7.Aptitude

7.1 Introduction

Aptitude for flintknapping is an area that has received very little attention in previous studies that focus on skill acquisition in flaked stone technologies. The effect of teaching and hours spent practicing might be considered the most important factors in determining the level of skill a knapper achieves and the rate at which this occurs. While teaching and practice have been shown in previous chapters to have had an effect on knapper skill level, they are not the only factors that contribute to skill acquisition. At the first skill evaluation for Oldowan technology, when knappers had received similar, small, amounts of teaching and practice, there was wide variety in the scores received. This variety, if not caused by differences in practice and teaching, must be due to differences in the individual aptitudes of the knappers who carried out these evaluations. Through the use of aptitude tests and questionnaires, carried out before any knapping in the project had taken place, the areas of aptitude that allowed knappers to gain high levels of skill in each of the technologies that the project focused on were investigated (see Appendix 2 for tests). This was done in the hope that these areas of aptitude would shed light on the areas of cognitive ability that would have been most significant in the evolution of modern human brains for allowing stone tool technologies to be realised. The aptitude tests used in this project draw heavily on the work of Deborah Olausson (1998; 2008). In her study Olausson gave questionnaires to modern flintknappers with the aim of discerning what qualities make an individual a good knapper and whether there were individual attributes that precondition someone to achieve a high level of ability in knapping (Olausson 2008, 34).

The tests given to knappers in the Learning to be Human Project comprised spatial ability tests and questionnaires covering previous craft experience and contact with flaked stone assemblages. This focus was due to the findings of previous studies that looked at areas of importance to knapping abilities. Olausson's study found that spatial intelligence was important for modern flintknappers, as well as creativity and manual dexterity (Olausson 1998, 110–1; Olausson 2008, 35–6). In addition to this research, data from brain scan studies have given indications of the cognitive areas that are involved in flintknapping. Knappers have been scanned after carrying out both simple flaking and handaxe style bifacial reduction (Stout & Chaminade 2007; Stout et al. 2008). This revealed activations in areas involving tasks associated with manipulable objects and fine finger movements, as well as bimanual co-ordination with expert performance in the case of Oldowan technology (Stout et al. 2008, 1944–6). In the case of handaxe manufacture activation was shown in areas involved in governing complex action sequence and motor demands involving precise manipulations of objects (Stout et al. 2008, 1946–7). The aptitude tests for the Learning to be Human Project therefore, were focused on areas that dealt both with mental and physical abilities, including spatial tests and information on contact with previous assemblages, as well as information on previous craft experience. It was posited that the areas covered by these aptitude tests were those most likely to have an influence on knapping skill acquisition. The results of these aptitude tests are detailed below, followed by comparison with the skill results for Oldowan, Acheulean handaxe and Levallois technology to observe the effect of aptitude on individual technologies. This is followed by a discussion of the implications of these results.

7.2 Aptitude Tests

Aptitude tests were given to knappers at the start of the project, before any knapping had taken place. The majority of participants in the project had had no previous knapping experience, but for those individuals who had had some experience questions were also asked about the extent of their previous knapping practice and their own rating of their skill. All knappers received spatial ability tests and questionnaires about previous craft experience and contact with flaked stone assemblages. Spatial ability tests were given to knappers at the end of the project as well as at the beginning to observe if there were any changes that might be attributable to knapping practice.

7.2.1 Spatial Ability

Spatial abilities have long been presumed important for successful flintknapping (Pelegrin 1990, 118). This view has been supported in recent years by the findings of brain scans of experimental flintknappers. These identified activations in areas associated with visuo-spatial representations, which involve the visualisation of shapes in three dimensions (Stout & Chaminade 2007, 1097). For this reason spatial ability tests were given to knappers at the start of the project, before any knapping had taken place, and at the end of the project's nearly two year period. The tests were devised by *Psychometric Success* and took the form of an IQ test, focussing on only spatial questions (see Appendix 2). Each knapper took two, 20 minute tests at the start of the project and the same two tests at the end.

Knapper	**1st Test Percentage Score**	**2nd Test Percentage Score**
A	86	92
B	82	86
C	87	87
D	88	89
E	89	91
F	87	89
G	72	87
H	83	84
I	89	96
J	74	LP
K	64	76
L	89	92
M	88	89
N	79	LP
O	69	LP
P	90	LP
Q	71	LP
R	82	82
S	88	LP
T	83	91
U	82	LP
V	92	LP
Θ	84	91
Average	83	88

Table 7.1. Scores for beginning and end spatial tests for each knapper, LP=left project.

The results of the first spatial ability tests are presented in Table 7.1. This shows that average ability was 83% at this point in the project. Interestingly the majority of core group knappers (A-H) show higher than average spatial ability. The results of the second spatial ability test are also presented in Table 7.1. The average result at this point had risen to 88%. In fact all but two of the knappers showed an increased spatial ability score between the first and second evaluations, suggesting that learning knapping skills improves an individual's spatial ability. The areas of the tests that showed the greatest improvement from the beginning to the end of the project proved to be those involving following directions to find a location on a map and mentally folding paper to identify positions of holes (Fig. 7.1). These groups of questions were,

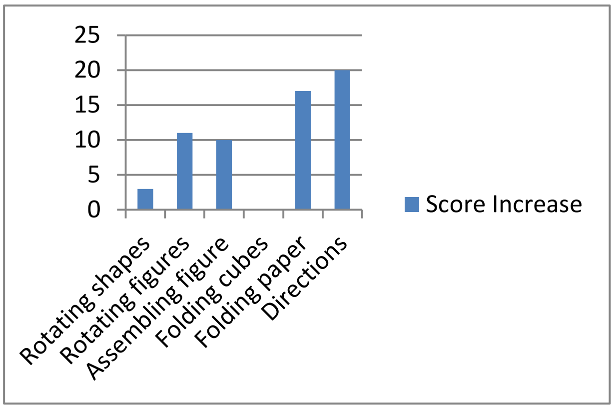


Figure 7.1. Score increase from beginning to end spatial tests in different question areas.

however, the last two sections on both tests so it seems likely that the greatest improvement shown by the volunteers from the start to the end of the project was in more quickly being able to perform spatial reasoning activities successfully.

The improvements shown by the knappers from the start to the end of the project suggest that spatial reasoning aptitude is a likely candidate for an area of aptitude that preconditions someone to achieve a high level of success in flintknapping.

7.2.2 Age and Sex

Age of knappers at the start of the project and sex were considered as possible areas that may influence a person's potential to achieve a high level of skill in flaked stone technologies. It is often stated that the majority of modern flintknappers are male (Olausson 1998, 96; Whittaker 2004, 1). On the basis of this, and of ethnographic accounts of knapping as a male activity, some researchers have inferred that prehistorically knapping would have been a male dominated task (see critique of this approach: Gero 1991, 163). There have, however, been no experiments directly comparing the work of male and female flintknappers to assess whether men have greater aptitude for flintknapping or whether other, perhaps social, factors influence the greater proportion of male modern flintknappers than female. For this reason, in this experiment the work of male and female knappers was compared. As this project relied on volunteer participants equal numbers of male and female knappers were not present in all groups, but overall a comparable number of male and female knappers were involved in the project (Table 7.2; Fig. 7.2).

Knapper	Age	Sex	Previous Craft Experience	Previous Contact with Flaked Stone Assemblages
A	20	M	0	2
B	19	M	0	3
C	20	M	2	2
D	20	M	4	2
E	20	F	4	2
F	24	M	8	10
G	25	M	3	2
H	18	F	0	2
I	19	F	7	2
J	32	F	4	1
K	18	F	0	0
L	19	M	0	0
M	29	F	2	1
N	19	M	2	0
O	18	M	1	0
P	18	F	0	0
Q	38	F	4	0
R	30	F	10	9
S	21	M	2	5
T	54	F	9	7
U	22	M	2	5
V	28	F	4	9
W	23	F	6	9
X	37	M	10	2
Y	46	F	4	10
Z	33	M	10	2
Γ	25	M	0	8
Δ	28	F	6	1
Θ	21	F	3	10
Λ	24	M	2	9
Ξ	51	F	10	10

Table 7.2. Aptitude results for age, sex, previous craft experience and previous contact with flaked stone assemblages (make into pie charts).

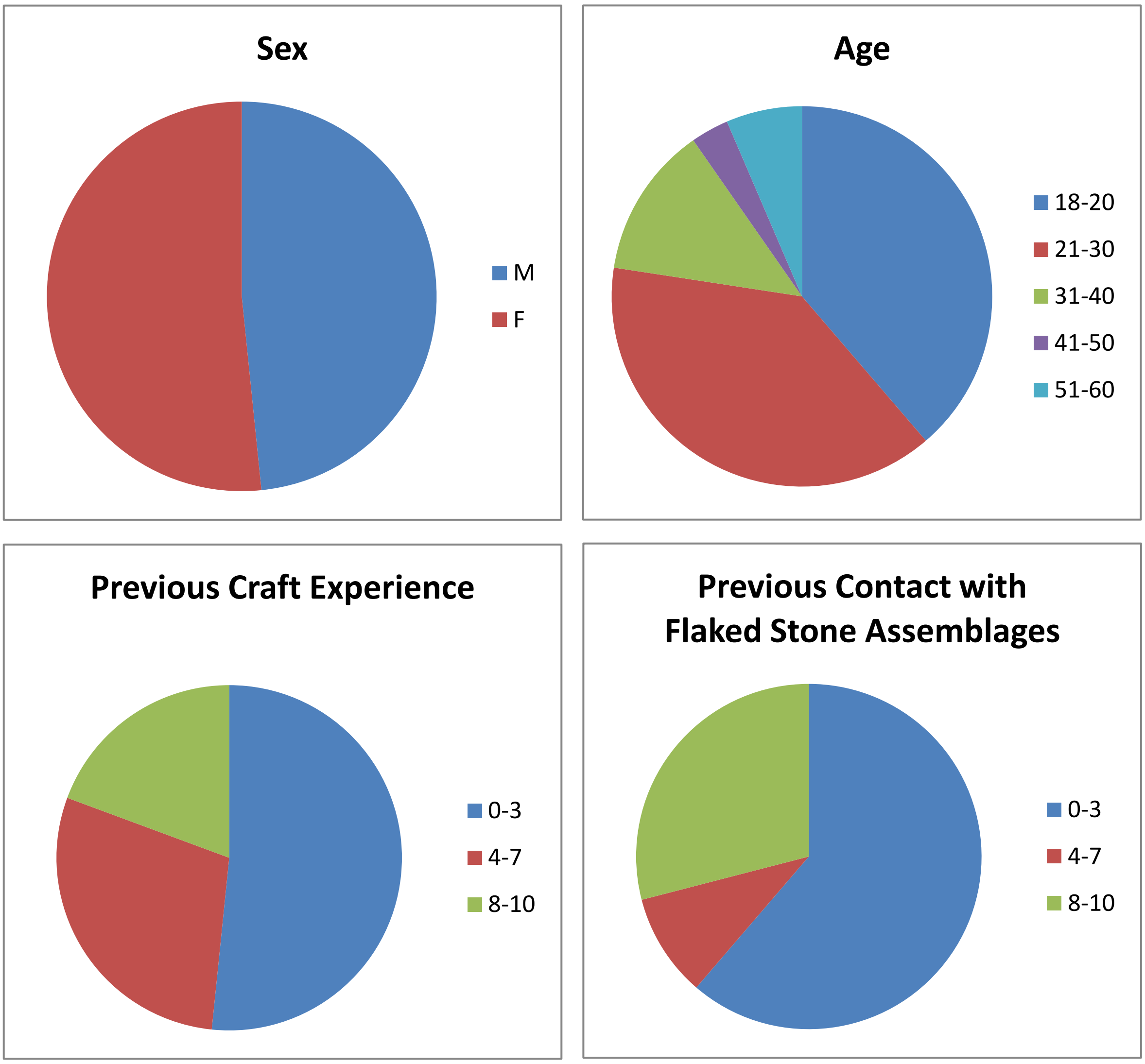


Figure 7.2. Sex, age, craft experience and previous contact with flaked stone assemblages of all knappers displayed as pie charts to better show the proportions of knappers in different categories at the start of the experimental program.

As well as sex, age of knappers was considered as a variable likely to affect ability to acquire skills in knapping. There has been much discussion about the age people first learnt to knap prehistorically (Bower 2007, 266; Finlay 2013, 155; Flenniken 1984, 198–9; Shea 2006). Ethnographic reports suggest that knapping apprenticeships may have begun at as young an age as 10 (Roux & David 2005, 93). People of different ages learn new skills in different ways and it was expected that age would have an impact on the levels of skill attainable for the knappers in the project, with older volunteers likely to find it more difficult to achieve high levels of skill in knapping. The age of knappers in the project is presented in Table 7.2. This shows that most of the knappers were aged 18-21 at the start of the project. The fact that the oldest knappers belong to the wider experienced group limits the useful comments that can be made on age, as this group had had knapping experience prior to the start of the project. However, three of the core and wider beginner groups, who performed more than one evaluation, were aged 24-30 at the start of the project and a comparison between their results and the younger knappers' could provide useful information on the effect of age on learning in flaked stone technologies.

7.2.3 Craft Experience

Previous research that has looked at flintknapping aptitude and brain scan studies have highlighted the importance of fine finger movements and manual dexterity to knapping ability (Olausson 2008, 36; Stout & Chaminade 2007, 1944). For this reason it was thought that experience of other crafts and level of skill achieved in these might influence the volunteers' ability to achieve high levels of skill in flintknapping as most crafts involve a high degree of manual dexterity to successfully accomplish. Knappers responded expressing knowledge of a wide variety of crafts, although, as would be expected, older respondents had a much wider range of knowledge than the younger knappers. This information was used to give a score of 0-10 to knappers based on the amount of experience they had had and the skill level they considered themselves to have achieved. The criteria for this are presented in Table 7.3. As can be seen from the aptitude results table (Table 7.2) the highest levels of previous craft knowledge stemmed from those who were in the wider experienced group and had had previous knapping experience, which limits what can be said about their aptitude for learning. There is, however, enough variety in the results of the wider beginners and core groups for the possibility of useful results in this area.

Score	Level of Experience
0	No previous craft experience
1	1 year or less experience of one craft at low level ability
2	Up to 3 years' experience of 1-2 crafts at low-medium level ability
3	Up to 3 years' experience of 1-2 crafts at high level ability
4	3-5 years' experience of 1-3 crafts at low-medium level ability
5	3-5 years' experience of 1-3 crafts at high level ability
6	Up to 6 years' experience of 2-4 crafts at low- medium level ability
7	Up to 6 years' experience of 2-4 crafts at high level ability
8	6-8 years' experience of more than 3 crafts
9	8-10 years' experience of more than 3 crafts
10	More than 10 years' experience of multiple crafts

Table 7.3. Criteria for assigning scores to previous craft experience.

7.2.4 Contact with Flaked Stone Assemblages

In addition to previous craft experience, previous contact with flaked stone assemblages was thought likely to have an impact on the knappers' ability to achieve high levels of skill in flintknapping. Viewing, handling and learning about flaked stone assemblages increases familiarity with the shapes and forms of this material and it seemed likely that this would aid replication of tools. Volunteers were asked to list previous experience with archaeological or replica flaked stone artefacts including university courses, handling museum collections or flintknapping demonstrations. This information was converted into a score from 0-10 based on the criteria presented in Table 7.4.

Score	Level of Experience
0	No previous experience
1	Introductory artefact module
2	Introductory artefact module and handling
3	Knapping Demonstration and Introductory module plus handling
4	Stone tool technology module
5	Stone tool technology module including artefact handling
6	Stone tool technology module, artefact handling and museum collection study
7	Stone tool technology module, artefact handling, museum collection study and knapping demo attended.
8	Multiple modules relating to stone tool technology, including artefact handling and museum collection study.
9	Multiple modules relating to stone tool technology, including artefact handling, experimental studies and museum collection study.
10	Extended study with research Level Contact (i.e Mphil/PhD)

Table 7.4. Criteria for assigning scores to previous contact with flaked stone assemblages.

The results of this, presented in the aptitude results table (Table 7.2), show the majority of those with the most contact belonged to the wider experienced group. This was the expected result as most of the wider beginners and core group were first and second year archaeology students, whose contact with stone tools, while in general greater than that expected from non-archaeologists, was limited to introductory classes and knapping demonstrations.

7.3 Results

The following section details the results of aptitude tests when compared with the three individual technologies that the project focussed on. Each area of aptitude has been examined with their relative impact on skill in the technology assessed.

7.3.1 Oldowan

Oldowan technology was the first knapping technique taught to the project participants. The evaluations in this technology involved simple flaking rather than replication of Oldowan tool types. Previous work in this area involving brain scans of individuals who had carried out flaking tasks had highlighted the importance of visuo-spatial representations and fine finger movements (Stout & Chaminade 2007, 1944), suggesting that high levels of ability in these areas may precondition someone to achieve a high level of skill in flintknapping.

Spatial Ability:

Spatial ability was considered a likely area of aptitude that would influence the level of skill a knapper could achieve in Oldowan technology. Scores for connaissance and savoir-faire ability achieved in the first evaluation, after each knapper had received around ten hours of knapping training and

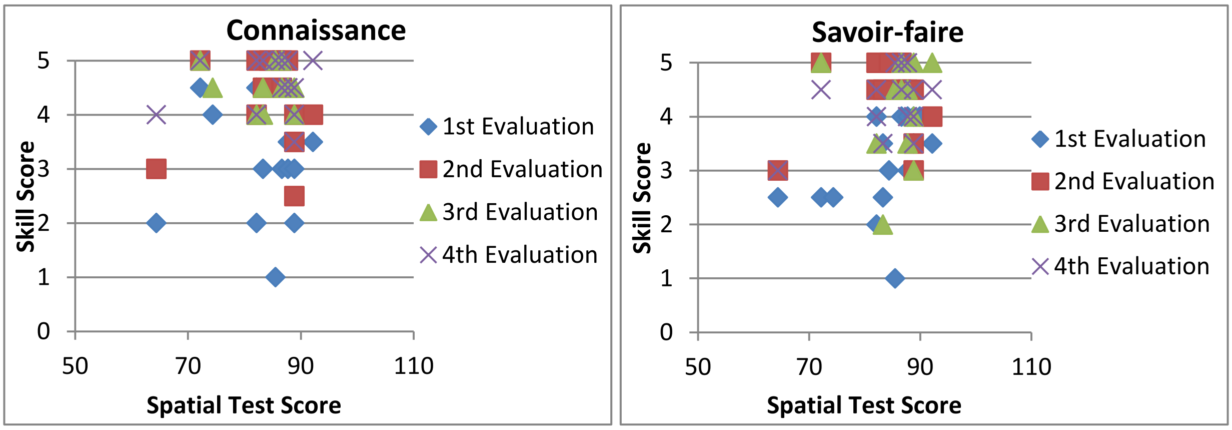


Figure 7.3. Spatial ability scores plotted against skill scores received for connaissance and savoir-faire

practice, were plotted against scores received in the first spatial ability tests to see if any correlation could be observed at this point in the project (Fig. 7.3). The results of this show no clear correlation between score received and spatial ability score. When the final evaluation score is considered with spatial ability results from the first evaluation it can be seen that, while there is no clear correlation again, the individual who scored lowest for spatial ability also achieved the lowest score for savoir-faire. This suggests that some level of spatial ability is needed to achieve a high level of savoir-faire skill in this technology but that this level is not an exceptionally high one. All the knappers in the study, with the exception of knapper K, had an appropriate level of spatial ability to allow a high level of skill to be achieved. This suggests that the majority of modern humans have appropriate levels of spatial ability to achieve a high level of success in Oldowan style technology and no extraordinary levels of spatial ability are needed in this case.

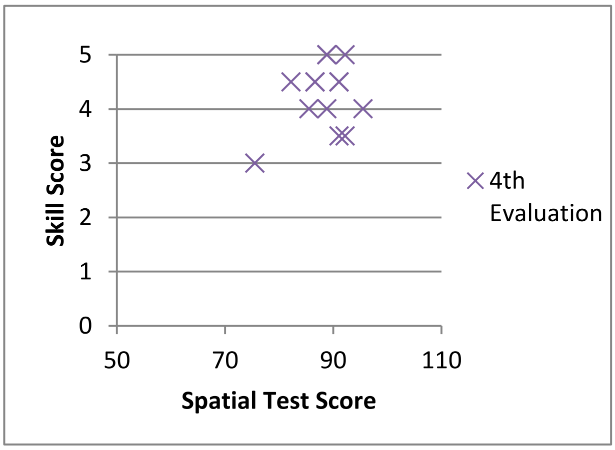


Figure 7.4. Spatial ability scores at the end of the project and scores received for savoir-faire.

Levels of spatial ability shown at the end of the project were also considered with scores for all three evaluations to observe if this better correlated with skill in Oldowan technology (Fig. 7.4). As with the first spatial ability test scores, no clear picture of correlation was indicated, however, if only the final evaluation scores were considered it could be seen that the knapper who received the lowest spatial ability score also achieved the lowest savoir-faire score in this evaluation. This supports the picture of a technology that is affected by spatial ability but does not require an extraordinary level to achieve high success.

Age:

The age of a knapper was considered likely to have an effect on their ability to learn skills in flaked stone technologies, with younger knappers expected to achieve higher levels of skill, in a shorter time period. Age of knapper was plotted against scores received in each evaluation to observe if there was any visible influence on skill level achieved (Fig. 7.5). This revealed no clear correlation between age and skill level achieved. To look at the results in more detail the savoir-faire score progression of different age groups of knappers was plotted (Fig. 7.6). It is difficult to form any definitive conclusions from these results as the majority of knappers fall into the 18-20 age group and only one knapper is in the 40-50 age group, however it does appear that this knapper showed more loss of savoir-faire ability through the evaluations than the other knappers. It is possible that this effect is due to knapper age, although other factors could also determine this result.

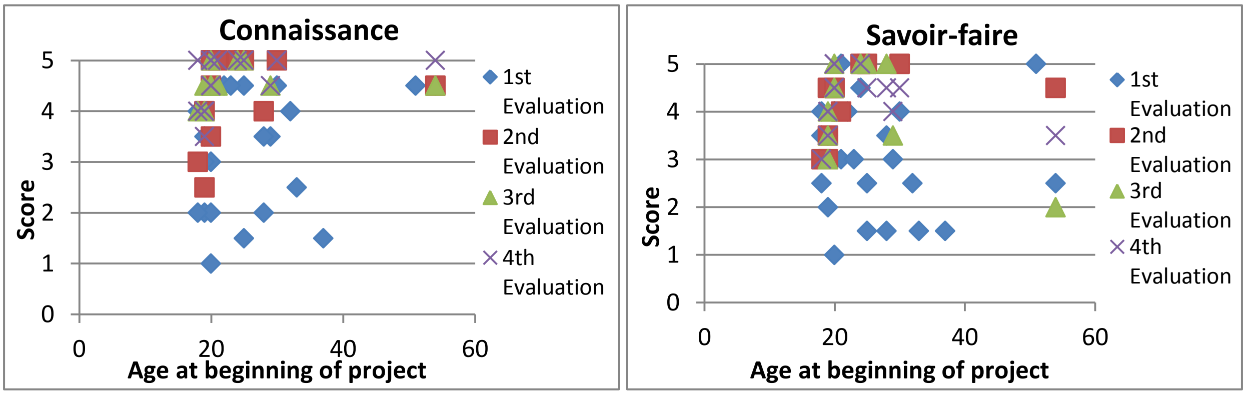
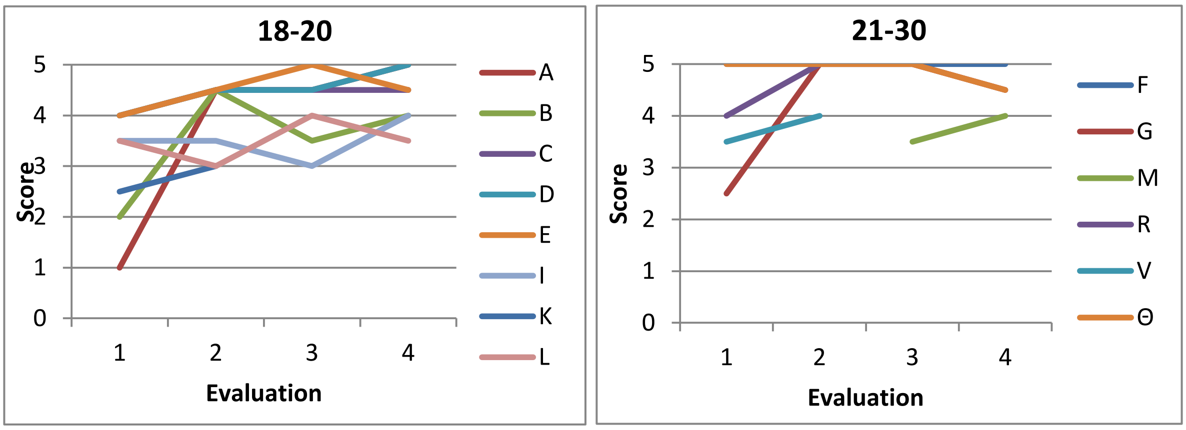


Figure 7.5. Age at beginning of the project plotted against scores received for connaissance and savoir-faire.



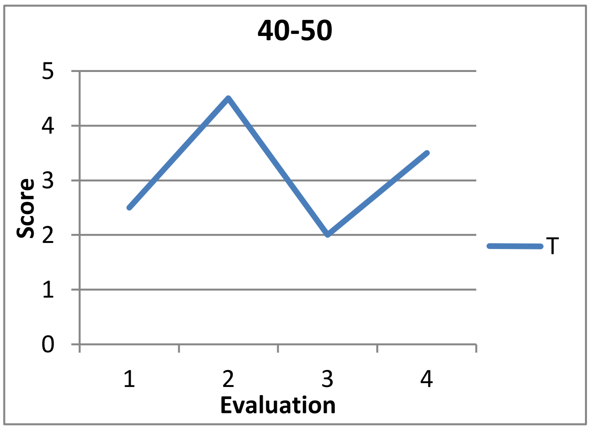


Figure 7.6. Knapper skill score progression for different age groups.

Sex:

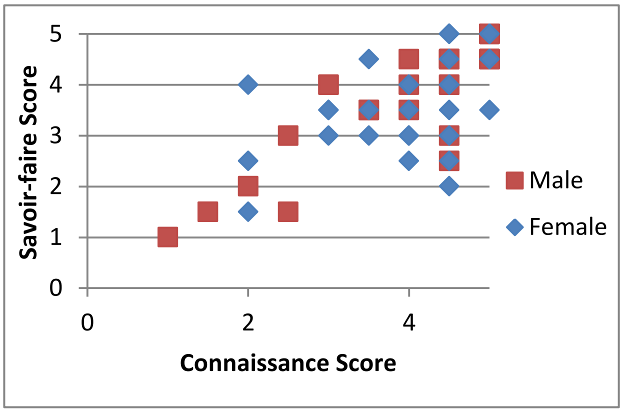


Figure 7.7. Skill scores achieved by male and female knappers.

Sex of knappers was considered as a factor that may have an influence on knapper skill level achieved (Fig. 7.7). It is often assumed that male hominins were most likely responsible for stone tool making in prehistoric communities, due to the high numbers of male modern flintknappers and ethnographic accounts of stone tool making being a male domain. Male and female knappers in the group showed similar figures for connaissance and savoir-faire skill in each evaluation suggesting that sex is not a factor in determining achievable skill level in this technology.

Previous Craft Skills:

It was thought likely that the knappers' previous experience of practical activities may have an influence on their ability to achieve high levels of skill in flaked stone technologies. Knappers were each given a score of 0-10 based on levels of previous craft experience. When compared to scores received for connaissance and savoir-faire in the skill evaluations it can be seen that, while for the first evaluation there is no clear correlation between score achieved and craft ability, by the second evaluation scores for both connaissance and savoir-faire appear to show some influence from previous craft experience level (Fig. 7.8). This can be seen in the fact that knappers who scored highly for previous craft skills received high scores for Oldowan skill. Knappers who had a lower level of craft experience, however, received variable scores for skill and were not restricted to low scores for either savoir-faire or connaissance. In the third and fourth evaluations the correlation between high craft experience and high skill scores for connaissance and savoir-faire is less marked, particularly in terms of savoir-faire.

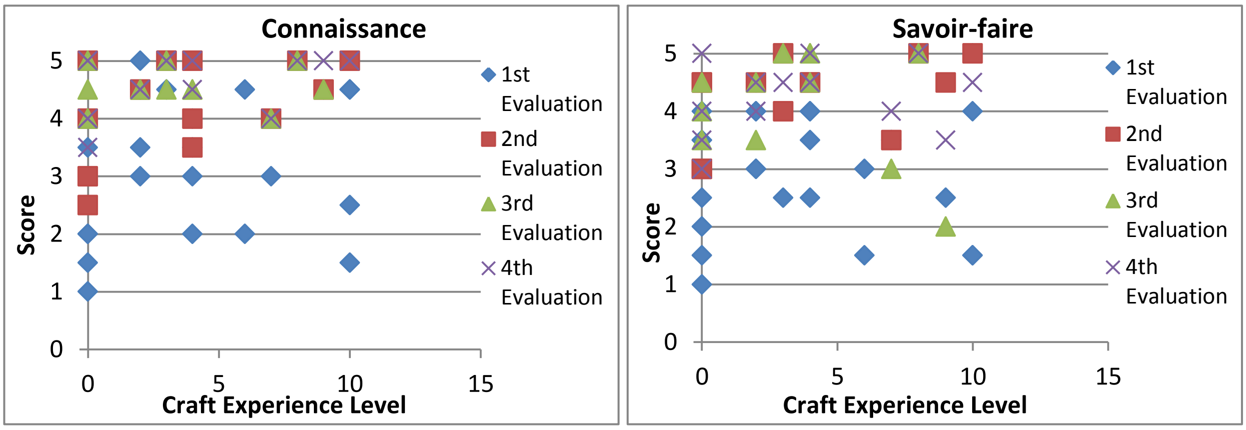
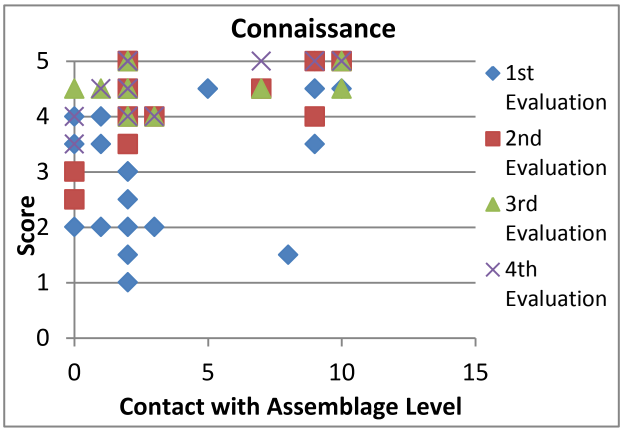


Figure 7.8. Previous craft experience level plotted against scores received for connaissance and savoir-faire.

This suggests that previous craft experience does have an influence on the ability of knappers to achieve high levels of skill in Oldowan technology. In this study it appears that individuals with the highest levels of previous craft experience were able to achieve high performance scores at an early period in the project, suggesting that this experience had the effect of speeding up the learning process for some individuals. Conversely, possessing a low level of previous craft experience did not prevent individuals from achieving high levels of skill. Some of the knappers with the lowest levels of previous experience received high scores in the Oldowan skill assessments from the first evaluation, while others received high scores in the third and fourth evaluations, presumably as a result of increased levels of practice and teaching as the project progressed. This suggests that previous craft experience alone does not account for flintknapping ability, although it plays a part in determining it.

Assemblage contact:

As well as previous craft experience, it was thought likely that previous contact with flaked stone assemblages would have an influence on the skill level achieved by knappers in the Oldowan skill evaluations. When the two factors are compared a similar picture to that seen for the craft experience, discussed above, is revealed (Fig. 7.9). Evaluation two scores show the clearest correlation with flaked stone assemblage contact levels, while evaluations three and four show this to a lesser extent. Interestingly, in this case, connaissance score seems to be most influenced by this factor, showing a stronger correlation with flaked stone assemblage contact level in each evaluation than is seen for savoir-faire score. This is likely due to knappers with a higher level of contact having attended course modules that included explanations of knapping principles, leading them to having a greater understanding of conchoidal fracture and a better ability to predict flake outcomes. As seen with craft experience level the influence on skill was most



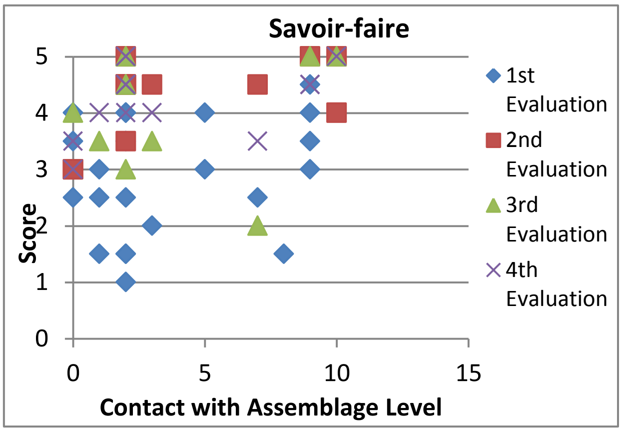


Figure 7.9. Previous contact with flaked stone assemblages plotted against scores received for connaissance and savoir-faire.

apparent in those with the highest levels of contact with flaked stone assemblages. Those with little or no contact prior to the start of the project showed a wide range of scores from the first evaluation. This suggests that while previous contact with flaked stone assemblages does have an impact on the skill achieved in Oldowan technology, it is not the only factor that determines how skill is achieved. As with craft experience it has the effect of speeding up the learning process, allowing knappers to achieve a higher level of skill earlier in the project.

7.3.2 Acheulean handaxe

Acheulean handaxe technology was the second technique taught to the wider beginners group and the third to the core and wider experienced groups. It was a popular technology with the knappers with a high level of attendance of taught sessions and the most practice hours of any technology. Previous work involving brain scans of knappers who had performed handaxe technology have indicated that areas that govern complex action sequences and precise manipulations of objects are activated during bifacial reduction (Stout et al. 2008, 1946–7). For this reason it was thought that both physical and mental abilities would influence the amount of skill achieved by knappers in this technology. The same areas of aptitude were assessed as for Oldowan discussed above.

Spatial Ability:

Spatial ability results were compared with skill scores for Acheulean technology to observe if high levels of spatial ability were important for allowing high levels of skill to be achieved (Fig. 7.10). As with the Oldowan results there is no clear picture of correlation between spatial ability and skill scores for connaissance or savoir-faire. The lowest scores achieved, however, do belong to the knapper with the lowest spatial ability score. This can be seen most clearly in the savoir-faire scores. Knappers with higher levels of spatial ability received a wide range of scores for ability in handaxe manufacture that are seemingly unrelated to their spatial ability levels.

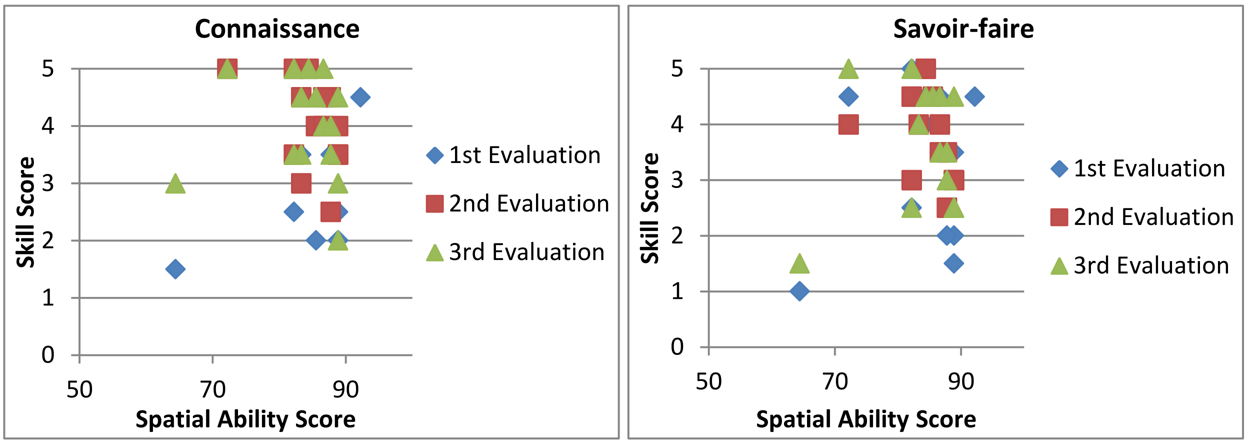


Figure 7.10. Spatial ability scores plotted against scores received for connaissance and savoir-faire skill.

This suggests that no extraordinary levels of spatial ability for modern humans are necessary to achieve a high level of success in handaxe technology. Average levels of ability are sufficient. Individuals with extremely low spatial ability (knapper K's ability was well below average), may not be able to achieve a high level of skill. The handaxe produced by this knapper in the first evaluation illustrates the difficulties these individuals may have faced (Fig. 7.11). Despite receiving training in this technology and seeing demonstrations of successful handaxe manufacture the knapper did not have the ability to remove flakes from more than one face. This suggests that the knapper was unable to make three dimensional judgements of the correct removals to produce the desired handaxe shape and was only able to produce a two

Figure 7.11. Handaxe produced by knapper K, showing effect of low levels of spatial ability. Colours indicate surface – blue = dorsal, black = ventral.

dimensional outline that mirrored that of a handaxe. The above information indicates that to successfully manufacture handaxes early hominins would need to be in possession of near modern human levels of spatial ability, as levels lower than this would be insufficient to allow for bifacial reduction.

Age:

As discussed above it was thought likely that age would have an effect on the level of skill knappers could achieve. It was assumed that older knappers would have more difficulty learning the skills necessary for handaxe manufacture than younger knappers. When the results are compared with scores received for connaissance and savoir-faire, this pattern was not shown (Fig. 7.12). Older knappers appear to receive higher scores for both areas of skill and do not show the same likelihood for skill loss as was seen in the Oldowan results. This is likely due to the fact that there were a higher proportion of older knappers in the wider experienced group than in the core and wider beginners groups. These knappers had had previous knapping experience at the start of the project and were therefore likely starting with a higher level of skill than the other knappers.

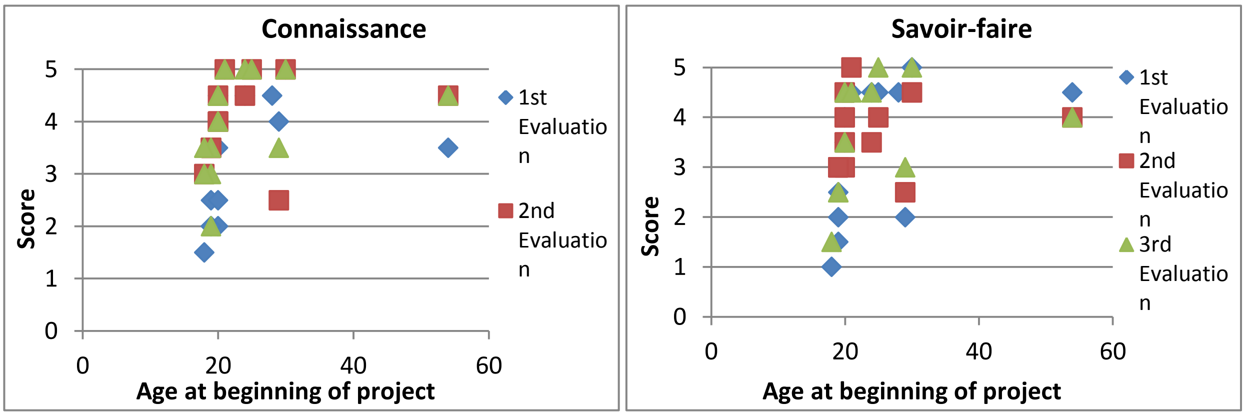


Figure 7.12. Age at beginning of project plotted against scores received for connaissance and savoir-faire.

Sex:

The results from the analysis of the effect of knapper sex on the scores achieved in the Acheulean skill evaluations support those seen in the Oldowan evaluations discussed above (Fig. 7.13). No significantly higher or lower results

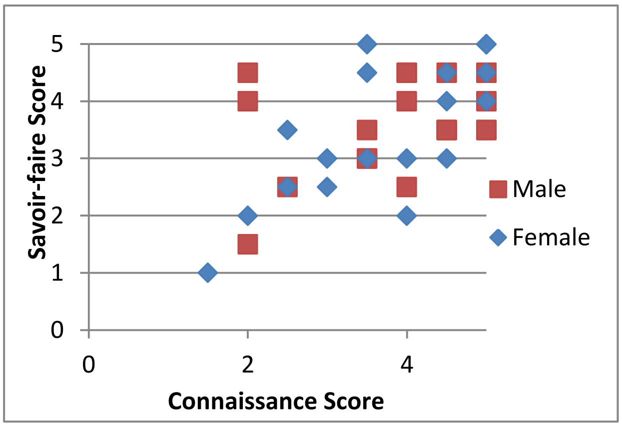


Figure 7.13. Skill scores received by male and female knappers for handaxe technology.

were produced by male or female knappers either for connaissance or savoir-faire. Both the highest and lowest scores produced belonged to female knappers, but each sex produced a wide range of results, suggesting that neither has greater aptitude for handaxe manufacture. If this activity was gendered prehistorically, this was likely due to cultural or social factors.

Previous Craft Experience:

As with Oldowan skill, previous craft experience was considered likely to have an impact on the levels of skill achieved in Acheulean technology. When craft skill level at the start of the project was compared with scores achieved for connaissance and savoir-faire some correlation can be seen (Fig. 7.14). Knappers with the highest levels of previous craft experience, in general, received high scores for connaissance and savoir-faire. The correlation of high skill levels with high levels of previous craft experience is most marked for savoir-faire skill and is apparent in all three of the evaluations carried out by knappers. This suggests the importance of a high level of physical prowess in enabling successful manufacture of handaxes. Practicing physical abilities can improve hand/eye co-ordination and manual dexterity, and it is clear from these results that these areas are important in bifacial reduction sequences. This

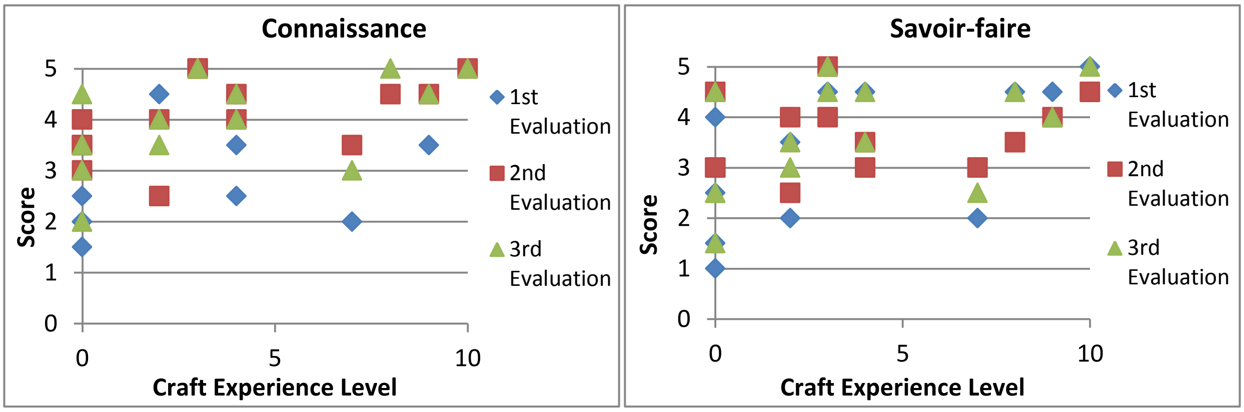


Figure 7.14. Previous craft experience plotted against scores received for connaissance and savoir-faire.

highlights the importance of practiced physical ability in Acheulean technology.

Assemblage contact:

Previous contact with flaked stone assemblages was compared with scores received for connaissance and savoir-faire (Fig. 7.15). This revealed a good level of correlation between these two variables, suggesting that a high level of contact with flaked stone assemblages may precondition someone to achieve a high level of skill in Acheulean handaxe technology. In the first and second evaluations, assemblage contact level most clearly correlates with connaissance skill, probably explained by the fact that those who showed the highest levels of contact had attended academic classes involving flaked stone technologies and in these had been previously introduced to the concepts that lie behind the fracture of materials such as flint and chert. They were thus better able to demonstrate these correctly during the skill evaluations. Savoir-faire skill, however, does also show some correlation with assemblage contact level. This suggests that familiarity with flaked stone objects allows for better production. This is possibly due to the theorised necessity of a mental template in handaxe technology. Repeated viewing and handling of handaxes and other bifacially flaked tools may have allowed knappers to more successfully create this mental template and thus more successfully produce a finished tool.

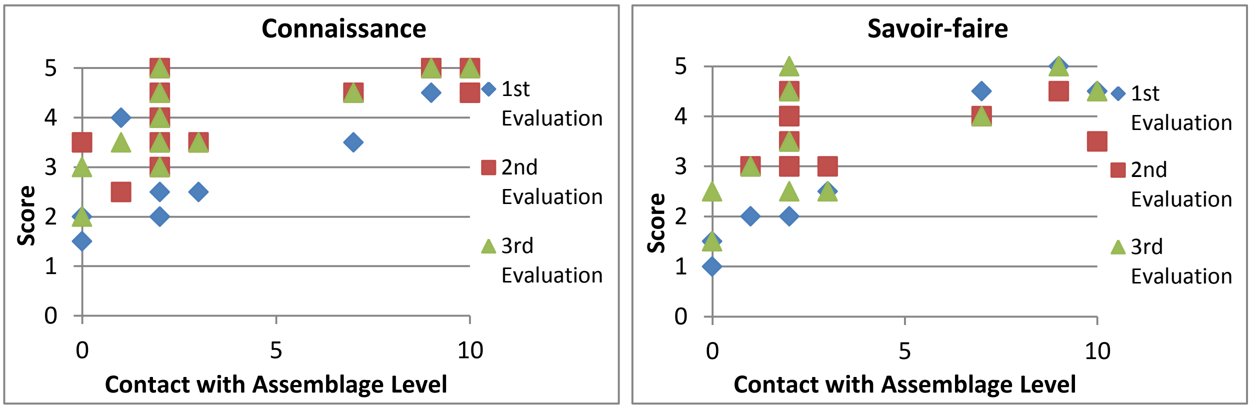


Figure 7.15. Previous contact with flaked stone assemblages plotted against scores received for connaissance and savoir-faire.

7.3.3 Levallois technology

Levallois technology was the third technique taught to the wider beginners group and the second to the core and wider experienced groups. It was the least popular technology taught in the project and this was reflected in low levels of practice among the knappers and poor attendance of taught sessions. Levallois technology involves hierarchically structured removals, with early flakes being removed to prepare the core for subsequent removals. For this reason it was thought that high levels of spatial ability would be significant in allowing a high level of skill to be achieved in this technology.

Spatial Ability:

The results of the spatial ability tests, when compared with scores for connaissance and savoir-faire are presented in Figure 7.16. This demonstrates that, contrary to the expected picture, there does not appear to be correlation between these two factors, with knappers with the greatest spatial ability producing high and low scores for both connaissance and savoir-faire. When only the first evaluation scores are considered, however, a different picture emerges (Fig. 7.17). Here there does appear to be some correlation, particularly in terms of savoir-faire score. This suggests that, at the earliest stages of learning Levallois technology, spatial ability is an important factor in determining the level of skill achieved in physical ability to carry out this technology. This means that those with higher levels of spatial aptitude were able to reach higher

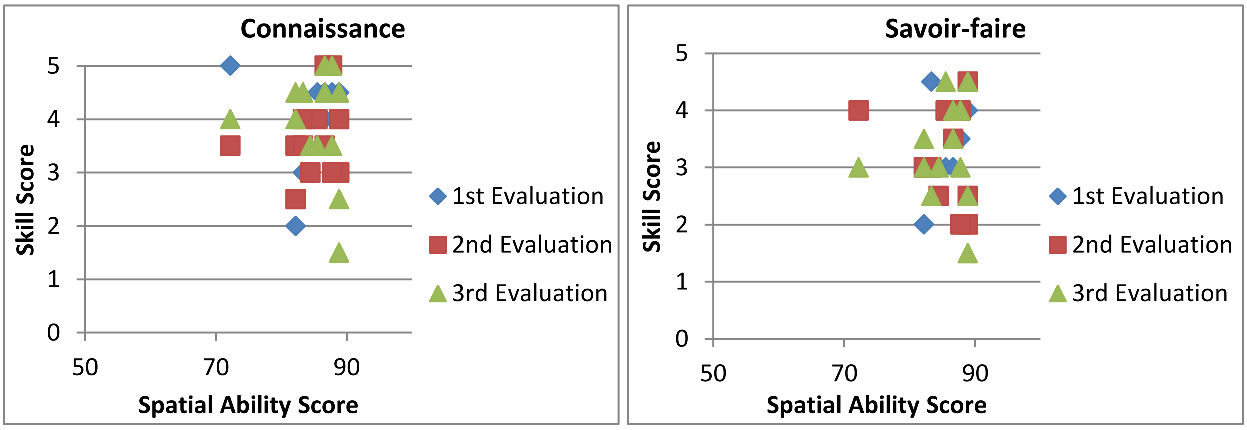


Figure 7.16. Spatial ability scores plotted against skill scores received for connaissance and savoir-faire.

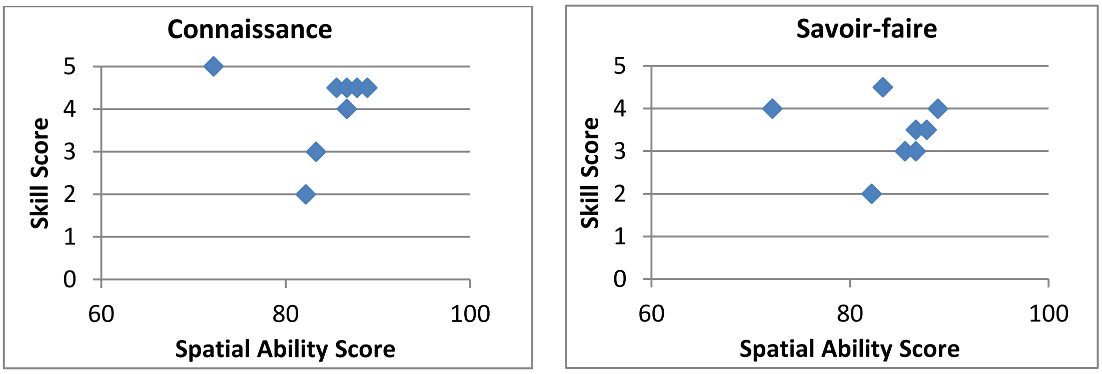
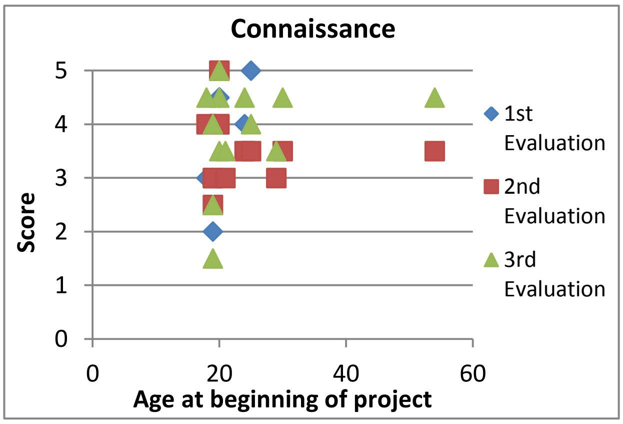


Figure 7.17. Spatial ability scores plotted against scores received in the first skill evaluation for connaissance and savoir-faire.

skill levels sooner than those with low levels. A number of knappers with high levels of spatial ability, as well as knappers with low levels, were demonstrated to be capable of gaining high skill levels in this technology. However, the effect that spatial aptitude has on determining skill early in the learning process indicates that importance of this area of aptitude to the Neanderthal knappers who first practiced this technique. High levels of spatial ability have the effect of speeding up the learning process, reducing the need for excessive practice or teaching and thus allowing for more efficient progress.

Age:

As with Acheulean handaxe and Oldowan technologies, age was considered as a variable that was likely to have an effect on the skill level achieved in Levallois technology. It was expected that older knappers would be less likely to achieve a high skill level and if high skill levels were achieved this would be at a slower pace to younger knappers. When knapper age is compared to skill for connaissance and savoir-faire scores it can be seen that age did not have a significant impact on the levels of skill achieved by knappers (Fig. 7.18). Older knappers were equally able to obtain high scores for skill both in connaissance and savoir-faire as younger knappers and showed these results in each of the evaluations they performed. When the scores across the evaluations for individual knappers in different age groups are considered, however, knappers in the 21-30 age group showed more of a tendency for skill loss in savoir-faire than knappers in the 18-20 age group. This result is likely affected by the low levels of practice seen in the wider experienced group (to



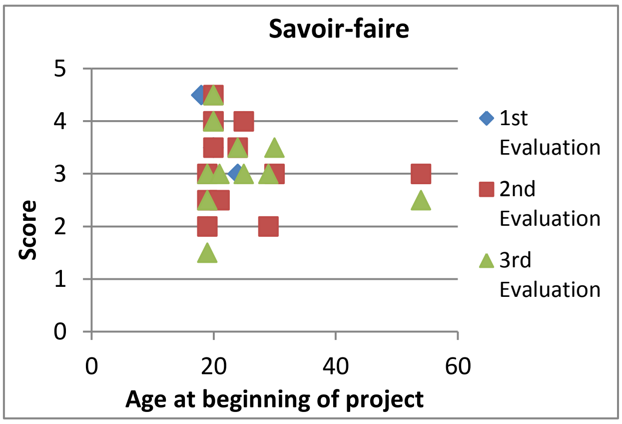


Figure 7.18. Age at beginning of the project plotted against skill scores received for connaissance and savoir-faire.

which most of these knappers belong) and thus can not entirely be attributed to knapper age. These results suggest that age is not a significant predictor of achievable skill level in Levallois technologies.

Sex:

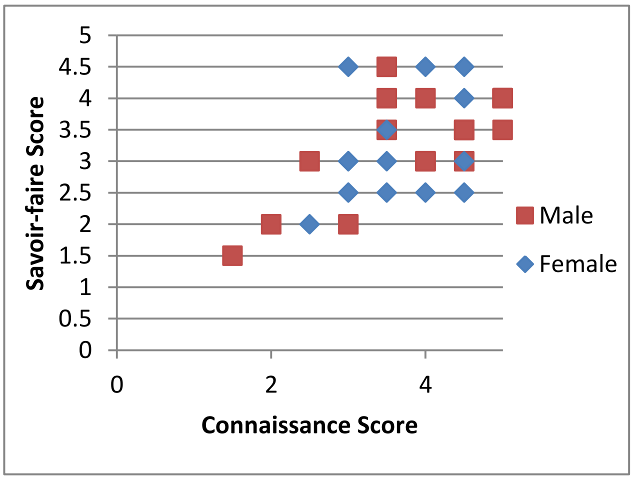


Figure 7.19. Skill scores received for male and female knappers in Levallois skill evaluations.

Along with age, sex of knapper was considered as a variable which may have an impact on skill, due to the prevalence of male knappers in modern knapping circles and the widely expressed assumption that tool making was a largely male domain prehistorically (Bamforth & Finlay 2008, 17; Whittaker 2004, 1). Scores for male and female knappers were compared (Fig. 7.19). This revealed no indication of better understanding or performance of the technology for either sex. Male and female knappers achieved high and low scores in each of the evaluations. This suggests that sex is not a factor in determining whether high levels of skill are achieved by Levallois knappers. Both male and female knappers are equally capable of achieving high levels of performance in this technology. If, prehistorically, this technique was the domain of male Neanderthals, this was due to factors other than ability.

Previous Craft Experience:

As with Oldowan and Acheulean handaxe technologies, previous experience in other craft types was thought likely to precondition knappers to achieve high levels of skill in Levallois technology, due to the likelihood of this increasing physical skills such as strength, manual dexterity and hand-eye coordination. For this reason levels of previous craft experience were plotted against scores received for connaissance and savoir-faire (Fig. 7.20). This revealed no strong picture of correlation between the two variables for any of the evaluations carried out by knappers. This contrasts with the results seen in the handaxe and Oldowan technology aptitude analysis, which showed some correlation. This may be due to the unique nature of Levallois technology, in that the techniques necessary for mastering performance in it are not likely to be mirrored in other craft types. General craft physical abilities are not sufficient in this technology and, because of this, new skills unique to Levallois must be acquired.

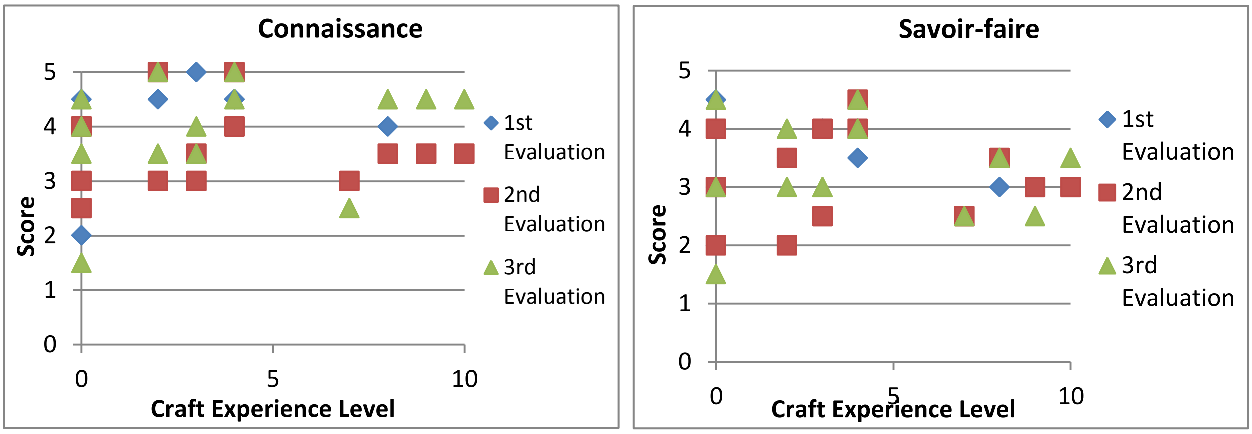


Figure 7.20. Previous craft experience plotted against scores received for connaissance and savoir-faire.

Assemblage contact:

Previous contact with flaked stone assemblages was also considered as a variable likely to impact on skill achieved in Levallois technology. Comparison between levels of contact and scores for connaissance and savoir-faire

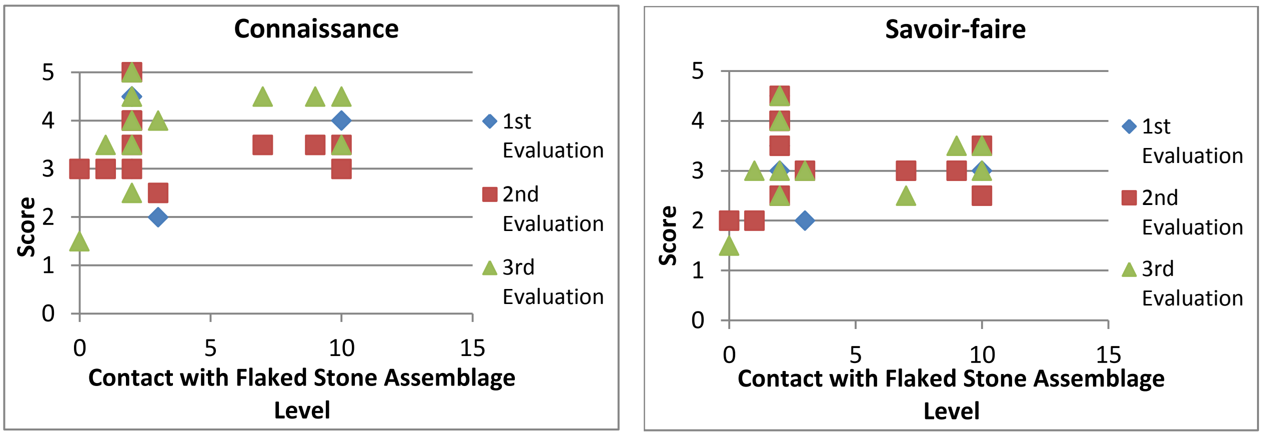


Figure 7.21. Previous contact with flaked stone assemblages plotted against scores received or connaissance and savoir-faire.

revealed no strong pattern of correlation (Fig. 7.21). This suggests that, contrary to the results seen for handaxe technology, extensive handling and familiarity with flaked stone material forms does not aid a knapper by preconditioning them to achieve a high level of skill in Levallois technology. This may be due to the fact that, in the case of Levallois technology as opposed to handaxe, the form of the finished tool is not fixed. The techniques needed to perform the task might be said to be more significant here, than the shape of the preferential Levallois flake produced as a result of the technology. An understanding of these techniques can not be gained by simply looking at examples of finished tools; it is only through teaching and practice that this knowledge can be acquired.

7.3.4 Connaissance and Savoir-faire

From the results presented above it can be seen that, in some cases, areas of initial knapper aptitude affected scores for connaissance and savoir-faire in different ways. Of the areas assessed it was expected that spatial ability and contact with flaked stone assemblages would have most impact on connaissance skill score, as this area of understanding involves the mental representation of forms and understanding of the sequences necessary to perform a task (Pelegrin 1990, 118). Previous contact with flaked stone assemblages would provide a stronger mental representation due to familiarity and, if it took the form of taught classes, may provide information on action sequences. Age, previous craft experience and motor ability were thought likely to impact on knapper's savoir-faire skill scores, as this area involves physical skills and abilities.

Where a difference was seen in the effect of different areas of aptitude on different areas of skill, the above analysis demonstrated that connaissance skill scores were best correlated with assemblage contact level for Oldowan and Acheulean handaxe technology. Savoir-faire scores, on the other hand, showed correlations with previous craft experience levels for Acheulean handaxe technology, and spatial ability for the first Levallois evaluation. These results support the expected outcome to some extent with assemblage contact (which often involved attendance of taught sessions on flaked stone technologies) allowing knappers to achieve higher levels of skill in understanding the means by which the technology is realised. In addition, as expected, higher levels of previous craft experience, implying a level of physical prowess and manual dexterity, was associated with higher scores for savoir-faire. Spatial ability for the first Levallois evaluation, however, more strongly correlated with savoir-faire than connaissance, an unexpected result. This suggests that, for this technology, physical ability is very closely tied in with spatial visualisation abilities. Without these spatial abilities a high level of physical success was not achieved.

These results show that, to a large extent, our understanding of the areas of aptitude that the terms connaissance and savoir-faire encompass is correct. A greater understanding of the interplay between these two areas is, however, necessary to account for the role of spatial ability and the effect high level skill in one area has on the other. This is discussed in more detail in the following chapter (Chapter Eight).

<u>7.3.5 Material Markers</u>

Achieving an understanding of the areas of aptitude that may precondition a knapper to achieve a high level of skill in a particular flaked stone technology is of interest when the abilities of early hominins are considered. Assessing the likely applicability of results gained from experimental studies to archaeological assemblages, however, depends on the visibility of these results in the materials produced by knappers, as it is largely through these materials that prehistoric behaviour can be established. To assess the visibility of the aptitude areas that were shown to correlate best with skill scores, these areas were considered with the material attributes of the different technologies that were demonstrated in previous chapters to be most affected by knapper skill level.

For Oldowan technology the material attributes that best indicated knapper skill were number of flakes produced and maximum flake length, while the areas of aptitude that correlated best with skill scores were previous craft skill level and previous flaked stone assemblage contact level. When these variables are considered alongside each other there is no strong pattern of association between these factors (Fig. 7.22). This suggests that high or low levels of aptitude in these areas are not visible in the materials produced and can only be inferred from other evidence of skill.

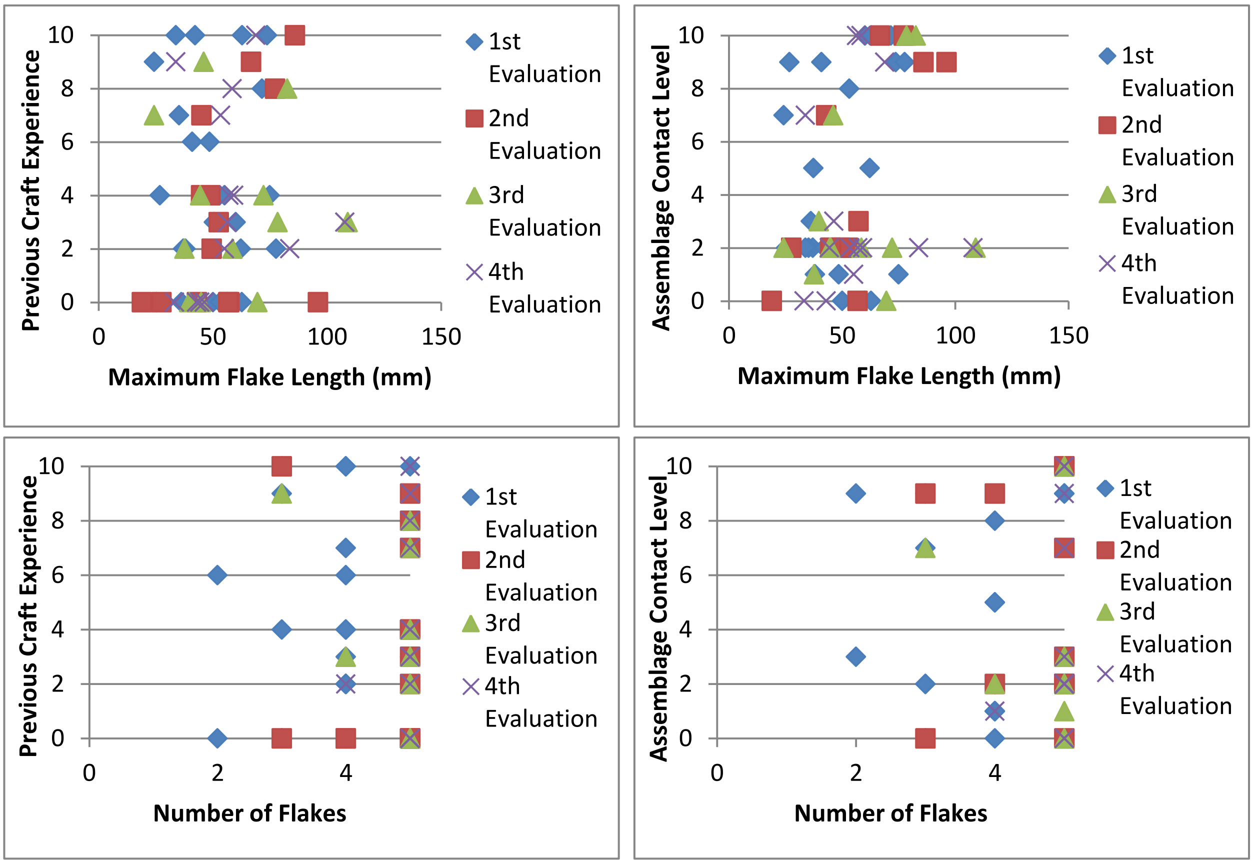


Figure 7.22. Oldowan material attributes sensitive to skill plotted against aptitude measures.

In the case of Acheulean technology the material attributes that most clearly indicated the skill of the knappers who produced them were maximum thickness of handaxe and handaxe mass and percentage platform type of debitage produced. The areas of aptitude that most clearly affected knapper skill were previous craft skill level and previous assemblage contact level. When these factors are plotted against each other it can be seen that both handaxe maximum thickness and handaxe mass show some level of negative correlation, while platform type percentage results do not show any such pattern (Fig. 7.23)

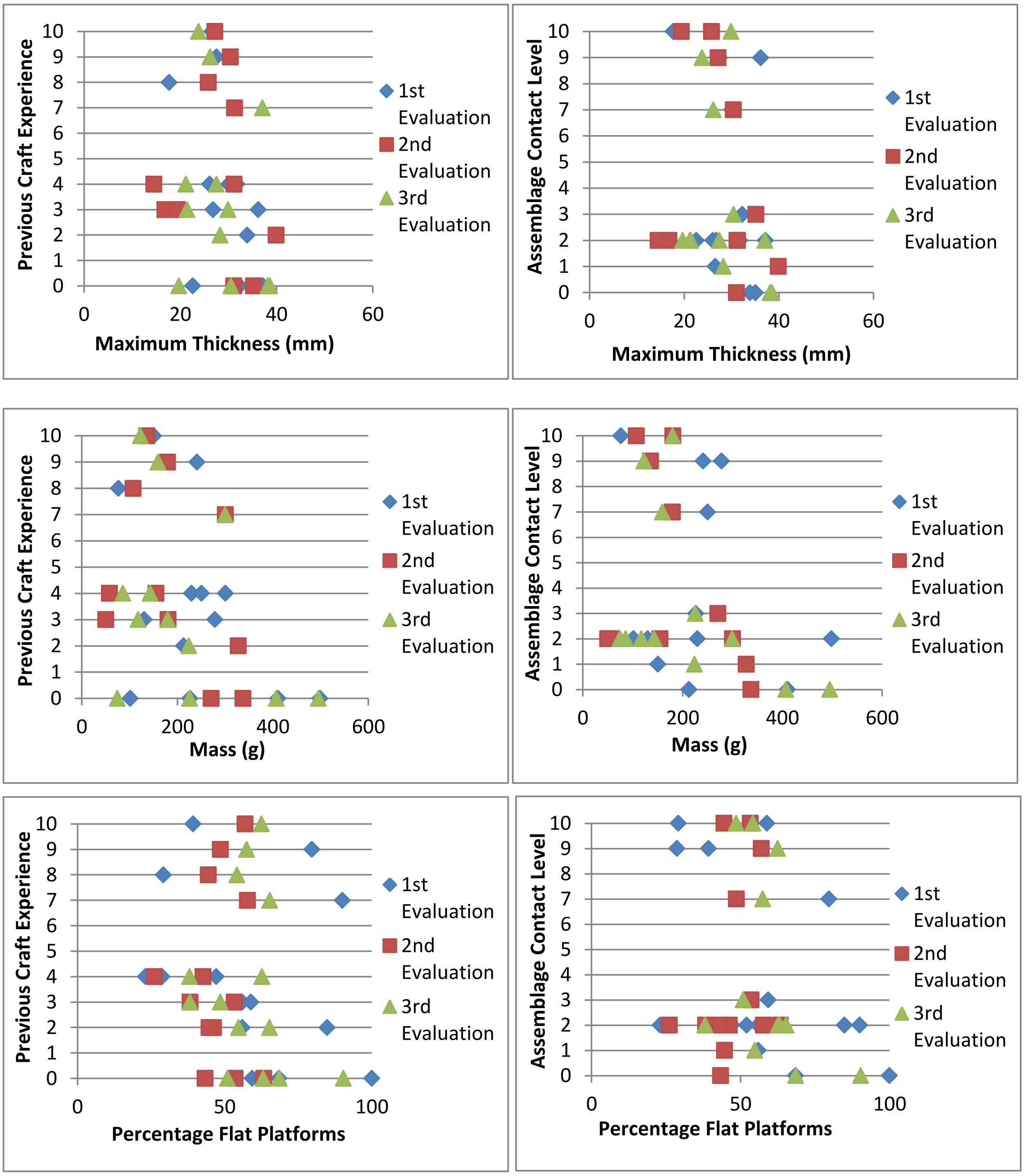


Figure 7.23. Handaxe attributes sensitive to skill, plotted against aptitude measures.

The results for handaxe mass and thickness both show the opposite to the expected result, such that those who had lower levels of previous craft experience and lower levels of assemblage contact produced heavier, thicker handaxes. In contrast the results of the skill score analysis showed these results associated with higher skill levels. When these results are observed in more detail it can be seen that the same levels of association are not seen in the first evaluation as in subsequent evaluations. The first evaluation is the point at which aptitude might be expected to have the greatest effect on performance, suggesting that the patterns seen are due to other factors such as amount of practice and attendance of taught sessions.

In the case of Levallois technology the most significant indicators of skill in terms of material attributes were core maximum length and mass including the preferential flake, maximum preferential flake thickness and preferential flake platform thickness, and dorsal and ventral flake percentages and dorsal flake platform type percentages. These variables were all considered alongside spatial ability score, which was the only area of aptitude that showed some level of correlation with skill scores in this technology (Fig. 7.24). The results of this reveal only preferential flake platform thickness showing a relationship with spatial ability. In the case of this measure, however, as the number of preferential flakes produced was low, the data is less reliable, meaning it would be difficult to apply this to archaeological assemblages.

To summarise, it appears that recognising individual areas of aptitude based on features of materials produced by knapping would be a difficult task. Instead, to address this issue, more experimentation should be carried out investigating the effect natural aptitude has on different types of technologies and knapping activities and from this inferring the necessary aptitude a knapper would need to achieve a particular material form.

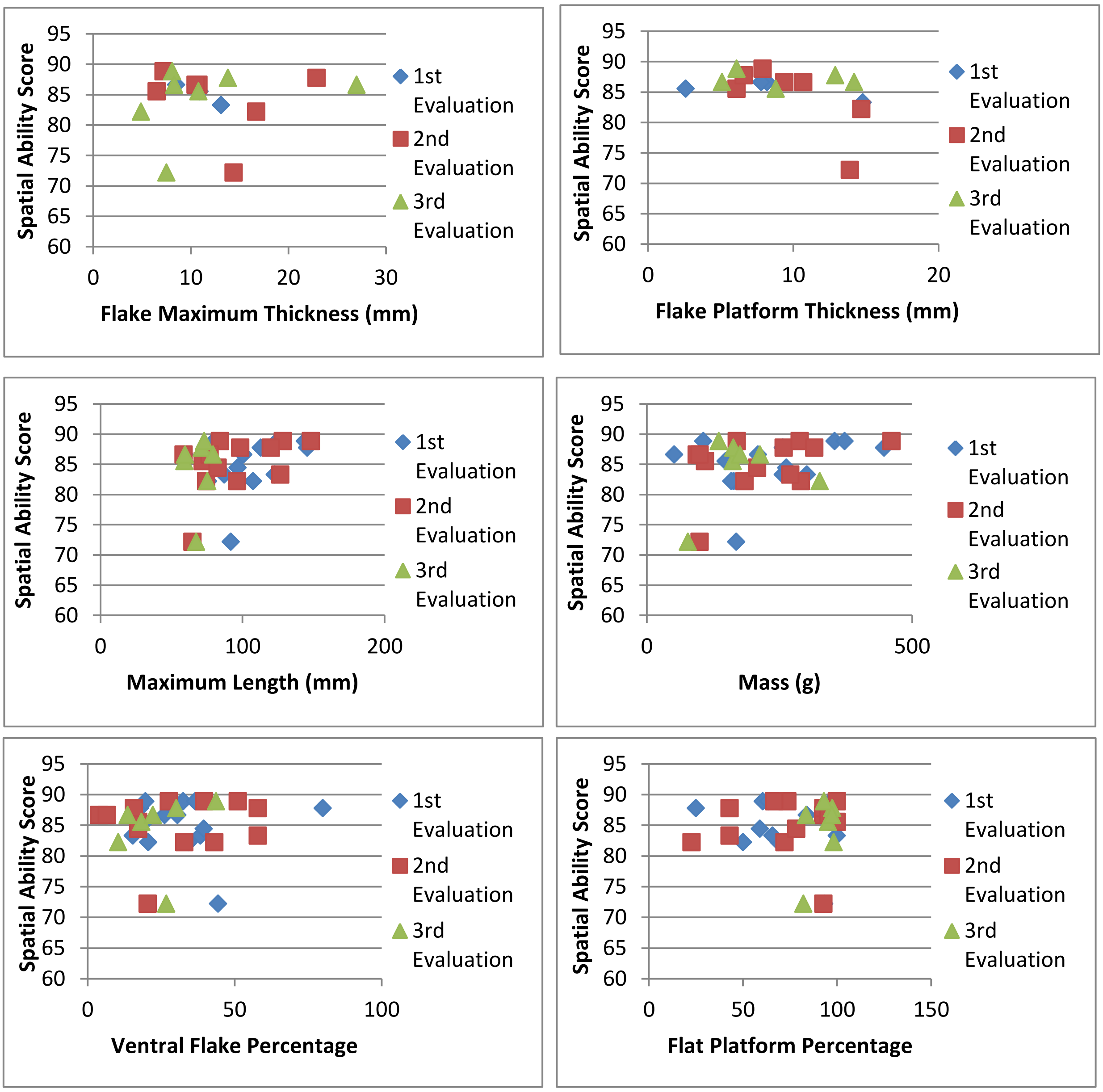


Figure 7.24. Levallois material attributes sensitive to skill plotted against aptitude measures.

7.4 Discussion

The identification of areas of aptitude that may precondition an individual to achieve a high level of skill in flintknapping is an important area of research. The experimental work presented here has provided a useful starting point for future studies, indicating the areas which appear to be the most significant in allowing high levels of skill to be achieved in different technologies. Of those assessed in this project, spatial ability, level of previous craft experience and previous contact were shown to have some impact on the levels of skill achieved by knappers. These results, however, did not present themselves equally for each technology. For Oldowan and Acheulean technology types the greatest influence was from craft skills and assemblage contact. For Levallois spatial ability was the only area that showed some correlation with skill level achieved. These differences highlight the more complex nature of Levallois technology when compared with earlier technologies. Skills gained from other craft types and handling and observation of flaked stone tools gave individuals an advantage when performing flaking and handaxe tasks, but had no obvious effect on Levallois techniques, suggesting that the necessary physical and cognitive skills for successful Levallois reduction go beyond what is necessary for other craft activities. This underlines the cognitive advances that Levallois technology represents compared to previous technologies and hints at the areas of cognitive ability that needed to be developed to allow this technology to be realised.

One of the questions that this thesis aimed to address was the implications that the acquisition of skill in early flaked stone technologies has for the cognitive developments that led to the evolution of modern human brains and intelligence. The areas of aptitude that have been shown to have an influence on skill level achieved give some indication of the cognitive processes that underpin these technologies. In the case of Oldowan and Acheulean handaxe technologies the areas that showed influence involved physical abilities such as manual dexterity and hand/eye co-ordination. This supports work involving brain scans of individuals who had performed flaking tasks, which showed activations in areas involving fine finger movements and manipulation of objects (Stout et al. 2008, 1944–6). In addition, the importance of previous contact with flaked stone assemblages indicates the necessity for forming strong mental templates, particularly in handaxe technologies. The presence of these templates has been much disputed, with some researchers arguing that handaxes give no indication of imposed form and thus no need for mental templates (Noble & Davidson 1996, 195) while others argue for the necessity for these templates and from this the ability of hominins to use symbols and, through this, language (Holloway 1969). The results of this aptitude analysis suggest that having a strong mental image of the required form can significantly speed up the learning process and enable knappers to achieve higher levels of skill in a shorter time frame. Of course, these results can not be directly related to the experiences of early hominin species. The modern knappers studied in the Learning to be Human project were not encountering stone tools in the same way that the prehistoric knappers would. Growing up surrounded by stone tools and stone tool manufacture would influence the formation of mental templates in a different way than studying them in a museum or academic context. The results, however, do suggest that in the modern group of knappers, having a strong mental image of handaxe technology can influence ability to achieve high levels of skill in knapping.

The Levallois results, however, do not show the same influences. Here the only area of aptitude that appears to have an impact on the skill level achieved is spatial ability, and this is only in the first evaluation. From this a number of implications can be drawn. In the case of Oldowan and Acheulean handaxe results spatial ability had limited impact on skill. A knapper with significantly lower than average spatial ability (Knapper K), performed significantly worse in the skill assessments for these technologies than the majority of knappers (Fig. 7.11). With the exception of this all other levels of spatial ability possessed by knappers appeared sufficient for a high level of skill to be obtained. Levallois technology, however, appears to require a greater than average level of spatial ability to achieve high levels of skill at an early stage in learning. This could be explained by the spatial complexity of a technology that allows the shape of the final piece to be predetermined by earlier removals. Previous research into the cognitive underpinnings of Levallois technology have highlighted the complex sequential nature of this activity (Wynn & Coolidge 2011, 84) and the implications this has for the presence of language in the Middle Palaeolithic (Eren & Lycett 2012, 1). Work refitting preferential Levallois cores indicated that the identification of a suitable distal convexity was the determining factor that formed the crux of subsequent removals (Schlanger 1996, 247). This identification relies on three dimensional spatial intelligence and the results of the aptitude analysis underline its importance. Further to this, this research indicates that, as greater levels of spatial abilities were more important for successful Levallois reduction compared with handaxe and simple flaking techniques, evolution of advanced spatial abilities may have been a significant cognitive development during the Middle Palaeolithic.

As well as cognitive implications, the results of the aptitude analysis also have implications for some widely held archaeological assumptions. Due to the fact that most highly skilled modern knappers are male, together with data from some ethnographic studies that shows knapping as a male activity, it is often assumed that flaked stone tool making was carried out by males prehistorically (Bamforth & Finlay 2008, 17). This has been challenged by some researchers who argue that there are accounts of female tool making and that strength is not an issue in most types of flintknapping (Gero 1991, 168, 173). The results of this study suggest that, based on ability alone, it is not possible to suggest modern human males as naturally better able to perform knapping tasks. High and low skilled knappers appeared equally in each sex, for each technology type that was evaluated during the project. Male knappers were not quicker in achieving high levels of skill and showed the same tendencies for loss of savoir-faire ability with lack of practice as female knappers. This does not necessarily mean that knapping was a task that was carried out by both males and females in the Palaeolithic. In this experiment knapping tasks were carried out by modern human knappers and we have no means of relating sexual differences between these groups to early hominin groups. It does, however, demonstrate that, if knapping was the domain of one sex exclusively, this can not currently be explained simply in terms of greater aptitude of this sex to the task. Other social or practical elements to this division of labour must be explored instead.

As a whole, these results begin to hint at the benefits that a greater understanding of aptitude for flintknapping would have for our understanding of the development of Palaeolithic flaked stone technologies. The work carried out here builds on that performed by Olausson (1998; 2008). In some respects the results support Olausson's findings. Spatial intelligence was found to be important as suggested by her survey work, as was manual dexterity. Other aspects of ability, however, could not be assessed from the data provided by volunteers in the Learning to be Human Project. Artistry and musical skill was not assessed here, nor were verbal or non-verbal reasoning, factors that may be relevant if links between language and tool use are confirmed. Future work could build on that presented here by testing for correlations between these areas and knapping skill to obtain a fuller picture of the natural abilities that may influence skill acquisition.

7.5 Conclusion

Understanding the areas that underpin aptitude for flintknapping is a subject that has the potential to provide a large amount of useful information that can aid our comprehension of flaked stone technologies. This is particularly applicable to studies that involve skill and learning. The results presented in this chapter have given insights into areas that are of significance to particular early technologies and can be applied more widely to knapping studies. From the results of this it is suggested that experience with multiple craft types, contact with flaked stone assemblages and high levels of spatial ability are the most significant areas of those assessed, in allowing a high level of skill to be achieved in flaked stone technologies. These areas involve both physical and cognitive aptitude, highlighting the necessity of these two areas of skill in determining the form that knapping performance takes. The way this information relates to connaissance and savoir-faire skills is discussed in more detail in the following chapter (Chapter Eight).

Beyond a simple understanding of the aptitudes that may allow someone to achieve a high level of skill in flintknapping, these results can also contribute to our understanding of the areas of cognitive evolution that allowed early flaked stone technologies to be developed. This has underlined the importance of spatial ability to Levallois reduction, suggesting that developments in this allowed Neanderthals to achieve success in this area. Further work is, of course, necessary to provide more data to support this finding. Focussed aptitude tests that investigate in more detail the areas highlighted as significant in these experiments will provide more information on the exact areas of physical and cognitive ability that are required. Taken together with further brain scanning studies that investigate the areas of the brain that are activated during knapping activities, this data could allow a fuller picture of the cognitive underpinnings of early technologies to be built up. This would provide an unprecedented level of information on the developments that were necessary for stone tool making and how this contributed to the evolution of modern human brains and intelligence.

7.6 Summary of Results

- For Oldowan and Acheulean handaxe technologies previous craft experience and previous contact with flaked stone assemblages had the greatest impact on skill.
- For Levallois technology spatial ability had the greatest impact on skill.
- Previous craft experience correlated best with savoir-faire skill.
- Previous contact with flaked stone assemblages best correlated with connaissance skill.
- Material markers that showed influence of skill did not show the same results for aptitude levels.
- Results suggest that Levallois technology requires greater levels of spatial ability than handaxe manufacture or simple flaking

8. Connaissance and Savoir-faire

8.1 Introduction

Many different areas of understanding and ability contribute to the level of skill an individual achieves in any particular field. In lithic studies, skill is often stated to involve two areas of understanding: connaissance and savoir-faire. One of the main aims of this research project was to investigate in more detail the concepts of connaissance and savoir-faire and how these can be related to archaeological assemblages. This idea of two opposed but linked areas of ability has been at the centre of many skill studies since the terms were first introduced to the field of flaked stone analysis by Pelegrin (1990). In simple terms connaissance is usually taken to refer to knowledge and understanding of the concepts involved in knapping a particular technology. It is often described as cognitive knowledge. Savoir-faire, on the other hand, refers to the know-how and physical abilities required to carry out a technology and is often described as practical knowledge. The level of skill an individual achieves represents the intersection of these two areas of understanding (Bamforth & Finlay 2008, 3). Understanding the different levels of each type of skill required by a particular technology can therefore give information on the cognitive and practical difficulties this technology involves. There does not, however, appear to be an overall consensus as to what each of these types of skill encompasses and how this would manifest itself in archaeological remains, although some researchers have provided suggestions (e.g Apel 2008; Lohse 2010; Roux & David 2005). The experimental work for this project aimed, in some part, to increase the utility of our current understanding of the concepts by providing a data set illustrating the effects of different areas of skill on a knapper's ability to create different forms and technological types, which could be applied to archaeological specimens.

This chapter aims to deal with some of the issues of identifying connaissance and savoir-faire skill by assessing previous work that has been carried out in this area and identifying differences in the ways these two areas have been defined. Comparisons have been made between these definitions and the findings of the Learning to be Human Project. Skill in the project was evaluated explicitly in terms of connaissance and savoir-faire from the start, in the hopes of providing a large data set that could be used to identify material markers that indicated high and low levels of skill in these two areas. The effect of learning in the project on these two areas of skill in the three technologies that the project focuses on is discussed and the means by which these areas of skill were evaluated in the experimental portion of this research is assessed below. This information has been used to suggest further work that should be carried out in order to gain a fuller understanding of the differential appearance of connaissance and savoir-faire in the archaeological record and our interpretations of it in archaeological literature. A fuller understanding of these two concepts are key to any study that aims to look at skill in detail and, for this reason, any work that can help to more fully define these areas will be of great benefit to the field of skill studies.

8.2 Background

As discussed above the concepts of connaissance (knowledge) and savoir-faire (know-how) were first introduced to lithic studies by Jacques Pelegrin (1990). Pelegrin identified these as two fundamental elements which have a distinct neuropsychological nature (Pelegrin 1990, 118). For Pelegrin, connaissance encompassed mental representations of forms and action sequences and involved explicit, declarative memory. Savoir-faire skill on the other hand involved knowledge of spatial and sequential transformations as well as intuitive motor operations. This know-how could only be acquired through practical knapping experience. Following on from this work, other researchers have discussed definitions of these two areas of skill, in attempts to expand our understanding of the concepts (e.g. Apel 2008; Lohse 2010; Olausson 2008). In general these have all highlighted the differences between the abstract connaissance and the physical savoir-faire, but have dissimilarities in the areas of understanding that each category is said to encompass. For instance, for Apel (2008, 98–9) mental pictures of technological forms are part of savoir-faire skill, whereas for Pelegrin (1990, 118) this area fell under connaissance skill. These differences illustrate the fact that the details that these terms encompass are not universally accepted and further work is needed to form firm and reliable definitions.

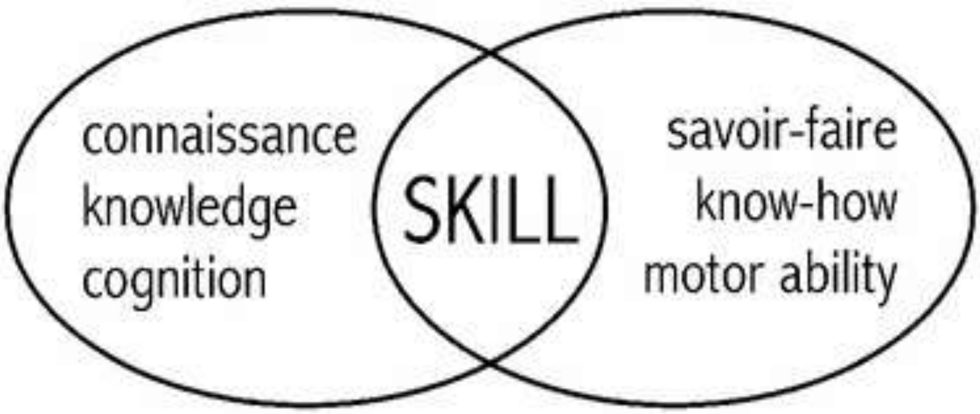


Figure 8.1. Definitions of connaissance and savoir-faire combining to form a person's skill (source: Bamforth and Finlay 2008, Fig. 3).

Bamforth and Finlay (2008), in an overview of the way archaeologists have studied skill, summarised these definitions and highlighted that knapper skill level lies in the intersection between these two areas of ability (Fig. 8.1). Little discussion has been given, however, to the overlap between these two areas of skill and the impact that an increase in level in one area would have on the other area. Without a certain level of understanding of knapping concepts it is not possible to practically continue knapping in a certain technology as mistakes are made that prevent further flake removals succeeding. Similarly without practical experience of a technology it is hard to see how concepts of knapping could be fully understood, particularly in prehistoric periods when the mechanics of conchoidal fracture would not have been explicitly understood. The two areas of understanding can not be entirely separated from each other and viewed in isolation.

It is often stated that savoir-faire is acquired through practice, while connaissance can be transmitted from one knapper to another through words (Apel 2008, 99; Olausson 2008, 30). This dichotomy appears in some ways simplistic, as a means of understanding how knowledge is transmitted in flintknapping. If correct, however, it suggests a route to assessing the need for teaching in early flaked stone technologies. If a technology is shown to require greater levels of connaissance than savoir-faire, then it could be stated that teaching would be of great importance in allowing high levels of skill to be achieved in that technology. This has implications for the social interactions of early hominins, which could give information on their differential cognitive abilities. If this picture of knowledge transfer is correct then the taught sessions in the project would have a greater impact on connaissance level achieved while hours spent practicing would have a greater impact on savoir-faire. This is discussed in the results section below.

Just as definitions of connaissance and savoir-faire differ, their application to archaeological flaked stone technology research show similar variability. In experiments that involve assessment of skill, an understanding of the differences between abstract and physical abilities might be thought to be essential in gaining a full picture of an individual's skill level. This could also be said to be the case for experiments involving testing the efficacy of different teaching and learning methods, as the impact of explicit instruction as opposed to personal practice on different areas of skill could be key. In practice, however, little previous attention has been given to the assessment of connaissance and savoir-faire ability and how they contribute to an individual's overall skill level. Of the experiments listed in Table 2.1, in Chapter Two, only Apel (2008) and Roux and David (2005) make explicit mention of connaissance and savoir-faire as concepts when looking at skill level achieved. In these two cases the ways in which connaissance and savoir-faire were identified and investigated took different forms. In the case of Apel this took the form of the attempted identification of different levels of connaissance and savoir-faire necessary for different stages in the manufacture of Danish Late Neolithic daggers. The levels decided for each stage were based on the judgement of an expert flintknapper (Errett Callahan) and the author (Apel 2008, 95). The results were then used for discussion of skill acquisition in terms of the stages at which an apprentice would undertake on his journey to a master craftsman. Roux and David, on the other hand, aimed to study the different roles of planning and motor abilities in the knapping of stone beads. To do this the action sequences of knappers of different levels of expertise were studied with the result that it was concluded that knowledge of methods and courses of action were not enough to produce high quality examples, with expertise lying in the regulation of elementary movements (Roux & David 2005, 104–5).

Explicit attempts to elucidate the differential effects of connaissance and savoir-faire on skill level achieved in knapping and the differential levels of these required at different technological stages can provide a considerable amount of useful data that gives an unprecedented level of information about knapping ability. The ways in which these areas are identified and tested for, however, need a greater level of standardisation if useful results that can be applied across a range of technologies and experiment types are to be achieved. The experimental evaluation of skill for the Learning to be Human Project was designed to fulfil some of these needs by providing an explicit methodology that aimed at identifying connaissance and savoir-faire skill separately and that could be applied more widely to experiments in this field. The means by which this was accomplished are discussed in the skill evaluation section and an assessment of the success of the methods is discussed in more detail below.

Apart from application of the concepts to experimental studies, researchers have also attempted to find evidence of connaissance and savoir-faire abilities in archaeological assemblages of flaked stone materials. Work that has been carried out in this area includes that by Lohse (2010), as well as some refitting studies that have tackled the issues of connaissance and savoir-faire by reconstructing reduction sequences (e.g. Bodu 1996; Bodu et al. 1990; Schlanger 1996). The work of Lohse involved assessment of the level of skill apparent in a Clovis blade technology assemblage. This enabled the identification of skill based on the levels of connaissance and savoir-faire apparent from differences in technological strategy and occurrence of errors visible on Clovis blade cores (Lohse 2010, 100). Refitting studies may complement this approach by focussing on the knappers' understanding of the technology and physical abilities in completing the required tasks, which are identified and related to the apparent skill level of the knapper. This is usually achieved through recognition of clear mistakes, such as stacked hinge and step fractures or breakage of tools, and by reconstruction of the knapper's strategy through observations of their reduction sequence and their reactions to certain circumstances such as unexpected internal flaws in their raw material (Bodu et al. 1990, 152). Apart from this, refitting studies that focus on identification of connaissance and savoir-faire, such as the work carried out by Schlanger (1996, 202), have used this model to give comment on the cognitive complexity of a particular technology. From this the necessary cognitive capacities of the knapper who made a particular refitted production sequence can be addressed.

The major difficulty with attempts to infer levels of connaissance and savoir-faire from archaeological materials is a lack of understanding of how these would manifest themselves. This is due to a lack of experimental work that has focussed strongly on separate identification of these two areas of skill. While manifestations of low physical ability might be expected to have clear archaeological signatures, for example tools broken during manufacture or flakes with hinge or step terminations, the identification of low levels of understanding of how to flake can be harder to address. Refitting studies provide some information on this area as the reconstruction of entire reduction sequences can reveal technological strategy and problem solving. Situations in which refitting is a possible or useful method that can be applied to materials are, however, very rare. For successful refitting, assemblages must be relatively complete and undisturbed. The majority of stone tool finds to not occur in such a condition. Experimental studies provide a means by which to begin to understand the effect of low skill of knapping on flaked stone tool forms, but this can only successfully be achieved if a clear definition of what constitutes connaissance and savoir-faire has been established.

A clear understanding of the effect of high and low levels of ability in connaissance and savoir-faire on flaked stone materials produced by knappers has clearly not yet been achieved. It is only through experimental work that involves overt attempts to identify different levels of the two areas of skill in a group of knappers, that the effects may be mapped. From the above it can be seen that an understanding of different areas of skill has been of great benefit to the field of lithic studies. Obtaining a fixed definition of the two areas, however, would increase the reliability and comparability of studies that take this as their focus. A greater understanding of the interplay between the two areas would also be of great benefit to the field, especially as regards their effect on the form of flaked stone tools found archaeologically. At the present time we do not have a secure enough understanding of the ways in which a person’s knowledge and know-how effects the forms of stone tool they can produce to successfully identify evidence of low and high levels of each area of skill based on archaeological remains alone. The experimental work carried out as part of the Learning to be Human Project, in part, aimed to provide this data linking connaissance and savoir-faire to produced materials. This, it was hoped, would allow for greater utility of these concepts to archaeological research, taking them from theory into practical applications.

8.3 Skill Evaluations

Skill in the project was evaluated in terms of both connaissance and savoir-faire. To achieve this, skill evaluations during the project were split into two parts, one designed to assess connaissance and one to assess savoir-faire. Skill in connaissance and savoir-faire was considered separately for each of the skill evaluations which took place throughout the project and for this reason it was important that a clear definition of what was meant by the two terms was established. For the purposes of this study areas of skill were defined using the scheme set out by Lohse (2010, 158), which, to a large extent, involves the most frequently applied definitions in each category:

Connaissance: critical thought, problem recognition, decision making, cognitive knowledge.

Savoir-faire: motor ability, dexterity, physical technique, practical knowledge.

Following Pelegrin in describing connaissance as “explicit and declarative” (Pelegrin 1990, 118), it was decided that assessment of connaissance skill would be based on a knapper’s ability to describe successfully how they would perform various knapping tasks for a particular technology. This, it was believed, would give information on the knapper’s understanding of how the technology should progress, what strategy was necessary for success and the decisions that had to be made to solve problems that were apparent in the material they were presented with. In the evaluations knappers were asked to identify where they would strike, with what angle and asked to predict the outcome of the blow. Further to this they were asked to remove flakes that were not only possible, but that were the next best removals for progressing the individual technology on which the evaluation focussed. This, it was assumed, would allow the assessor to establish the knapper’s understanding of technologically focussed strategy for Oldowan, Acheulean handaxe and Levallois technologies. Strategy and action sequences are areas that have been stated as belonging to connaissance skill (Pelegrin 1990, 118).

Knappers also had to consider the outcome of their actions and how it would alter the surface of the core or tool for subsequent removals, as they were asked to describe how they would take two to five flakes from each sample piece. This information related to their ability to visualise outcomes and make decisions based on these. The areas of knowledge that this involves have been related to connaissance skill (Pelegrin 1990, 118). In addition to this, all the sample pieces presented to the knappers contained areas that might be considered as problems that needed to be addressed when knapping. These included cortical areas, cracks in the material, square edges and material inclusions (Chapter Three, Figs 3.3, 3.4 & 3.5). These challenges were intended to test knappers' ability to recognise problems and identify solutions. It was believed that the information provided in this part of the evaluation would successfully indicate their connaissance abilities and thus the score achieved in this area would accurately reflect their understanding of how to knap specific technologies.

In contrast the savoir-faire portion of the skill evaluations involved simply asking a knapper to produce a particular technology type and observing them while this took place. Scores given in this part of the evaluation were based on knappers' physical ability to carry out the technology. This encompassed the areas most often associated with savoir-faire skill – their manual dexterity, including the angle and force of their blows and the position and grip of the piece being shaped and the hammerstone used to shape it. It also involved, however, an assessment of technological strategy as their appeared no clear way of separating this from the physical success of the knapping. Use and style of platform preparation, for instance, was considered as relating to savoir-faire as it was only through these means, in some cases, that flakes could continue to be taken if the edge angles of a piece had been altered to such an extent that no further flaking was possible without adjustment. For this reason it was felt that inclusion of some information on strategy in the savoir-faire scores would not greatly bias the data produced. Savoir-faire skill has been stated to take the form of intuitive knowledge rather than declarative (Apel 2008, 99). For this reason knappers, during this part of the assessment, were not asked to explain their choices or describe how they were about to knap. This enabled the assessors to assign scores based solely on performance without considerations of the knappers success in achieving what they intended or their ability to describe individual techniques or methods. It was hoped that, based on these methods, an accurate picture of a knapper's savoir-faire ability could be built up.

As discussed above, very little experimental work has previously been carried out that expressly attempts to quantify connaissance and savoir-faire skills separately. For this reason methods described above, while based on literature defining connaissance and savoir-faire skill, were not based on previous experimental methodology in this area. As a result of this, it was thought likely that the results produced would highlight areas that needed improvement and methods that should be altered to give more reliable results. This is discussed in more detail in the assessment of success section below. Despite this, as one of the first studies to directly address the dichotomy between connaissance and savoir-faire directly, the methodology does represent an important step in our understanding of skill level from flaked stone assemblages.

8.4 Results

The scores received for connaissance and savoir-faire for each technology have been presented in the technological results chapters (Chapters Four, Five and Six) and analysed to some extent in the aptitude chapter (Chapter Seven). In this section the scores are discussed in greater detail and the relationship between the two variables is assessed. For each evaluation in each technology knappers received two scores out of five, one that related to their connaissance skill and one that related to savoir-faire. Questions that this study aimed to answer included: (1) whether there were differences in the rate at which connaissance and savoir-faire skills were acquired; (2) the effect of practice and teaching on connaissance and savoir-faire skill; (3) the differences between levels of connaissance and savoir-faire necessary for different technologies; (4) the areas of aptitude that might precondition someone to achieve a high level of connaissance and savoir-faire skill; and (5) how high and low levels of connaissance and savoir-faire might manifest themselves in archaeological assemblages. It was hoped that this information could be related to differential cognitive abilities in the different hominin species that practiced the three technologies on which the project focussed and so indicate areas of cognitive evolution that may have contributed to the development of modern human brains and intelligence.

To deal with the first question of those listed above, the identification of the rates at which connaissance and savoir-faire skills are acquired, it can be seen from the results that there are differences in the ways the two areas of ability are learnt. For Oldowan flake and Acheulean handaxe technology connaissance skill scores showed a greater level of stability once achieved than savoir-faire skill scores. Savoir-faire scores in these two technologies decreased as well as increased through the skill evaluations in the project, while connaissance scores, in general, increased sharply between the first and second evaluations and remained stable after this point (Chapter Four, Fig. 4.1, 4.2; Chapter Five Fig. 5.1, 5.2). Levallois technology showed the opposite result with savoir-faire scores more stable than connaissance scores, which were prone to loss of ability for some of the evaluations, with one knapper in fact steadily losing ability across the three skill evaluations for Levallois (Chapter Six, Fig. 6.1). Savoir-faire ability, as a practical skill that involves manual dexterity and physical skill requiring repetitious practice to master, would be expected to be more susceptible to loss of ability, especially if required practice hours were not carried out. Connaissance ability, as a cognitive, explicitly learnt skill would be expected to show less loss, except in cases of loss of memory (Apel 2008, 98). This means that while the results for the Oldowan and Acheulean follow the expected pattern, the Levallois results need more explanation. It is possible that connaissance knowledge required for achieving success in Levallois was not fully acquired by the majority of knappers in the group. For evaluations that took place soon after teaching sessions, knappers may have been able to remember enough of the technology to receive a reasonable score, but never fully understood it. This would mean the more time that elapsed between the taught session and the evaluation, the more likely it would be that knappers forgot what they had been taught.

Following on from this, the question of the effect of teaching and practice hours on skill level achieved must be addressed. In the preceding chapters (Four, Five and Six) scores received for connaissance and savoir-faire were compared with hours spent practicing and in taught sessions and relationships between these factors were highlighted. Based on our current understanding of connaissance and savoir-faire skill, and if the methodology used in the skill evaluations was indeed suitable for correctly identifying skill in these two areas, it would be expected that hours spent in taught sessions would have a greater impact on connaissance skill score and practice hours would have a greater impact on savoir-faire skill score. The results of the analysis showed that for all the three technologies that the project focussed on both teaching and practice had some impact on skill level achieved. For these two variables, however, individual effect on connaissance and savoir-faire skill varied across the technologies. For Oldowan and Acheulean handaxe technology practice and teaching appear to have had an effect on both areas of skill, however, for handaxe, practice had a slightly more significant impact on savoir-faire ability than on connaissance (Chapter Five, Fig. 5.10). Another aspect of the skill scores' relation to practice and teaching was the fact that it is apparent from the results that continued practice was necessary to maintain high levels of skill in savoir-faire in Oldowan and Acheulean handaxe technology. This was not the case with connaissance skill, which, as discussed above, in general remained stable after a high level had been achieved in these two technologies. This necessity for continued practice in the case of savoir-faire skill highlights the practical nature of the task and suggests that the means by which this ability was assessed during the project accurately evaluated the practical aspects of knapping in these technologies.

For Levallois technology a different picture is presented with both taught and practice hours having a greater impact on savoir-faire, than connaissance skill (Chapter Six, Figs 6.4 and 6.6). This was the expected outcome in the case of practice hours, but an unexpected result for teaching. If our assessment of skill in connaissance and savoir-faire for this technology are correct then this result could perhaps be explained by the more cognitively complex nature of Levallois technology compared with the preceding types. It is apparent from the results of the skill evaluations that the majority of knappers did not achieve a full understanding of the requirements and strategies necessary for successful Levallois manufacture during the time period of the project. It is likely that a considerably larger number of taught sessions than was possible during the course of the experiment would be necessary to have an impact on the knappers' connaissance. This hints at the necessity for teaching in this technology, having implications for the social interactions of the Neanderthal knappers who first practiced this technique.

The differences seen in the results for teaching and practice between the three technologies highlights the unique nature of each of the three technologies in regards to the ways in which skill was acquired in each. In Oldowan technology connaissance and savoir-faire scores showed fairly equal representation, with slightly greater tendency for loss of skill in savoir-faire. Handaxe technology showed a greater tendency for loss of savoir-faire skill, while connaissance results appear similar to those seen in Oldowan. Levallois technology, on the other hand showed more stability for savoir-faire results than for connaissance. By considering these results a picture of the different nature of each of these technologies can be built up. Oldowan technology is, in terms of cognitive and practical requirements, not a complex task for modern human knappers to accomplish. In both areas the skills required for high level skill were achievable by all knappers in the project. The skills could be learnt in a relatively short period of time and did not require an extreme level of practice to maintain.

Acheulean technology, in terms of cognitive requirements remains relatively straightforward, with the majority of knappers in the project able to achieve a high level of skill. There does, however, appear to be a greater requirement for physical skills in this technology. Scores achieved for savoir-faire in handaxe manufacture were, in general, lower than those seen for simple flaking and this area of skill showed a greater loss if practice levels were not maintained. This suggests an advance in manual dexterity and physical ability between the periods when Oldowan was the predominant technology and periods when handaxes were in use. Physically, handaxe technology requires a greater control over the three dimensional manipulation of an object as removals are made to produce a specific shape, rather than simply a sharp edge. It is also apparent that the skills required to achieve high level skill in this technology were not obtainable by all the knappers in the project. This is highlighted in the results comparing the spatial ability scores with scores received for savoir-faire in this technology. In this case, while an average level of spatial ability was sufficient to allow a high skill level to be achieved, a knapper with a significantly lower level of spatial ability to the majority of the group produced very poor results and, in the first evaluation, was unable to visualise shaping the handaxe to such a degree that the piece was knapped unifacially. This illustrates the fact that, while average levels of spatial ability among modern humans are sufficient for high levels of skill to be achieved, low levels of spatial ability prevent successful handaxe manufacture. From the first evaluation, scores were very variable and in some cases remained this way through the subsequent evaluations, even among knappers who had performed similar levels of practice and attended similar numbers of practice sessions (Fig. 8.2). This hints at near modern human levels of manual dexterity as a requirement for the examples of highest skill level knapping of handaxes.

Figure 8.2. Handaxes produced in the final evaluation by knapper D (left) and knapper G, displaying different levels of skill. These knappers had similar levels of practice (photo: Whitlock 2013).

In Levallois technology the results show a more confused picture. While savoir-faire scores remained stable after an initial increase, connaissance skills were much more variable, showing loss as well as gain through the three skill evaluations. From this it can be surmised that Levallois technology involves a far greater cognitive engagement than Oldowan flake or Acheulean handaxe. The level of physical skill required, on the other hand, appears to be less than for handaxe technology and at a similar level to flaking. This is reflected by the fact that technologically focussed practice had a greater impact on skill for handaxe technology than for Levallois. This meant that while improvements in skill seen in handaxe technology were predominately tied to increased hours of practice in handaxe and biface technologies, all knapping practice contributed to the scores received for Levallois technology (rather than just Levallois knapping practice). The cognitive requirements, however, appear to be of a much higher level than the practical and compared to those required for simple flaking and handaxe manufacture. Similar to the way savoir-faire skills were lost in handaxe technology, connaissance skills were lost in Levallois if knappers did not maintain high levels of practice and attendance of taught sessions through the project. This suggests that, for the majority of knappers the requirements of the technology were not, at any point, fully understood. Without a full understanding of the sequences of action necessary for the technology, if frequent practice or teaching did not take place, knappers were unable to explicitly state the requirements of the technology during the evaluations. This suggests that the major advances seen between handaxe and Levallois manufacturers were cognitive, more than physical, in nature and involved increases in abilities for retaining understanding of complex sequences of actions and strategies. The fact that no knapper achieved the highest scores possible in this technology for savoir-faire (contrary to scores seen in handaxe and flaking evaluations) suggests that physical abilities may not be entirely separable from cognitive. The concepts of embodied cognition provide a model for explaining this (Ingold 2000, 375–6).This theory highlights the importance of the physical changes that arise as a result of learning in affecting how skill manifests itself, beyond a simple dichotomy between cognitive knowledge and physical ability.

This is reflected in the results of the spatial ability aptitude evaluations when compared to scores received for connaissance and savoir-faire. In the first evaluation for Levallois, scores for both connaissance and savoir-faire correlate well with the spatial abilities of the knappers. This highlights the importance of spatial ability in this technology, especially in the early stages of the project. This correlation was not seen in the other technologies suggesting that advancement of spatial abilities was a significant area of development for Neanderthals. The differences seen in the requirements of these three technologies reflect the increasing complexity of behaviour from the Lower to

Middle Palaeolithic. Observing the differences in connaissance and savoir-faire allows inference to be made about the necessary areas of cognitive advancement that allowed these technologies to be realised. Although this information is highly speculative, it has suggested areas that future research may focus on, with the potential to provide new information about early hominin cognitive processes.

The three technologies on which the project focussed have each been shown to have a unique character with regards to the ways in which connaissance and savoir-faire skill are acquired and are represented in the results. In many respects, however, it can be seen that the results for Oldowan style flaking and Acheulean handaxe technology show a greater degree of similarity to each other than to the results for Levallois technology. This is likely due to the more advanced nature of Levallois technology, especially in terms of the concepts that must be understood for successful manufacture. These differences hint at the cognitive advancements that existed between the Neanderthal Levallois knappers and the *Homo erectus* and *heidelbergensis* handaxe knappers. Apart from differences in the effect of teaching and practice on this technology Oldowan flake and Acheulean handaxe both showed similarities in areas of aptitude for which a high level was required to achieve a high level of success, whereas a different pattern was seen for Levallois.

When the overall effect of the aptitude measures tested prior to the start of the project on connaissance and savoir-faire skill scores are considered it can be seen that, while some aptitude areas affected both equally, others had a specific influence on one area of skill. Where there was a noticeable difference in the effect of aptitude on skill level, a high level of previous craft experience best predicted a high score in savoir-faire skill evaluations, while a high level of previous contact with flaked stone materials best predicted a high score in connaissance skill evaluations. These results conform to the expected picture for aptitude in flaked stone technologies. It would be expected that experience of craftwork would precondition someone to achieve a high level of success in savoir-faire as it necessarily involves experience of physical activities, which would likely improve manual dexterity, hand/eye co-ordination and strength. Contact with flaked stone assemblages, on the other hand, implies greater knowledge and understanding of flaked stone materials. As, in many cases, this contact took place as part of an academic class it may also imply greater background knowledge of flake mechanics and thus an increased ability to successfully predict flake outcomes. Further to this, contact with flaked stone materials may help knappers to produce a better mental template of the form a stone tool type should take. This area of ability has been suggested as being part of both connaissance and savoir-faire ability but the results of this analysis suggest it would fit most closely into a connaissance model.

The results described above were shown in the Acheulean and Oldowan evaluations, but were not apparent to such an extent in the Levallois results. Here the only area that showed some correlation was spatial ability with the first Levallois evaluation, as discussed above. There are two possible explanations for these differences. The first is that the methodology, while suitable for identifying levels of connaissance and savoir-faire in simple flaking and handaxe technologies, is not applicable to Levallois technology. The second is that Levallois connaissance and savoir-faire are not subject to the same influence of aptitude as the other technologies. The assessment of success of the methodology is discussed in more detail below, but if the second explanation is correct then perhaps, in the case of connaissance ability, the requirements for this technology were too complex to be influenced by contact with flaked stone materials. Additionally, as a more complex technology, the sequence of actions that represents successful Levallois manufacture may not be covered in introductory classes involving artefact handling and flaked stone tool types. The results seen for savoir-faire are harder to explain as it seems likely that the physical skills needed in many craft types would also be applicable to Levallois assemblages. The results seen here may be due to the majority of knappers who showed high levels of previous craft experience belonging to the wider group. This group, in general, had lower levels of practice and poorer attendance of taught sessions, which may have influenced the scores they received for Levallois despite their high levels of physical ability in other craft areas. The aptitude analysis as a whole has been helpful in highlighting areas of ability that influence skill in connaissance and savoir-faire, as well as indicating results that may represent problems with the skill evaluation methodology.

The above results have provided useful information through which suppositions about the nature of connaissance and savoir-faire and the implications these have for the development of modern human brains and intelligence can be constructed. In order that this data is truly applicable to archaeological materials, however, it would be necessary to identify the effect different levels of connaissance and savoir-faire ability have on the materials produced during flaked stone tool manufacture. In each of the skill chapters (Four, Five and Six) individual material attributes of the items produced in the skill evaluations were assessed in terms of their correlations with skill scores for connaissance and savoir-faire. While the majority of attributes showed similar influence from connaissance and savoir-faire levels, this analysis revealed some material markers that showed greater correlation with levels in one area of skill rather than the other. To summarise this information, areas that showed a greater influence from connaissance were for Levallois technology: maximum thickness of preferential flake, platform thickness for preferential flake and mass of preferential flake. These areas are all related to the preferential Levallois flake produced by some knappers during the savoir-faire portion of the skill evaluations. Only markers of Levallois technology showed greater influence from connaissance than savoir-faire. This highlights the importance of connaissance ability in allowing successful manufacture in this technology compared with the other techniques. It also highlights the difficulty of inferring connaissance levels from archaeological remains as very few material attributes showed greater influence from connaissance than savoir-faire.

Areas that showed a greater influence from savoir-faire included for Oldowan technology: number of flakes produced and flake length, for Acheulean handaxe technology: handaxe maximum thickness and index of asymmetry for plan view, for Levallois technology: maximum length of core, core mass, number of debitage flakes produced per 100g, debitage termination type percentages, dorsal/ventral flake counts and debitage platform type percentages. As would be expected due to the physical nature of savoir-faire ability, far more material markers showed a greater influence of savoir-faire than for connaissance. Number of flakes produced and maximum length of items produced are highlighted as the most prevalent areas for influence of savoir-faire ability across the three technologies.

This information suggests means by which it would be possible to identify the differing levels of connaissance and savoir-faire ability of which a knapper's skill level consists. This method, however, can not provide even close to the level of information it was possible to discern from knapping performance. Perhaps the only way it would be possible to access knapping performance based on archaeological remains is through refitting studies. Although only useful in cases where the majority of the reduction sequence remains in situ, this technique can provide an unprecedented level of information about an individual's strategy and decision making as well as identifying physical ability through identification of missed hits and knapping errors. The few material attributes that showed a high level of influence from connaissance skill illustrate the importance of this method for identifying this area of skill. The work reported by Schlanger (1996), for instance, of the refitting of a Levallois reduction sequence provided information about the strategy employed by the Neanderthal knapper and through this their cognitive abilities. From the results of this study it was clear that identifying a suitable distal convexity was the most important factor in determining subsequent removals. Without refitting, this element of the knapper's strategic planning would be unknown. This may be the best method for identifying differing levels of different types of skill in the work of prehistoric knappers, however, the information provided by the material attribute analysis from this experimental work gives suggestions for methods to use if suitable collections are unavailable. This is particularly the case for Levallois technology, in which the clearest distinction was shown in attributes that were influenced by individual areas of skill. Levallois technology did, however, have the smallest sample size for testing and thus further work is needed to test whether the patterns observed in this work are replicated in future experiments.

In summary, the results of the Learning to be Human experimental program have revealed new information that help us understand the areas of skill that fit into the categories of connaissance and savoir-faire. The differences of required levels of each to allow high skill levels to be achieved in each of the evaluated technologies paints a picture of gradually increasing complexity through the three technology types. Interestingly the greatest advance seen between flaking and handaxe manufacture is in physical, rather than cognitive, ability. This reflects a need for greater control over the position, force and angle of the blows used to remove bifacial flakes for successful handaxe thinning and shaping. Levallois technology, however, shows a requirement for far greater connaissance reflecting a much more cognitively complex technology compared to the earlier techniques. The physical requirements for this technology remained much the same as for simple flaking. Levallois technology, however, also requires a degree of spatial awareness such that high levels of spatial ability allowed the knappers who possessed this to achieve highly skilled performances at an early stage in the project. This information on differing cognitive complexity backs up previous work investigating the cognitive requirements for Levallois that have highlighted the importance of an understanding of complex strategies for highly skilled performance. All the three technologies have been shown, however, to require at least average levels of spatial ability to allow a high level of skill to be achieved, particularly in terms of savoir-faire. This demonstrates the levels of cognitive capability in this area that is represented by highly skilled examples of this work found in the archaeological record. The analysis of these results has also highlighted areas of the methodology that may need improvement or refinement to produce truly reliable results for identifying connaissance and savoir-faire skill. These are discussed in more detail in section 8.7 below.

8.5 Implications for Interpreting Hominin Behaviour

Beyond the implications for different technological requirements for connaissance and savoir-faire discussed above, the experimental results can be shown to have implications for reconstructions of hominin behaviour and social lives. While there is always the limiting factor of the use of modern human experimental subjects, it is possible to use the evidence detailed above to discuss aspects of hominin life that have been highlighted by other researchers. In this section I will focus on the evidence of the importance of practice, the presence of individual variability and the unique challenges of Levallois technology as areas that the experimental results produced during the Learning to be Human project can address.

One of the major findings of the comparison of time spent practicing with skill levels achieved for connaissance and savoir-faire was the importance of continuing practice hours in order to allow a high level of skill to be maintained. The results clearly showed that for some individuals a reduction in hours spent practicing corresponded with a loss in skill that was particularly apparent in terms of savoir-faire skill (Figs 4.6, 5.9 & 6.7). This need for continued practice has implications for the behaviour of early hominins and the interpretation of early knapping sites. For instance, sites where a huge quantity of knapped materials are found, such as Boxgrove (Pope & Roberts 2005), Cuxton (Shaw & White 2003) and Broom (Hosfield & Chambers 2009) may be the result of this need for practice to maintain skills in an environment where raw material was effectively unlimited. 'Habitual' resharpening of handaxes can be seen in the same light (e.g. evidence from Boxgrove; Pettitt & White 2012, 157). This phenomenon could be the result of hominin knappers necessarily needing to knap on a regular basis or risk losing knapping skill. This is supported by evidence of fireside knapping from Beeches pit in Suffolk (Preece et al. 2006). Here the spatial distribution of debitage, nodules, handaxes and hearth features suggests that hominins performed several handaxe manufacturing sequences around a fire. The fact that knapping was apparently integrated in hominin life to such an extent suggests that continued knapping practice was recognised as important in Palaeolithic times, as it was in the experimental results reported here.

A major focus of many studies of prehistoric flintknapping has been the potential to identify individual variability in the tools and patterns of debitage produced by knappers (e.g. Gamble & Porr 2005). While this was not one of the factors addressed directly in the experiment, some indications of individual variability were identified in the group. This is particularly interesting as all knappers in the group were taught by the same people and thus variability could be thought likely to be limited. One of the areas where this individual variation can be seen most clearly is in the time individual knappers took to perform handaxe and Levallois technologies. While this showed wide variation between individuals it could not be related to skill or levels of teaching and practice (Figs 5.5, 5.6 & 6.4). Time taken did, however, show strong consistency between each evaluation for individuals, suggesting that knapper choice played a big part in determining this factor. Other factors that showed strong links to individual knappers included tendency to break handaxes. One knapper (C) broke handaxes in each of his evaluations. This knapper was also observed to have a particular style of blow that did not alter between evaluations. These areas of individual variation suggest that there is the potential to identify knappers, even if teaching was provided by the same person to all. This information can be related to the concept of routinized behaviour, particularly when this is seen in terms of the chaîne opératoire of handaxe manufacture. This is a way to access the individual in the Palaeolithic by investigating personal routines of behaviour such as stone tool manufacture and food processing (Gamble 1996, 63–71). The experimental results suggest that routines of behaviour can be established very early in the process of learning to knap and can be quite resistant to change. Further analysis of knapping behaviour through examination of the videos of skill evaluations will be able to shed more light on this issue and highlight the individual nature of knapping choices.

The results of the analysis of skill and Levallis technology have revealed that this type of flaked stone manufacture appears to be separated from handaxe and Oldowan style flaking both in terms of complexity and in the amount of time needed to master the technique. This has implications for previous interpretations of Neanderthal life cycles and for the long-term working memory model suggested by Wynn and Coolidge for understanding Neanderthal cognition (Wynn & Coolidge 2011). Interpretations of the Neanderthal life cycle and childhood stages have indicated that Neanderthals may have had a shorter childhood than modern human populations (Pettitt 2000; Ramirez Rozzi & Bermudez de Castro 2004). There are also indications that very few Neanderthal individuals lived beyond the age of 40. This relatively short childhood and lifespan could be said to limit the learning time available to Neanderthal knappers, as it is likely the majority of skills learning took place in childhood, and the potential for master knappers to be available to teach skills to the next generation. No knapper in the group fully mastered the technology in the nearly two year period of experimental knapping, suggesting that a significant portion of time needs to be devoted to Levallois technology to allow high levels of skill to be achieved. This would significantly impact on the short Neanderthal childhoods and might explain sites such as Baker's Hole in Kent where an extremely large number of Levallois sequences are found (Scott 2010).

The failure of the majority of the group to fully understand the concepts that lie behind Levallois manufacture point to the cognitive complexity required to successfully produce a preferential Levallois flake. This complexity has been seen in terms of working memory by Wynn and Coolidge (2004; 2011). Long-term working memory is the long term storage of information on skills and motor behaviours that does not fade rapidly and can be called upon when knapping. Wynn and Coolidge have demonstrated through the analysis of refitted sequences of Levallois removals that this type of memory could have been utilised by Neanderthal knappers (Wynn & Coolidge 2011, 100). They also state that it can take more time to establish than verbal or declarative memories (Wynn & Coolidge 2004, 470). While the results of the experiments can not conclusively point to the existence of a long- term working memory, they do give indications that support the idea. Knappers had not established the necessary skills and understanding in their long-term working memories and thus were not able to call upon them in later evaluations. In the first evaluation knappers still had a verbal or declarative memory of being instructed to perform knapping tasks and thus were able to achieve higher scores for connaissance at the beginning of the evaluations than the end. Further practice and teaching would have been necessary for them to establish the sequences and behaviours necessary for successful knapping in their long-term working memory.

The above information highlights some areas in which the experimental results can begin to address concepts of hominin behaviour. Further analysis of the experimental data, particularly in terms of analysis of individual knapper choice in the videos of skill assessments and comments on the learning process are likely to provide more information that can be related to behaviour. This suggests the importance of experimental projects for addressing theories of hominin behaviour in the Palaeolithic and points to ways to back up archaeological interpretations.

8.6 Case Studies

In this section the potential of the results will be illustrated by the use of two case studies that highlight the extent of the information that can be gained from a long term experimental study of this nature. The first relates some of the differences noted in the learning of male and female knappers in the group and the second highlights some of the problems an individual knapper had with learning to knap in different situations. These anecdotal accounts illustrate the actual reality that lies behind the empirical data of the skill evaluations and materials analysis and indicate how much information that can be missed if measurements alone are relied upon. The further studies discussed in the section below will build on the work described here to more fully build up a picture of knappers' learning during the project.

Case Study 1:

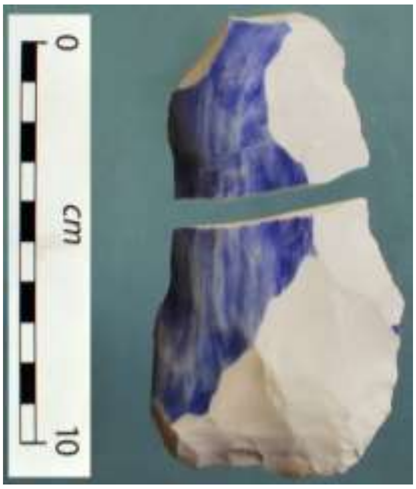


Figure 8.3. Broken handaxe made by knapper C.

The skill assessment results for each of the technologies show that male and female knappers produce the same range of skill results with no clear pattern of either sex being better able to perform flaked stone technologies (Figs 7.4, 7.13 & 7.19). Observations of knappers through the project, however, did reveal some differences in the way men and women learned to knap. While these differences can not be related to hominin behaviour, they do have some interesting implications for the reasons the majority of modern flintknappers are male. When given free choice of raw material male knappers tended to choose larger initial flint nodules and flakes than female knappers, as well as bigger hammerstones. While this can, to some extent, be related to knapper hand size (women tend to have smaller hands, making larger hammerstones hard to handle) this can not entirely account for it. Men also had more of a tendency to break the pieces they made across the technology types that were practiced and to produce fatal overshot terminations in Levallois and bifacial technology types (Fig 8.3). This can be seen in the results of the skill assessments and was also apparent through practice sessions and seems to stem from hitting tools too hard. While Levallois was by far the least popular technology of those introduced to the experimental group, in the core group (which consisted of 2 female and 6 male knappers) Levallois was practiced more extensively by female knappers and was more successfully performed (Fig. 8.4). While some parts of Levallois technology require a certain amount of force, the majority of the process favours accuracy over large amounts of strength. Male knappers in the group tended to prefer knapping bifaces. Bifacial knapping is one of the most popular techniques with modern commercial flintknappers, while very few of these individuals produce Levallois cores at a high level. The fact that the majority of modern knappers are male may be connected with this.

Figure 8.4. Levallois cores and flakes produced by knappers E and H.

Case Study 2:

Fig 8.5 First core produced by knapper B.

This case study deals with knapper B, who performed consistently poorly in the skill assessments for the more complex handaxe and Levallois technologies. This knapper showed no real control over knapping from the start of the project (Fig. 8.5) and showed no large improvement at any stage (Fig. 8.6). He had a strong tendency to batter edges and

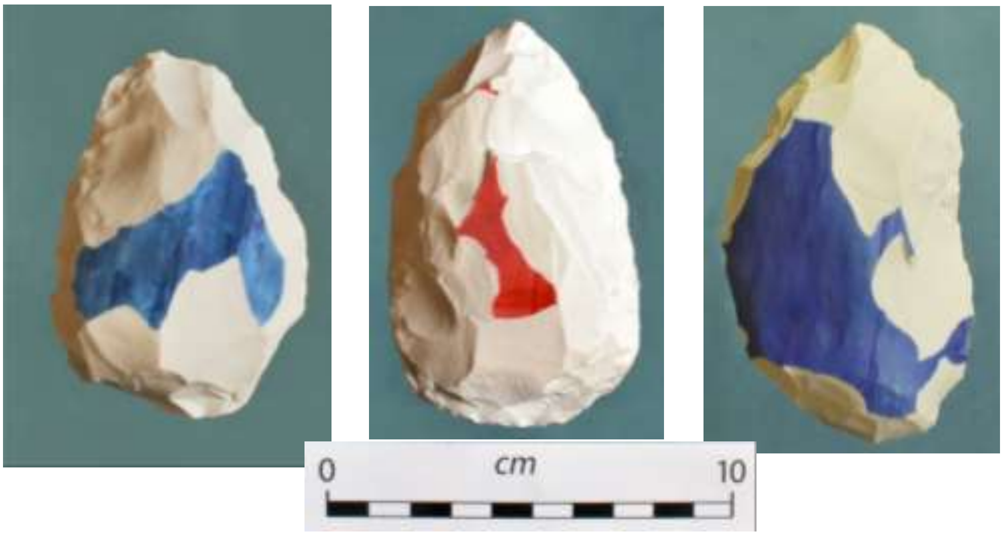


Figure 8.6. Handaxes produced in each evaluation by knapper B.

rarely performed any type of platform preparation. For the transmission chain experiments that formed a separate part of the project knappers were asked to copy the work of each other. When this was done without guidance knapper B produced handaxes similar to those he produced during the skill assessments – with features that indicated low skilled knapping and very little control over the shape of the product. One of the experiments for the transmission chain, however, required direct supervision while handaxe manufacture was taking place. When this task was in progress each blow was directed by an expert knapper, although only verbal, not physical intervention took place. The handaxe produced by knapper B, in this case, showed signs of highly skilled work. The piece was thin relative to its width, it showed a clear defined shape and no edge battering (Fig. 8.7). This indicates that the knapper did have the motor skills to carry out the task, he was just unable to perform the technology without direct supervision. This case study indicates the complex nature of skill in handaxe technology. Even with adequate motor skills and multiple teaching and practice sessions knapper B was not able to produce a handaxe showing signs of expert ability due to his lack of understanding of the sequence of operations needed for this task. This also highlights the fact that it can be hard

Figure 8.7. Handaxe showing expert performance

to assess skills based on asking an individual knapper to produce a single tool.

8.7 Assessment of Success and Further Work

The methodology for this work represents one of the few experimental research projects to expressly attempt to identify knapper skill in connaissance and savoir-faire separately. As such the means by which connaissance and savoir-faire skill are identified and assessed are innovative and not replicative of previous successful experiments. For this reason a consideration of the success of this project, in separating a knapper's connaissance from their savoir-faire ability, and in accurately assigning a score to this, is necessary if the reliability of the results is to be established. In order to investigate this, the results of the project are considered in terms of the expected results based on previous literature that has evaluated the concepts of connaissance and savoir-faire. This is, of necessity, a speculative approach and without further work in this area, to some extent replicating the methodology used here with different groups of knappers, it is not be possible to properly assess the utility of these methods. For this reason the assessment of success is followed by suggestions for future work that may be used to provide a greater level of information on the identification of connaissance and savoir-faire based on archaeological remains. The assessment of success focusses on three key areas. First, the areas of ability that were considered to belong to the connaissance and savoir-faire categories are assessed. Secondly, the accuracy of the two areas of the skill evaluation in identifying the individual areas of ability is considered. Finally, the choice of areas of aptitude for investigation is discussed.

The areas of understanding that were considered as representative of connaissance and savoir-faire were taken from Lohse (2010, 158). This work was chosen as the areas stated (listed in skill evaluation section above) represented those areas that were most often assigned to each category in the literature, excluding those that were disputed. From the results of the project the two areas, thus described, do appear to represent distinct spheres of knowledge. This is apparent from the fact that in the skill evaluations, clearly different patterns were seen in the way skill was acquired in each area. For Oldowan and Acheulean technologies, however, the patterns of learning seen for savoir-faire do not fit well into the template set out by Pelegrin (1990, 119). In this work he states that motor skill is remarkably persistent, maintaining itself even when practice is intermittent. This was not shown to be the case for these technologies. Savoir-faire score appeared highly dependent on continued practice in the technology with much loss of skill seen as practice levels dropped. The opposite picture was, however, seen for Levallois technology with stable levels of savoir-faire ability produced. Despite these issues the distinct results for connaissance and savoir-faire learning clearly indicate that two separate areas of skill are represented. These areas to some extent show different rates of skill acquisition and are affected differently by factors such as practice, teaching and aptitude.

The second area that must be addressed is the accuracy of the two parts of the skill evaluations for identifying the individual areas of skill. From the analysis of the results of the skill evaluations, compared with the literature describing the different areas of skill, the methods used in the connaissance skill evaluation do accurately test for factors that relate to connaissance skill. An area that is often highlighted as an important feature of connaissance is explicit knowledge. The fact that knappers in the evaluations had to describe their choice of flake removal required them to express their explicit understanding of how to knap a particular technology and thus scores received would include this area of connaissance. Other areas that were intended to be assessed in this section of the evaluations were decision making, critical thought and problem recognition. The fact that the sample cores used for this part of the evaluation included areas of difficulty allowed problem solving abilities for each technology to be assessed. Indeed, one of the most common comments on performance in the connaissance evaluations was that knappers did not deal with the most significant problem on the piece. This also allowed assessment of their decision making. The fact that knappers were required to described two to five removals for each piece also allowed strategic planning to be assessed, fully covering the areas of skill that have been taken to belong to the connaissance category.

In terms of evaluation of savoir-faire skill, however, there are some problems with the separation of this area from connaissance. Assessment of performance in savoir-fare involved observing a knapper physically manufacturing flakes, a handaxe, and a Levallois core and preferential flake.

This necessarily involved knappers utilising both their connaissance and their savoir-faire abilities and will doubtless have had an effect on the score for skill received in this part of the evaluation. While evaluation by experienced knappers was focussed on assessing the physical aspects of the knapper's performance for the savoir-faire evaluation, the knappers' technological strategy and cognitive understanding of how to knap will have influenced the physical aspects of their performance. The neurological changes that come about through increased physical practice must also have an impact on knappers physical and cognitive skill (Ingold 2000; Stout et al. 2008). This means it would be difficult, if not impossible, when observing their performance to separate the physical from cognitive aspects of their skill. The scores received for savoir-faire then, are not solely representative of their physical ability. It has been shown, however, that there were clear differences in the ways skill was acquired in the two areas assessed by the project. This suggests that, while savoir-faire scores may have included aspects of connaissance ability, to some extent they can be used to give information on how physical abilities were learnt throughout the project.

The third area highlighted for assessment of success is the choice of areas of aptitude that would best relate to flintknapping ability. With the exception of sex all the assessed areas prior to the start of the project showed some level of correlation with skill score for either connaissance or savoir-faire in at least one of the technologies that was evaluated. This suggests that all the areas assessed could be related to flintknapping ability to some degree. Based on the results of the aptitude analysis, however, suggestions can be made as to other areas of aptitude that could be usefully assessed to give information on the likely level of skill a knapper could achieve. These include physical measures of hand size, arm length, height and weight. As the increased requirements between Oldowan flaking and Acheulean handaxe were physical more than cognitive these measures could give useful information on the likely physical capabilities of a knapper and indicate which areas of physical attributes precondition someone to achieve a high level of success in this technology. Other than these areas, aptitude tests that could give further information about the strategic planning and problem solving abilities of individuals could be useful for indicating further the cognitive abilities of a knapper that would relate to their abilities to perform complex technologies. A full scheme of aptitude tests based around these areas, in addition to the measures that were used in the Learning to be Human Project, would be invaluable in providing information on the areas of natural ability that may precondition someone to achieve a high level of skill in early flaked stone technologies.

Apart from the above, it can be suggested that the biggest impact that future work could make is in achieving a fuller understanding of savoir-faire ability. A study that could fully separate the connaissance skill from the savoir-faire, if this is indeed possible, would be a useful advance in our understanding of the ways skill in this area is acquired. If aptitude tests were applied it could also help to indicate the areas of natural ability that would precondition someone to gain a high level of skill in this area. To do this accurately it would be necessary to separate the physical abilities necessary for knapping a particular technology from their technological strategy understanding, that fits better into the connaissance area of skill. This could involve, rather than simply asking a knapper to create a handaxe or Levallois core as was the case in the skill evaluations in this project, asking them to perform particular knapping tasks on a core or tool that had been pre-formed to a particular place in the technological sequence. Additionally this could involve removing individual flakes using unifacial or bifacial style of knapping or performing platform preparation tasks isolated from the reduction sequence. Scores could then be given to knappers based only on their physical ability to carry out a particular task, rather than this combined with their technological strategy. This methodology would run the risk of separating the testing too far from the original activity but represents a possible means by which skill in savoir-faire could be entirely separated from connaissance. This was not achieved successfully by the methods employed in the project’s skill evaluations.

Beyond this, repetition of the methods employed in the project, using larger groups of knappers, with more varied backgrounds would be the most useful area of future work. The results of the comparison of age with scores achieved in knapping gave some indication that savoir-faire abilities were more prone to loss in older knappers (Chapter 7, Fig. 7.5). As the majority of the group were aged 18-25, however, these results could not be relied upon as a true reflection of the effects of age. A study that included a wide range of ages would be able to test the reliability of the patterns observed here. Further to this, a study involving observing children learning knapping skills would be invaluable. It is known from ethnographic accounts that, among modern human knapping groups, children as young as 10 have been engaged in knapping activities (Roux & David 2005, 93). It is likely, therefore, that knapping skills were first learnt in childhood prehistorically. It is also clear that children learn new skills, particularly physical skills, in a different way to adults (Finlay 2013, 155). For this reason, if an understanding of prehistoric skill acquisition, based on archaeological remains, is to be achieved studies involving children could be key. Studies focussing solely on people with wide experience of various crafts could also be useful as it is likely that physical skills were more extensive in prehistoric periods than they are among the majority of students studied in the project. This may have had an impact on the results seen for savoir-faire in the skill evaluations. These suggested methods have the potential to build on the results of the experimental program described in this work to enable a more complete understanding of flintknapping skill acquisition and its utility in identifying connaissance and savoir-faire skill.

The methodology utilised in this project is innovative in many respects, particularly with regards to the clear distinction that it made between connaissance and savoir-faire ability. There have been shown to be some issues with the ways savoir-faire ability was identified and evaluated. Despite this, it is clear from the results that a distinction is apparent in the ways connaissance and savoir-faire abilities were acquired and the ways they impacted the performance of the knapper in the three technologies on which the project focusses. Work to refine the methodology and the utilisation of volunteers with varied background would be of great use in extending our understanding of the ways connaissance and savoir-faire skill are acquired and of the implications this has for the evolution of modern human brains and intelligence.

8.8 Conclusion

As has been seen from the above, while further work could be of great benefit in expanding the results of the project and indicating their likely reliability, the experimental work here has produced useful results that can be used to expand our understanding of the concepts of connaissance and savoir-faire. It has also suggested differences in the levels of these two areas required for different technologies. The changes seen with successively more recent technologies can be related to necessary cognitive changes in the hominin species who first practiced these. These findings, to some extent, back up previous work that has focussed on identifying the cognitive requirements of various technologies, for example studies into Levallois cognitive requirements that have suggested that it requires the understanding of complex sequences of action (e.g. Wynn & Coolidge 2011). In other respects, however, they provide new information that goes beyond that previously discussed. For example they highlight the fact that the major advance in ability needed from Oldowan technology to Acheulean is in physical control over a number of variables, including the ability to accurately position blows, support both the percussor and the piece being worked on and to control force appropriately. Work that has investigated the gestures that need to be learnt in order to produce a handaxe has highlighted the importance of the type of percussion support, the position of the blank and the angle of percussion (Geribàs et al. 2010, 2868-9). These areas could be the focus of future work that fully investigates the different physical requirements of Oldowan flake and Acheulean handaxe knapping.

Without an approach that focusses on identifying the two individual areas of skill it would not be possible to gain this level of information particularly in terms of cognitive inferences. The application of the results to archaeological remains has been shown to be a more complex matter. While many material attributes showed the influence of savoir-faire ability, very few showed only connaissance influence. For this reason it has been suggested that refitting studies would be best used if the goal of research is to identify connaissance ability in an assemblage. A number of material attributes can be used to give information on specifically the savoir-faire abilities of a knapper, most notably the length of a produced object and the number of flakes produced during reduction.

The information provided by this experimental study will be of great use to those seeking to understand ways in which skill is acquired in connaissance and savoir-faire. It is often stated that connaissance skill is transmitted through words, while savoir-faire skills are acquired through practice (Apel 2008, 99). The results of this study suggest a more complex picture, better following the model of embodied cognition than a strict separation of cognitive and physical ability. Connaissance and savoir-faire were both affected by teaching and practice, suggesting that it is only through a combination of the two methods that a high level of skill in knapping performance in the group of modern knappers could be achieved. The teaching provided in the project, however, was in no way intended to replicate prehistoric teaching methods and can not be said to be relatable to the experience of growing up in a community in which stone tool manufacture was part of everyday life.

In summary, while it is not possible to state that the results of this project allowed secure connaissance and savoir-faire ability to be identified in isolation, the data go some way to identifying how two distinct areas of skill were acquired by knappers in the project. There are clearly strong links between these two elements of skill and it may not be possible to entirely separate them when considering a knapper's skill level. The methodology utilised in this project, however, points the way for future work that can focus more closely on areas of a knapper's connaissance and savoir-faire and increase our understanding of the ways skill is acquired in each.

9. Conclusion

9.1 Introduction

In this concluding chapter the success of this study in fulfilling the aims set out in the introduction and answering the main research questions is assessed. The overarching aim of this research was to investigate, through experimental means, the ways skill is acquired in early flaked stone technologies. The data gathered over the course of the nearly two year experimental project has been analysed in a number of ways to achieve these ends. While the focus has been on identifying the differential effect of teaching, practice and aptitude on skill acquired by a knapper, attempts have also been made to identify the cognitive requirements of particular technologies and use these to answer questions about the evolution of modern human brains and intelligence.

Below, the original aims of the research are summarised, followed by a detailed assessment of success in answering these questions. Following this, a critique of some current methods used to identify knapping skill is provided, based on the new data produced during the experiments. A summary of the findings of this thesis is then provided, followed by suggestions for future work that could be carried out to expand understanding of skill in flaked stone technologies further.

9.2 Aims and Research Questions

The experimental work carried out as part of the Learning to be Human Project and described in this thesis represents an attempt to gain an understanding of skill acquisition in Lower and Middle Palaeolithic flaked stone technologies. The basic aims of this project were to track learning and skill acquisition in the group of experimental knappers over a two year period. At a more in depth level, the reasons behind differential skill acquisition were investigated. This took the form of mapping, in detail, the teaching, practice and natural abilities that influenced the skill level achieved by knappers. The aim was to use the information acquired to provide evidence for the cognitive requirements of early technologies, with the intention to use this to make comment on the likely cognitive capacities of the early hominins who first practiced these technologies.

In order to fulfil these aims, the study focussed on answering four major research questions:

- How is high level skill obtained in flintknapping?
- What role do practice, natural aptitude and teaching play?
- How is this reflected in connaissance and savoir-faire?
- Can we recognise this archaeologically?

Below, success in answering these questions is assessed. Beyond these areas this study also aimed to critically assesses the means by which we currently identify skill in archaeological lithic assemblages. This was attempted in terms of techniques and material attributes used to identify high and low skill in archaeological assemblages. This information is provided in the "Assessment of Accepted Measures of Knapping Skill" section, below.

9.2.1 How is High Level Skill Obtained in Flintknapping?

At the simplest level the question that this thesis aimed to answer was how high level skill, as opposed to moderate or expedient level ability, is obtained in flaked stone technologies. For success in addressing this question it would be necessary for knappers in the project to have reached expert levels of skill in the technologies on which the project focussed. The results of the skill score analysis for each of the technologies has revealed that, while high level skill was achieved in simple flaking and handaxe technologies, no knapper achieved a truly expert level of ability in Levallois technology. This means that while there is the opportunity, using the data produced in the project, to map an individual's learning from no knapping experience to expert performance in handaxe and flaking, this is not possible with the Levallois results.

Despite this, mapping of flintknapping learning in the project did allow another of the project aims to be fulfilled; namely the identification of skill levels, in the work of project participants, that goes beyond a simple divide between skilled and unskilled, adult and child, or expert and beginner. In previous studies knapping has often been categorised in these simple terms, which does not acknowledge the range of different competencies that the performance of a knapper can encompass (Bodu et al. 1990; Grimm 2000; Fischer 1990). Focussed analysis of the work of knappers in the Learning to be Human Project has allowed five separate skill levels to be identified in the case of Oldowan style flaking and Acheulean handaxe, and six levels in the case of Levallois technology (Table 9.1). These levels are based on a detailed understanding of the levels of connaissance and savoir-faire ability that contribute to a knapper's performance.

Skill Level	Technologies	Description
Beginner	Oldowan, Acheulean, Levallois	Low connaissance, low savoir-faire
Novice Natural	Oldowan, Acheulean, Levallois	Low connaissance, high savoir-faire
Adept	Oldowan, Acheulean, Levallois	Medium connaissance, low-medium savoir-faire
Adept Natural	Levallois	Medium connaissance, high savoir-faire
Crafter	Oldowan, Acheulean, Levallois	High connaissance, medium savoir-faire
Experienced	Oldowan, Acheulean, Levallois	High connaissance, high savoir-faire

Table 9.1. Skill levels identified based on knapper performance.

Observing knappers' progress through these identified skill levels in more detail, it can be seen that there appear to be two separate paths that can lead a knapper to achieve a high level of skill in flaked stone technologies. These paths can roughly be related to knappers with physical aptitude for flintknapping, and those without, whose skill is determined more directly by levels of practice and teaching. Knappers who show natural ability for knapping tend to fall into the novice natural category in the first evaluation, whereas those without generally fell under the beginners category. This level of ability relates to knappers who performed well in the savoir-faire section evaluation, but received a low score in the connaissance section. This can be seen most clearly in the first evaluation for Oldowan style flaking which was the first evaluation carried out by knappers and took place for each when around 10 hours of knapping had been carried out. The materials produced by knappers showing this skill level appear more similar to those produced by knappers falling under the expert category, despite low levels of understanding of the principles of the technology in the novice natural group (Fig. 9.1). Knappers who showed this result were in the minority – for the majority of knappers learning progressed more quickly in connaissance than savoir-faire ability.

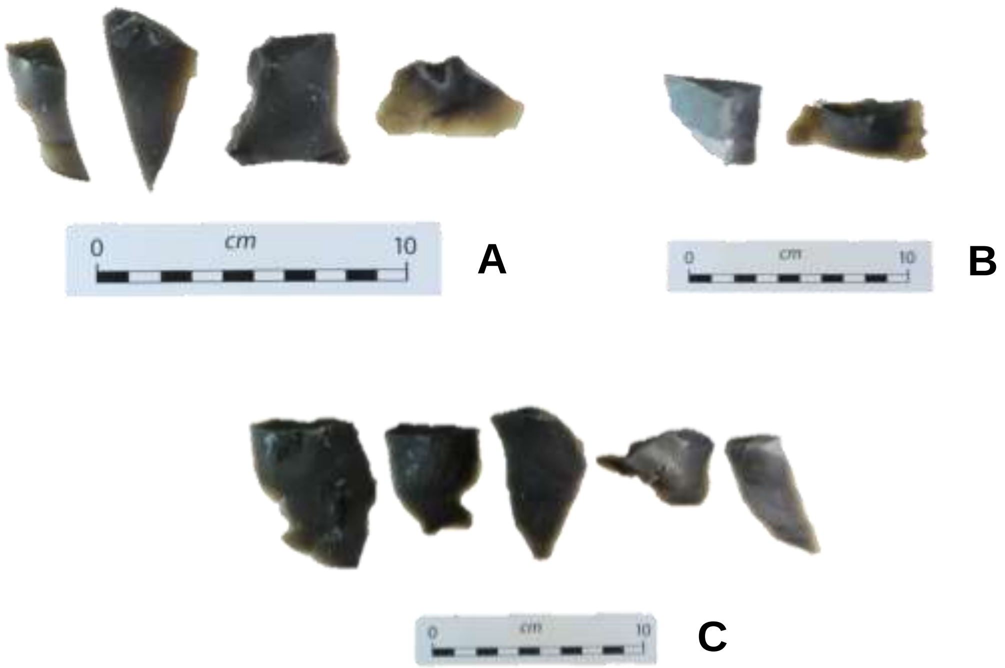


Figure 9.1. Flakes produced in the first evaluation by A) a member of the novice natural skill level, B) a member of the beginners skill level, and C) a member of the expert skill level (Photos: Whitlock 2011).

This finding highlights the importance of understanding the array of different levels of understanding and abilities that is encompassed by the appearance of high level knapping skill in archaeological materials. Based on an analysis of material produced during the evaluations, it has proved difficult to separate the work of those who have high levels of innate ability for knapping from those who achieved a high level of skill due to taught skill and continued practice. The use of platform preparation, however, does not appear in natural ability skill levels and suggests a means at addressing this problem.

It is interesting to note that in Levallois technology one more skill level was identified than for Oldowan or Acheulean handaxe technology and that this level represented knappers who showed a medium level of connaissance but a high level of savoir-faire. This extra level in which knappers showed higher savoir-faire than connaissance reflects the high level of conceptual complexity inherent in Levallois technology. In this technique the high level of physical ability displayed by knappers, probably gained from practicing other technological types, was not mirrored by their understanding of the complex sequence of actions that is necessary for successful Levallois manufacture. This suggests that skill acquisition in Levallois technology takes a different form to that seen in simple flaking and Acheulean handaxe. This finding also highlights a possible issue with the methodology used in the project. Knappers were taught multiple stone tool technologies and it is clear that, in some cases, knapping in one technology affected performance in another. This can be seen in the Oldowan results in which, in the final evaluation, knappers were producing a higher percentage of platform preparation errors than in early evaluations. When this was investigated in more detail it became clear that the majority of these errors were those of over preparation and the use of counter-productive preparation techniques. This can be related to knappers learning techniques of platform preparation in other technologies and applying these to Oldowan flaking, even when this was unnecessary.

The data produced in the Learning to be Human Project have been shown to be useful in identifying the ways in which a high level of skill is obtained in early flaked stone technologies. While the highest levels of skill were not identifiable in Levallois technology the mapping of the skill levels achieved by knappers through the project has allowed individual knapping journeys to be followed, providing an unprecedented level of information about the stages that lead to knapping expertise.

9.2.2 What Role do Practice, Aptitude and Teaching Play?

The second research question that this study was designed to address was the role that practice, teaching and aptitude play in determining the skill level achieved by an individual knapper. Teaching, practice and aptitude, as identified and tested for in the project, have all been shown to have an effect on the amount of skill displayed by knappers in each of the technologies in which they were evaluated. The three factors, however, did not affect each technology equally. Acheulean handaxe skill was shown to be more clearly affected by teaching than simple flaking, but only if this teaching was focussed on bifacial techniques rather than knapping techniques in general. Levallois technology showed an even greater requirement for teaching. It appeared that the levels of teaching provided in this technology were not sufficient to allow knappers to gain mastery of this technique during the time period of the experiment. This suggests that skill in handaxe and Levallois technology is improved more significantly by teaching than simple flaking techniques. High levels of skill in flaking could be gained in a very short period of time, simply through natural abilities of the knapper or by a small amount of knapping practice. This evidence can not be used to make definitive statements about prehistoric teaching as no attempt to reproduce prehistoric teaching was made and the knappers in the project were modern humans with modern human cognitive capacities. The fact that teaching had a greater impact on handaxe and Levallois technologies suggests that, if teaching was practiced by early hominins, it would have significantly improved ability to achieve high skill levels in these technologies and had the effect of speeding up the learning process. For Oldowan style technologies teaching may have been unnecessary.

Practice was shown to affect skill levels achieved in each of the technologies evaluated in the project. While it is sometimes stated that practice affects savoir-faire ability, while teaching affects connaissance ability (Apel 2008, 98–9), this was not shown to be the case based on the results of this experiment. Practice affected scores received for connaissance and savoir-faire in each technology. Continued practice was, however, shown to be necessary to maintain high levels of savoir-faire skill in flaking and handaxe technologies but not to maintain high levels of connaissance. In the case of connaissance, once a certain level of ability had been attained very little loss was seen in these two technologies. If additional practice levels between evaluations fell, savoir-faire scores tended to show a similar fall. This suggests that in handaxe and simple flaking, at the early stages of learning, continued practice is essential if skill levels are to be maintained. This pattern was not seen in Levallois technology, perhaps due to its more complex conceptual nature.

This study has also highlighted areas of aptitude that were shown to correlate with skill achieved in replicating early flaked stone technologies. These areas were previous craft experience, previous contact with flaked stone assemblages and spatial ability. As with the practice and teaching effect, aptitude did not influence all three technologies equally. Levallois skill was only shown to correlate with spatial ability, and this only in the first evaluation for core group members. Acheulean handaxe and Oldowan style flaking, however, showed correlations with previous craft experience and contact with flaked stone assemblages. The fact that Levallois technology was shown to be less influenced by knapper aptitude, at least in the areas tested in the project, suggests that teaching and practice have a stronger effect on skill level achieved in this technology than the innate abilities of individual knappers. Of course it is not possible, from the results of the experimental work, to make definitive conclusions about Neanderthal aptitude, as these hominins had different brain structures and likely different cognitive capacities to the modern humans studied. In addition to this, early hominins would have grown up surrounded by stone tools and tool manufacture, a very different learning experience to that provided in the project. The results do, however, suggest areas where it may be useful to look for knapping aptitude and future studies could build on this work to provide a greater understanding of these issues.

This study has identified differences in the effect of teaching, practice and some areas of aptitude on three different early flaked stone technologies. In this it has achieved, to some extent, its research aim. There is, however, much future work that could be carried out to further investigate these concepts. For instance an investigation that compared knapping carried out only in taught sessions or skill acquired only through personal practice could provide useful information on the differences in learning by these methods. Ultimately it is not possible for us to recreate the conditions that would have surrounded knapping learning in prehistoric communities. The data produced in the experimental skill acquisition in this project do, however, provide evidence of possible effect of teaching and highlights areas for future investigation.

9.2.3. How is Skill Reflected in Connaissance and Savoir-faire?

The third research questions that this study aimed to answer relates to the separation of skill into two different areas of ability: connaissance or cognitive skill and savoir-faire or physical skill. In this study a variety of methods were used to try and address the nature of connaissance and savoir-faire skill and its appearance in early flaked stone technologies. The crux of these attempts was the separation of skill evaluations into sections that assessed connaissance skill and sections that addressed savoir-faire. To a large extent this approach appears to have had success in identifying two separate areas of skill in that differences could be noted in the ways in which skill in connaissance and savoir-faire were acquired across the three technologies in which the knappers were evaluated. In Oldowan technology connaissance and savoir-faire appear fairly equal in their acquisition, although savoir-faire shows slightly more variability with loss as well as gain showing across the four evaluations knappers undertook. Acheulean technology showed a similar result to Oldowan in that connaissance skill increased sharply between the first and second evaluations and subsequently, for the majority of knappers, remained stable at this level. The savoir-faire results were, however, more variable than for Oldowan technology, with greater tendency for loss of skill and, in general, lower scores produced, particularly in the wider group. Levallois technology showed the opposite result with connaissance the variable aspect of skill in this technology and savoir-faire showing more stability, although no knapper received the highest scores for this, unlike in handaxe or simple flaking technologies.

The results of this analysis have been used to obtain information on the cognitive requirements of the three different technologies and from this make comment on the cognitive capabilities of the early hominin species that first practiced them. Using this approach builds up a picture of greater advances in physical ability between the Oldowan and Acheulean, and cognitive ability between the Acheulean and Levallois technologies. This picture is supported by the aptitude evidence which shows correlation with previous craft experience in the flaking and handaxe evaluations, as well as with previous contact with flaked stone assemblages. The only correlation seen in the Levallois results is with spatial ability. This suggests that advances in spatial abilities would have allowed Levallois knappers to learn the skills necessary for Levallois style manufacture more efficiently and successfully.

The analysis of connaissance and savoir-faire has, however, identified some problems with following an approach that entirely separates these areas of skill. The evidence from the Acheulean and Levallois evaluations highlighted the links, as well as the differences between connaissance and savoir-faire and the ways in which savoir-faire was assessed during the evaluations necessarily involved assessing cognitive as well as physical knowledge. It became apparent that without a level of connaissance in these two technologies it was not possible for physical abilities to progress beyond a certain level and without a certain level of physical ability it was not possible for understanding of the technology to be fully achieved. This supports the ideas of embodied knowledge and cognition that stress the impact of physical changes brought about by practicing new skills on the cognitive understanding of learning in the technologies practiced (Coward & Gamble 2008, 1970). This highlights the difficulties of completely separating these two areas, when instead the links between them and the effect one has on the other should be the focus.

The results of the analysis of connaissance and savoir-faire skill have been shown to have some utility for providing information about the different cognitive and physical requirements of the three early technologies on which the project focussed. Further work is needed, however, if a greater understanding of connaissance and savoir-faire is to be achieved and, in particular, this must focus on the interplay between cognitive and physical knowledge and ability. This information can be used to provide greater evidence for cognitive and physical advances in the Palaeolithic and the effect advances in one area would have on the other.

9.2.4. Can We Recognise this Archaeologically?

In assessing the utility of the information provided by the experimental work described in this thesis it is necessary to consider the archaeological visibility of the results described. This was a focus from the start of the project with an emphasis on identifying material attributes of tools, cores and debitage that are sensitive to knapper skill. The results of the materials analysis identified attributes in each technology that may be correlated with knapper skill level. For Oldowan technology those that best identified skill were number of flakes (with greater number produced associated with higher skill levels) and length of flake (with longer flakes associated with higher skill levels). In Acheulean handaxe technology markers that best indicated skill were handaxe maximum thickness (thinner handaxes were associated with higher skill levels) and platform type of debitage (greater percentage of faceted platforms were associated with higher skill levels), although handaxe length, width and mass also showed some correlation with skill. In Levallois technology for cores maximum length (shorter cores associated with higher skill) and mass including preferential flake (lighter cores associated with higher skill) were the best indicators of skill. For the preferential flake maximum thickness (thinner flakes associated with higher skill) and platform thickness (thinner platforms associated with higher skill) best showed this, while dorsal and ventral flake percentages (higher percentages of dorsal and lower percentages of ventral flakes associated with higher skill levels) and platform type of debitage (higher percentage of dorsal flakes with flat platforms associated with higher skill level) showed knapper ability best.

These material attributes indicate the success of the methodology in identifying areas of flaked stone technologies that indicate skill level. The identification of skill levels based on knapping performance has been discussed above. From performance it was possible to identify up to six different skill levels. Based on material analysis (See discussion in Chapters Four, Five and Six) it seems likely that it would only be possible to identify at most three skill levels that roughly corresponding to beginner, moderate skilled and experienced knapper. Even with this there is a good deal of overlap between the levels highlighting the difficulties in assessing skill based on single tools or knapping episodes.

In addition to this, some of the measures that were identified as best indicating knapper skill level were reliant on measures of percentage occurrence in a knapping sequence. To recognise this archaeologically it would be necessary for the knapping sequence to be both attributable to the work of a single knapper and be found largely intact. This highlights the importance of carrying out refitting studies to properly identify skill as this would, in general, allow work to be associated with a single knapper (although it has been demonstrated that in some cases more than one knapper would work on a knapping sequence - Lohse 2010, 170). Refitting studies have the greatest potential to relate not only the physical skill of a knapper to the remains of their manufacturing, but also their cognitive skill by shedding light on their strategic choices.

The results of this study have been shown to have the potential to provide useable evidence to relate the study of knapping performance to its material evidence. Future work should build on this by assessing whether the skill seen in the knapping performance is replicated in a judgement of the skill shown in the tools produced by knappers by independent lithic analysts and flintknappers. This should allow identification of whether patterns seen archaeologically can be related to actual knapping performance and the skill inherent in this.

9.3 Assessment of Accepted Measures of Knapping Skill.

A supplementary aim of this study was to assess the utility of currently accepted measures of knapping skill. The methodology used in this project was designed to analyse the areas of knapping that are most often said to be influenced by skill. The data produced during this experiment has provided empirical data that may be used to investigate whether this relationship with skill has a basis in fact. Of the variables that have been identified as markers of high and low skill (Figs 2.1 & 2.2) only a few were shown in this project to have a relationship with skill. While this does not mean, in every case, that the marker is not a good indicator of knapper skill, in some cases in the analysis the opposite of the expected pattern was seen. In these cases further investigation is warranted to gain a better understanding of why this disparity is seen. Measures of efficiency, termination type and symmetry are singled out for discussion.

Efficiency of production is a measure that has been used as a feature of flaked stone reduction that can be related to knapper skill level (Eren et al. 2011, 2736; Root 1997, 41). This is due to the theorised ineffectual or wasteful use of raw material by low skilled knappers and their failure to rejuvenate pieces (Bamforth & Finlay 2008, 6). In addition to this, highly skilled knappers are said to be able to produce exceptionally large pieces and utilise as much of the initial raw material size as possible (Bamforth & Finlay 2008, 5). If this had been the case in the Acheulean handaxe and Levallois evaluations it would be expected that the knappers achieving higher scores would produce larger tools, with a smaller mass of debitage produced to achieve this end. This did not prove to be the case. In both technologies more highly skilled knappers produced smaller, lighter and less wide pieces. This appears to be due to inexperienced knappers abandoning attempts at manufacture at an early stage as a result of their lack of understanding of the latter stages of these technologies as well as their creation of edge angles that are unsuitable for further reduction (Fig. 9.2). More skilled knappers were able to adjust unsuitable angles using platform preparation techniques or were skilled enough not to cause these problems in the first place. This highlights problems with using efficiency as a measure of skill in handaxe and Levallois technologies, particularly in the earliest stages of learning. Equally, simply equating large tools with highly skilled knappers is problematic. Thickness of tool was a more useful measure in the case of handaxe manufacture and one that is widely accepted as related to knapping skill with more experienced knappers better able to thin pieces.

Figure 9.2. Handaxe produced in evaluation 2 by knapper L, showing edge angles unsuitable for further removals without adjustment.

Handaxe symmetry is a phenomenon that has been much discussed. This has been undertaken in terms of functionality of symmetry (Machin et al. 2007), what this symmetry can tell us about the cognitive capacities of early hominins (Ambrose 2001), as well as the implications this has for speech and language in hominin species (Holloway 1969). Symmetry has also been related to skill, in that highly symmetrical pieces have been assumed to be the work of expert knappers (Bamforth & Finlay 2008, 5). The results of the analysis of handaxes produced during evaluations support this, to some extent, with a moderate level of plan view symmetry in the first evaluation increasing to a high level in the second. It is apparent, however, that plan view symmetry was not a difficult concept for knappers in the group to master. Profile view symmetry, on the other hand, showed a much more complex relationship with skill and the majority of knappers in the group were not able to achieve a high level of symmetry in this area. This suggests that bifacial plane symmetry may be more associated with the highest levels of skill achievable than plan view symmetry, suggesting that this would be a better indicator of expert production.

The third measure that has been highlighted for discussion is termination type. Termination type is a very commonly used indicator of skill in flaked stone technologies as it is often equated with knapping error (Bamforth & Finlay 2008, 6). In the materials produced during the skill evaluations for the Learning to be Human Project a simple relation between termination type and knapper skill was not apparent. In each of the technologies assessed flake termination type was considered as a variable likely to show skill and in each case there was no clear correlation between decreasing percentages of hinged or step terminations and knapping connaissance or savoir-faire skill. This suggests that the reasons hinge and step terminations are produced are more complex than simply error. Even highly skilled knappers produce some hinge or step fractures in their reduction sequences and, because of this, termination type may not prove to be a useful measure in assessing knapping skill.

In addition to this, the distinction seen in the Levallois results compared with handaxe and Oldowan technologies has highlighted the necessity of applying only appropriate measures of skill to individual technologies. Skill does not manifest itself in the same way in all flaked stone technologies. While some material attributes indicated skill equally in handaxe and Levallois technology (i.e. maximum length of core/handaxe, platform type of debitage) others could not be equally applied (i.e. maximum thickness of core/handaxe, efficiency of flake production, debitage termination type). A good understanding of the chaîne opératoire of each technology can help to indicate which material attributes are most likely to demonstrate skill. Interestingly, in Levallois technology there appeared to be some separation in material attributes that were most affected by connaissance skill and others that were more affected by savoir-faire skill. If these results are upheld by future studies they offer a good opportunity for identifying different areas of skill from archaeological remains. This can be hard to address based on material evidence alone.

In summary, the results presented in this thesis, while to some extent supporting commonly used markers of skill (i.e. flake length, handaxe thickness, platform preparation type, strategic complexity), have also highlighted some areas where further investigation is necessary to securely identify the relationship with skill. Through focussed studies that look in detail at these areas our understanding of the effect of knapper skill on materials produced will be improved and through this our identification of knapping learning in the archaeological record will benefit.

9.4 Conclusion

The information provided by the experimental work of the Learning to be Human Project has been shown to be of great utility in addressing a number of research questions relating to the acquisition of skill in early flaked stone technologies. The unprecedented level of detail provided by the logging of practice hours, attendance of taught sessions and initial aptitude has been used to make comment on the cognitive requirements of different early technologies and has the potential to be analysed further to provide greater information to help answer questions in this area. While logistical reasons prevent the majority of studies from taking such a long term focussed approach to studying lithic learning, the benefits of this are clear and further studies that replicate, to some extent, the methodology could progress the field even further.

Addressing hominin cognitive abilities through stone tool remains is a field that will never be able to provide definitive answers to the complex questions it poses. The results of this project, however, have provided useful empirical data that begin to hint at the cognitive differences between three early technologies. These differences must, to some extent relate to cognitive difference in the hominin species that first developed these technologies. Understanding hominin cognitive capacities can give information on the processes of evolution that led to the development of modern human brains and intelligence. Through focussed experimental work, such as is described in this thesis, we can begin to access this information and form more secure conclusions about the influence of learning flaked stone technologies on our evolution and the influences of increased cognitive abilities on the manufacture of stone tools.

9.5 Future Work

As an innovative experimental program there is much scope for future work that can build on the results presented here. Some of this was discussed in previous chapters including replicative experiments using a wide range of individuals with different ages and backgrounds such as children and craft professionals, and further testing of specific physical skills that could better isolate savoir-faire skill from connaissance. In addition to this, further analysis of the materials and data produced in the project could allow for a greater level of information to be gathered about skill acquisition in prehistory. Examination of the comments made by individuals on practice forms could give insights into what knappers themselves perceived as breakthroughs in their learning and help to elucidate what, for them, were the most difficult areas of the individual technologies to master. Analysis of variation in form between the materials produced by individuals during the evaluations would also be helpful in investigating standardisation of forms through the learning process. Current work is underway in mapping the gestures of each knapper in achieving a technology through analysis of videos taken during skill evaluations. The dataset produced in this project has the potential to provide an unprecedented level of information on learning in flaked stone technologies. Through this experimental project the relationships of material to performance have begun to be mapped and there is much scope for this to continue in future studies.

Appendix 1 – Recruitment Information.

Recruitment Emails

Core Group:

Dear Student,

This is an invitation to take part in a collaborative experimental research project led by Professor Bruce Bradley. The Learning to Be Human Project will examine the influence of technological development on the evolution of the human brain. This will be investigated through three integrated approaches, all of which will use a study group of modern flintknappers. We are looking for volunteers to form part of this group of flintknappers, who will be trained by Bruce Bradley over a period of two and a half years. You have been sent this as a second year student.

The study will involve fMRI brain scans of the chosen group before, during and after practical learning (supervised by Dr. Dietrich Stout, Emory University, USA). Learning and skill acquisition will be tracked through observational/interview methods using current techniques and the development of innovative methodologies (supervised by Prof. Bruce Bradley, Exeter). The group will also be involved in 'transmission chain' design research, where an individual knapper makes copies of an original object, and an example from this is used as a model by the next individual in the copying chain, and so on (supervised by Prof. James Steele, UCL).

Being involved in the project will have a number of benefits but also involves agreeing to a level of commitment, as the research is long-term. The project will run over a period of two and a half years with the final scan taking place in September 2012. Throughout this period the study group will be required to take part in taught knapping sessions and continue to practice knapping between these sessions. The details of this commitment will be more fully explained in the project presentation meeting. fMRI scanning also involves specific qualifications limiting who can be involved in the project.

The benefits of the project involve the rare opportunity to learn knapping skills from an expert knapper over an extended period. The knapping training will involve sessions in Texas, Denmark and France and will give the group opportunities to look at flaked stone assemblages from these areas. The networking and knapping skills gained from this will be useful for developing your own research projects and could be of use for dissertation projects.

If you are interested in becoming involved in this project or have any questions do not hesitate to email me (Nada Khreisheh) and Bruce. The project presentation meeting will take place on Wednesday 27th October at 10.00-11.00am and will cover the project plan and its requirements in more detail.

Many Thanks,

Nada Khreisheh

Dear All,

We have unexpectedly got place available for 2 people to become members of a core group of knappers in the Learning to be Human experimental knapping project. Becoming members of this group would involve agreeing to a greater level of commitment than I have previously outlined in the information sent to you but would also involve greater benefits. I have attached a document outlining in greater detail what these commitments and benefits are.

We are looking for right-handed students who have no previous flintknapping experience and will be able to attend taught knapping sessions at Exeter, in Texas, Denmark and France. Attendance of these sessions will be funded by the project. These knappers will have to agree to MRI scanning of their brains at periods during the study. For this reason we can only accept people who qualify for brain scanning (no tattoos, metal implants etc).

The sessions in Texas will be taking place over the Easter holidays from 3rd April-3rd May so students who wish to take part will need to be available for this period.

If you are interested please get back to me as quickly as possible as we want to make arrangements for the sessions in the next few weeks,

Many Thanks,

Nada Khreisheh

Wider Group:

Dear Knapper (or prospective knapper),

This is an invitation to take part in a collaborative experimental research project led by Professor Bruce Bradley. The Learning To Be Human Project will examine the development of knapping skill and will be focussed on, but not limited to, handaxe and Levallois technologies. This will be investigated through three integrated approaches, all of which will use a study group of modern flintknappers. We are looking for volunteers to form part of this group of flintknappers, who will have the opportunity to receive flintknapping training from Professor Bruce Bradley and use the experimental facilities at the University of Exeter. Knappers of any experience level can take part in the project and need not be based in Exeter.

Learning and skill acquisition will be tracked through observational/interview methods using current techniques and will require you to fill out forms covering knapping practice sessions and provide examples of your work for analysis. An initial assessment of knapping skill level will also be carried out at the start of the project. Being involved in the project will have a number of benefits but also involves agreeing to a level of commitment. The research is long-term, with the project running from January 2011 through September 2012. Throughout this period the study group will have the opportunity to take part in taught knapping sessions based at the University of Exeter and will be expected to continue to practice knapping between these sessions. An average of 2 hours a week of knapping practice will be the minimum expected. For sessions based at Exeter material and tools will be provided.

The benefits of the project include the rare opportunity to learn knapping skills from an expert knapper over an extended period. You will also be able to use the experimental facilities at the University of Exeter for knapping practice. The aim of the teaching sessions will be to get the participants as expert as possible in specific technologies. The knapping training will involve working with a group of flintknappers of all levels and afford excellent opportunities to collaborate with people working in this field. The networking and knapping skills gained from this could be useful in developing your own research or career.

Unfortunately, we are not able to fund travel, housing or subsistence expenses.

If you are interested in becoming involved in this project or have any questions do not hesitate to email me,

Many Thanks,

Nada Khreisheh (N.N.Khreisheh@ex.ac.uk)

Knapper Information Forms

Core Group:

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CORE VOLUNTEER INFORMATION AND APPLICATION

Study: Learning to be human: Skill acquisition in stone tool making

Principal Investigator:
Professor Bruce Bradley,
Department of Archaeology,
University of Exeter,
Exeter,
EX4 4QE

Phd Student:
Nada Khreisheh,
Department of Archaeology,
University of Exeter,
Exeter,
EX4 4Q

DATE: 29/12/2010

Introduction
We invite you to take part in the above research study. Before you decide, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with one or both of us if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

This study is of the acquisition of skill involved in learning to make simple stone tools, specifically Oldowan style core reduction, Acheulean handaxe making and Levallois core technology, but may be extended into more complex technologies. The purpose of this study is to explore the ways in which groups of learners acquire skill in tool making activities, what roles aptitude, practice and teaching play in this and how this may have contributed to the evolution of modern human brains and intelligence. The different ways skill is achieved in learning to make different technologies may give us information on how our ancestors acquired skill. If learning to make stone tools demands a high level of brain activity, then such tool making could have been one factor leading to expanded brains and increased intelligence in human evolution.

Participants
If you agree to participate, you will be one of up to 20 subjects who will be participating in this research. You have been selected because you are a healthy, right handed adult with no prior experience making stone tools.

What will happen if I take part in this study?
If you agree to be in the study, you will be asked to come to the Wellcome Department for Imaging Neuroscience, 12 Queen Square, London for a brain scan (once at the start of the project in January 2011, once part way through the project in late 2011 or early 2012 and finally at the end of the project in September 2012). The brain scanning will take about 45 minutes. The type of brain scan used in this study is called *magnetic resonance imaging* or MRI. This type of brain scan is safe and has been used by brain researchers across the world for more than 20 years. However, the MRI scanner does generate a very strong magnetic field that can cause metal objects to become very hot. Therefore, if you have any metal implants (including but not limited to pacemakers, braces, permanent eyeliner, and tattoos near your head that contain iron-based pigments) then we will not be able to scan you.

The MRI scanner is a small enclosed space. If you are claustrophobic or have anxiety about enclosed spaces, we will not be able to scan you. The MRI scanner also makes a lot of noise.

The noise the MRI scanner makes is quite loud so during the experiment you will be provided with earplugs and headphones. We can talk to you through the headphones and you can talk to us through a small microphone at all times. In addition you will have an alarm button with you to stop the experiment at any point if you wish.

When you are in the brain scanner we will show you movies on a computer screen. After each movie you will be asked to answer a question about what you have seen by pressing a button.

The brain scans we perform are designed for research rather than clinical examination. However, if an unexpected finding is seen in your scan, your GP will be informed and the finding will be discussed with you if this is appropriate.

In addition to the brain scanning you will also be studied as you learn to reproduce 3 specific technologies (Oldowan style core reduction, Acheulean handaxe making and Levallois core technology) over a period of 1 year and 9 months. As you gain expertise more complex technologies may also be introduced. Teaching in the technologies will be provided by Professor Bruce Bradley at the University of Exeter, assisted by Nada Khreisheh and Antony Whitlock. This teaching will take the form of structured sessions that will take place in the Department of Archaeology at Exeter and through personal practice. One session (April 2011) is planned to take place at the Gault Site in Central Texas. All project related expenses will be covered*. Another session may take place at Lejre, Denmark is September 2011 if arrangements can be made, otherwise this two week session will be in Exeter. Finally, a two week session is planned for April/May 2012 in France. Again, all project related expenses will be covered*. Participants will be expected to agree to a level of a minimum of 2 hours a week of knapping practice (averaged by month) and participation in all arranged sessions. You will have access to the experimental facilities at the University of Exeter for practice and materials and tools will be provided for sessions that take place here.

Learning and skill will be initially assessed through questionnaires and/or interviews that detail previous experience of knapping and other craft activities. Aptitude tests will be carried out on the group focussing on spatial aptitude by means of a spatial reasoning test and you will also be asked to take part in motor skill aptitude testing.

During the project at set intervals, you will knap a sequence to produce examples of specific technologies, with the knapping sequences recorded and the products analysed. You will also be required to fill out forms during practice sessions that detail what you practice, for how long, whether or not you receive instruction and with what success.

You will need to fill in a personal medical form (this will be kept confidential and only be used in case of a medical emergency).

What about results and your data protection?
We will not provide any results because this is a research project. The results will be published in a scientific journal and if you wish we will provide you with a copy when it appears. No one will be able to access information about you as all your results information will be held in an anonymous form. The skill analysis data will be available to you on request but you will not have access to the data of any other project members. All information that is collected about you during the course of the research will be kept strictly confidential and stored securely in accordance with the Data Protection Act 1998. Participation in this study will in no way affect your legal rights. The data will be used only for the purpose of informing the research questions in this study, and will only be accessed by the research team. The results of this study will be disseminated in peer-reviewed scientific journals and may be included in popular publications/media, but you will in no way be personally identifiable without prior written permission from you. The data will be retained indefinitely and securely, and may be accessed in the future by the research team for comparison with future data.

Voluntary Nature of Study
Taking part in this study is purely voluntary and there are no penalties or negative consequences of any kind associated with the choice not to participate. Learning to make stone tools is a benefit associated with participation. Viable alternatives do exist for obtaining this benefit. You may choose not to take part or may leave the study at any time without providing a reason.

Ethical Considerations
All ethical aspects of this project will have been approved through appropriate procedures. The brain scanning has been certified by the University of Exeter, School of Humanities and Social Sciences ethics committee (certificate held by PI) and the knapping study has been approved by the University of Exeter, College of Humanities ethics committee (certificate held by PI).

Benefits of Participation
There are many possible benefits of participation in this project. These may include, but not be limited to, acquisition of expertise in flint knapping, the opportunity to study archaeological collections, development of a network of peers and academics, application to other aspects of university studies and foreign travel.

Funding

This study has been funded by the Leverhulme Trust

If you would like further information or if you have specific questions, please contact us at the address below:

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EX4 4QE
01392 262490
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Nada Khreisheh
Department of Archaeology
University of Exeter
Exeter
EX4 4QE
N.N.Khreisheh@ex.ac.uk

*Costs covered will include travel to and from the UK, internal travel at the destination, food, housing and supplies. You will be expected to supply personal travel insurance, any visa costs and cover for personal expenses.

If you wish to volunteer to take part in this project please sign and date below and return to Professor Bruce Bradley or Nada Khreisheh at the above address. You will be provided with a copy for your records:

Signature…………………………..   Date……………………………

Email………………………………

Wider Group:

CONFIDENTIAL

VOLUNTEER INFORMATION AND APPLICATION

Study: Learning to be human: Skill acquisition in stone tool making

Principal Investigator:
Professor Bruce Bradley,
Department of Archaeology,
University of Exeter,
Exeter,
EX4 4QE

Phd Student:
Nada Khreisheh,
Department of Archaeology,
University of Exeter,
Exeter,
EX4 4QE

DATE: 29/12/2010

Introduction
We invite you to take part in the above research study. Before you decide, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with another if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

This study is of the acquisition of skill involved in learning to make simple stone tools, specifically Oldowan style core reduction, Acheulean handaxe making and Levallois core technology; other more complex technologies may also be included. The purpose of this study is to explore the ways in which groups of learners acquire skill in tool making activities, what roles aptitude, practice and teaching play in this and how this may have contributed to the evolution of modern human brains and intelligence. The different ways skill is achieved in learning to make different technologies may give us information on how our ancestors acquired skill. If learning to make stone tools demands a high level of brain activity, then such tool making could have been one factor leading to expanded brains and increased intelligence in human evolution.

Participants
If you agree to participate, you will be one of up to 20 subjects who will be participating in this research. You can participate with any level of prior knapping experience and you do not have to be based at the University of Exeter to take part.

What will happen if I take part in this study?
You will be studied as you learn to reproduce 3 specific technologies (Oldowan style core reduction, Acheulean handaxe making and Levallois core technology) over a period of 1 year and 9 months. As you gain expertise more complex technologies may also be introduced. Teaching in the technologies will be provided by Professor Bruce Bradley at the University of Exeter, assisted by Nada Khreisheh and Antony Whitlock. This teaching will take the form of structured sessions that will take place in the Department of Archaeology at Exeter and through personal practice. Participants will not have to participate in the structured teaching sessions but will be expected to agree to a level of a minimum of 2 hours a week of knapping practice (averaged by month). You will have access to the experimental facilities at the University of Exeter for practice and materials and tools will be provided for sessions that take place here. You will provide your own materials if you practice elsewhere.

Learning and skill will be initially assessed through questionnaires and/or interviews that detail previous experience of knapping and other craft activities. Those who have previous experience will also be asked to make examples of the specific technologies they have previously practiced so that the sequences and products can be assessed. Aptitude tests will be carried out on the group focussing on spatial aptitude by means of a spatial reasoning test.

During the project at set intervals, you will knap a sequence to produce examples of specific technologies, with the knapping sequences recorded and the products analysed. If you are not based at the University of Exeter this assessment will be carried out over Skype*. You will also be required to fill out forms during practice sessions that detail what you practice, for how long, whether or not you receive instruction and with what success.

*Other assessment arrangements may be made on a case by case basis. If materials are sent to Exeter for analysis the cost of posting will be covered by the project.

What about results and your data protection?
We will not provide any results because this is a research project. The results will be published in a scientific journal and if you wish we will provide you with a copy when it appears. No one will be able to access information about you as all your results information will be held in an anonymous form. The skill analysis data will be available to you on request but you will not have access to the data of any other project members. All information that is collected about you during the course of the research will be kept strictly confidential and stored securely in accordance with the Data Protection Act 1998. Participation in this study will in no way affect your legal rights. The data will be used only for the purpose of informing the research questions in this study, and will only be accessed by the research team. The results of this study will be disseminated in peer-reviewed scientific journals and may be included in popular publications/media, but you will in no way be personally identifiable without prior written permission from you. The data will be retained indefinitely and securely, and may be accessed in the future by the research team for comparison with future data. Any material gathered to be analysed will be offered to the participants when the project is concluded or, if they do not wish to keep it, it will be stored for future study or safely discarded.

Voluntary Nature of Study
Taking part in this study is purely voluntary and there are no penalties or negative consequences of any kind associated with the choice not to participate. Learning to

make stone tools and/or improving your is a benefit associated with participation. Viable alternatives do exist for obtaining this benefit. You may choose not to take part or may leave the study at any time without providing a reason.

Ethical Considerations
All ethical aspects of this project will have been approved through appropriate procedures. The knapping study has been approved by the University of Exeter, College of Humanities ethics committee (certificate held by PI).

Benefits of Participation
There are many possible benefits of participation in this project. These may include, but not be limited to, acquisition of expertise in flint knapping, development of a network of peers and academics.

Funding
This study has been funded by the Leverhulme Trust

If you would like further information or if you have specific questions, please contact us at the address below:

Professor Bruce Bradley
Department of Archaeology
University of Exeter
Exeter
EX4 4QE
01392 262490
B.A.Bradley@ex.ac.uk

Nada Khreisheh
Department of Archaeology
University of Exeter
Exeter
EX4 4QE
N.N.Khreisheh@ex.ac.uk

If you wish to volunteer to take part in this project please sign and date below and return to Professor Bruce Bradley or Nada Khreisheh at the above address. You will be provided with a copy for your records:

Signature…………………………..   Date…………………………………

Email………………………………   Skype ID…………………………….

Appendix 2 – Aptitude Tests.

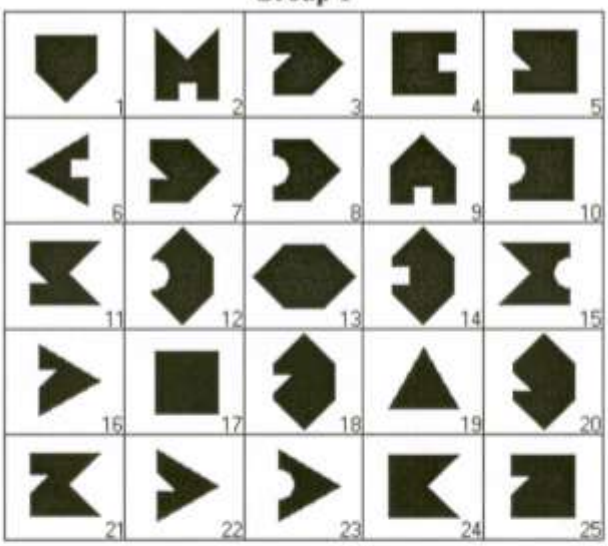
Spatial Ability – Test 1

Psychometric Success – Spatial Ability

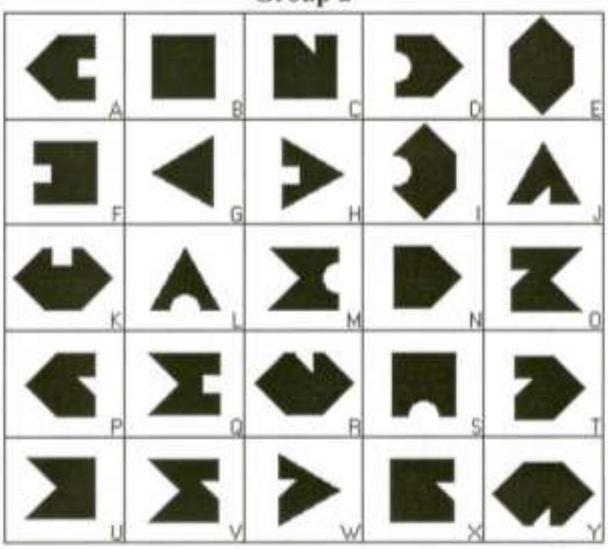
Spatial Ability Test 1: 45 Questions
Answer as many questions as you can in 20 minutes.

The shapes in Group 1 and Group 2 are identical, although some of them may be rotated. Which shape in Group 2 corresponds to the shapes (1 to 25) in Group 1?

Group 1



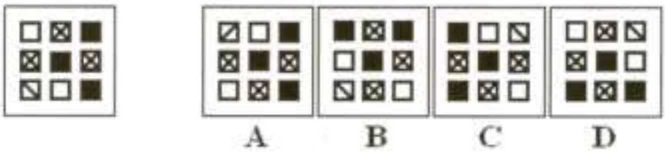
Group 2



1)	2)	3)	4)	5)
6)	7)	8)	9)	10)
11)	12)	13)	14)	15)
16)	17)	18)	19)	20)
21)	22)	23)	24)	25)

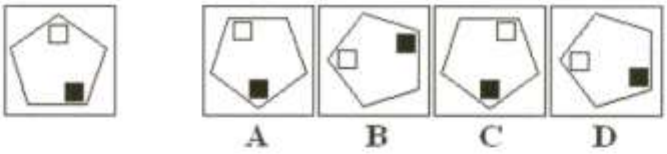
In the figures shown below, one of the shapes (A-D) is identical to the first figure but has been rotated.

26) Which figure is identical to the first?



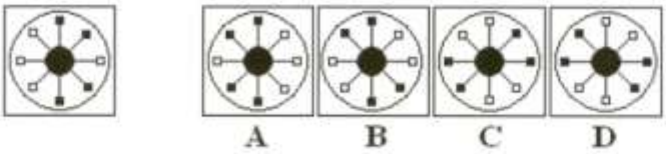
A B C D

27) Which figure is identical to the first?



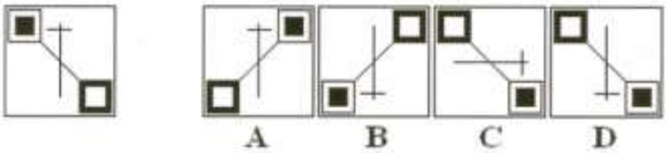
A B C D

28) Which figure is identical to the first?



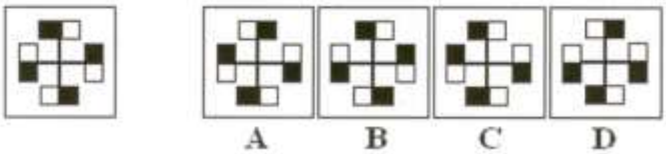
A B C D

29) Which figure is identical to the first?



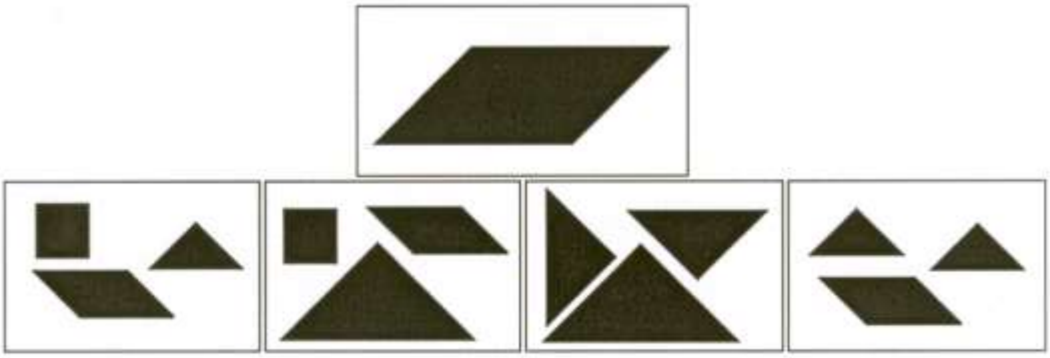
A B C D

30) Which figure is identical to the first?



A B C D

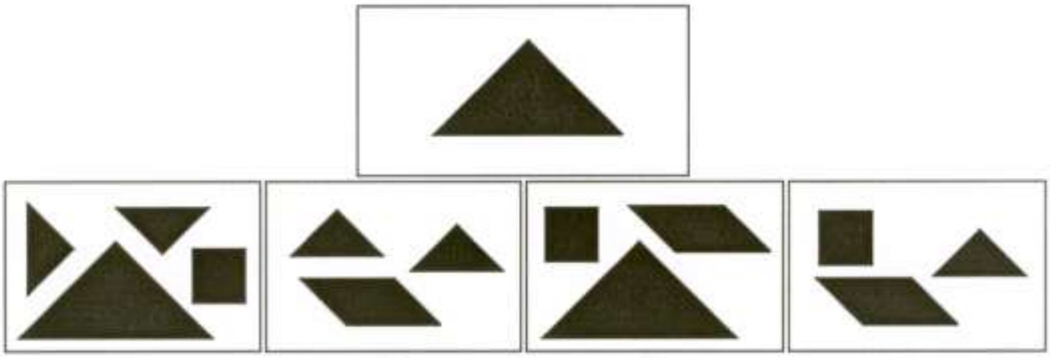
31) Which group of shapes can be assembled to make the shape shown?



A B C D

A B C D

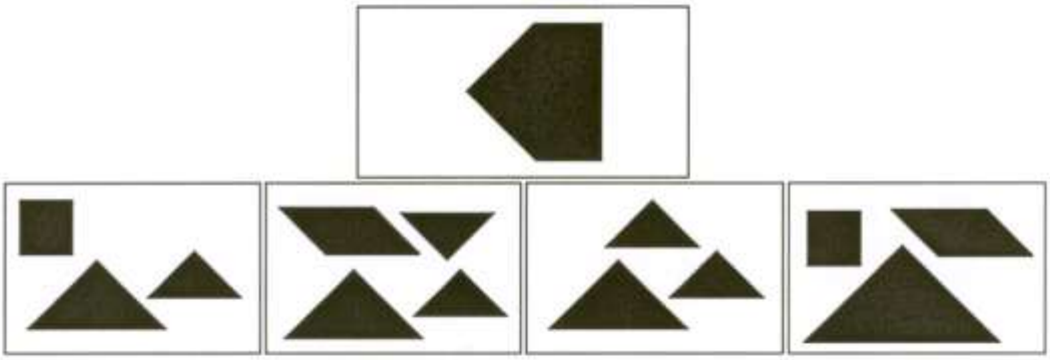
32) Which group of shapes can be assembled to make the shape shown?



A B C D

A B C D

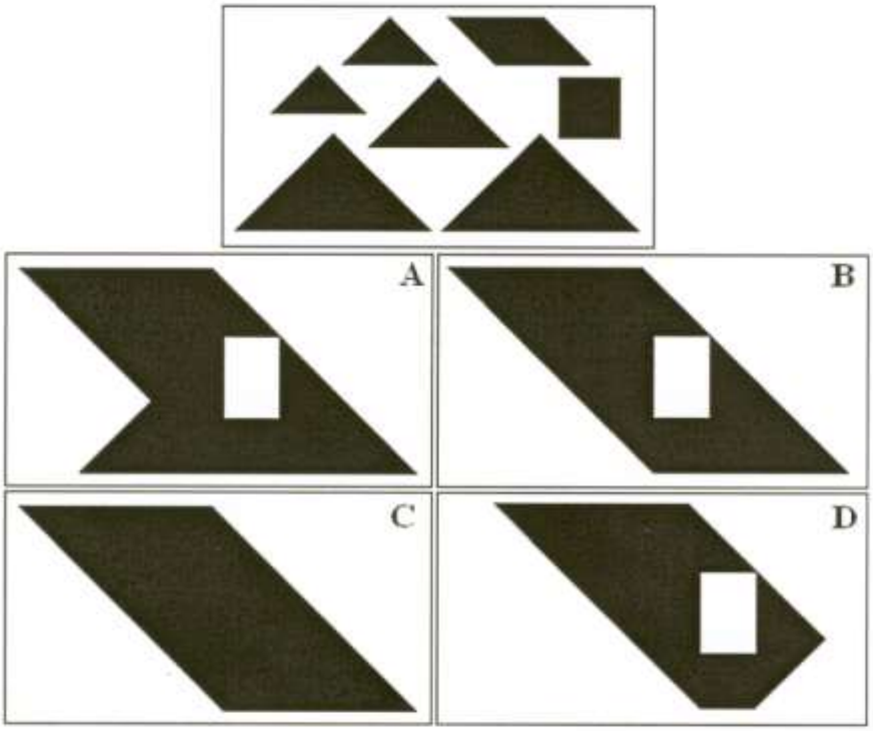
33) Which group of shapes can be assembled to make the shape shown?



A B C D

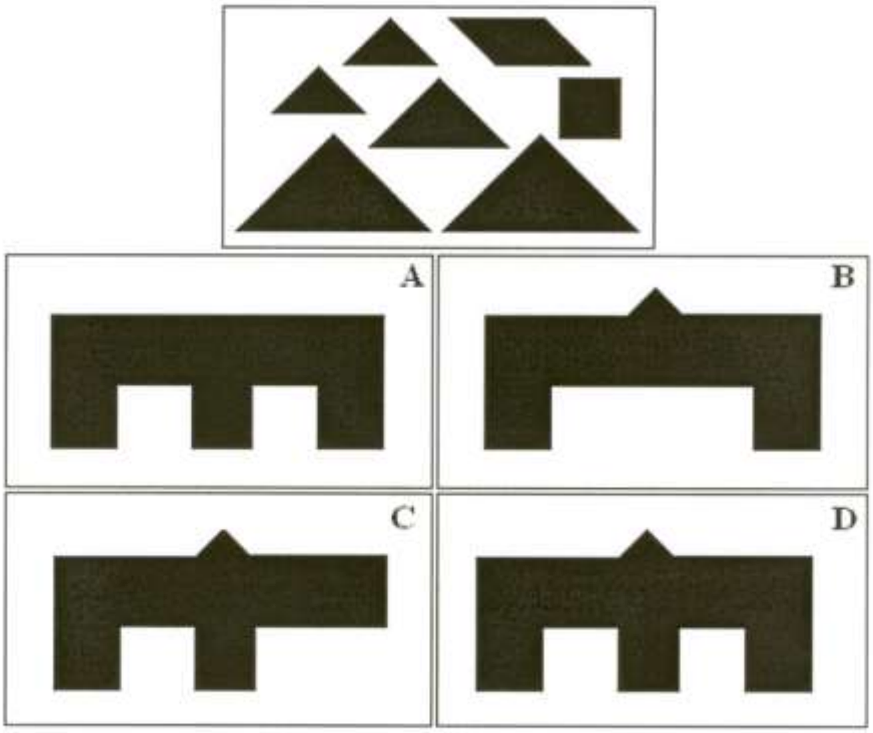
A B C D

34) Which shape can be assembled using all of the individual shapes shown?



A B C D

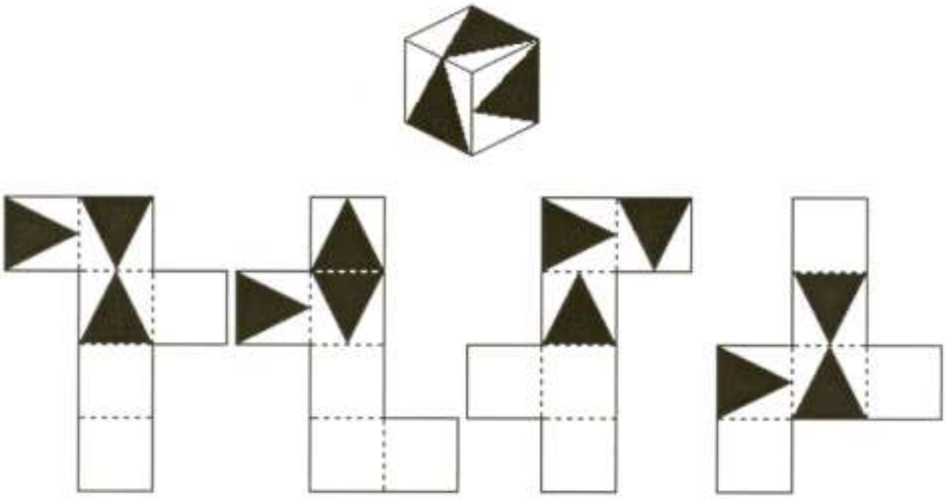
35) Which shape can be assembled using all of the individual shapes shown?



A B C D

Which pattern can be folded to make the cube shown?

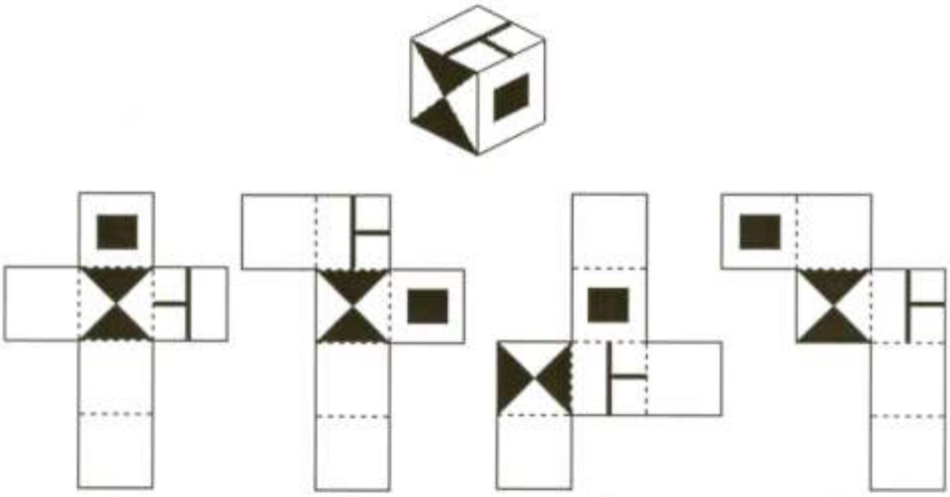
36)



A B C D

A B C D

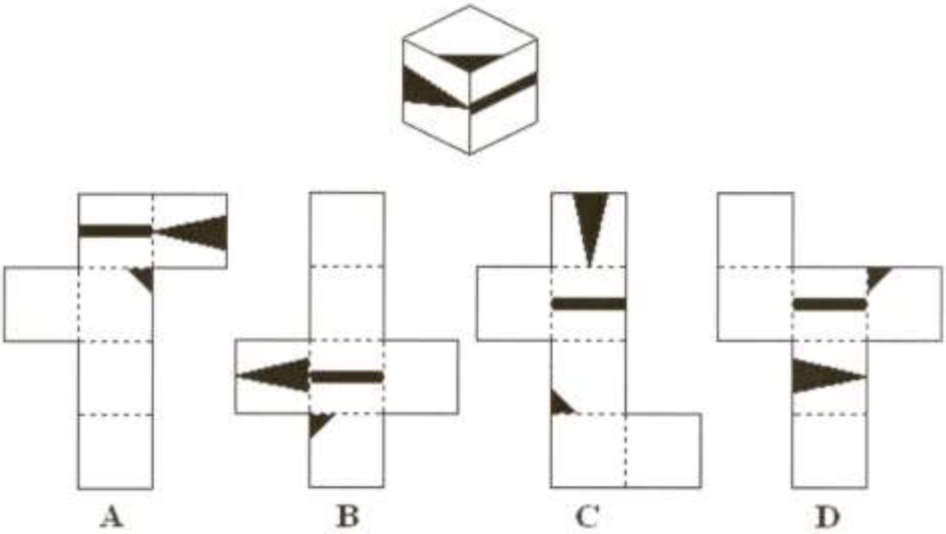
37)



A B C D

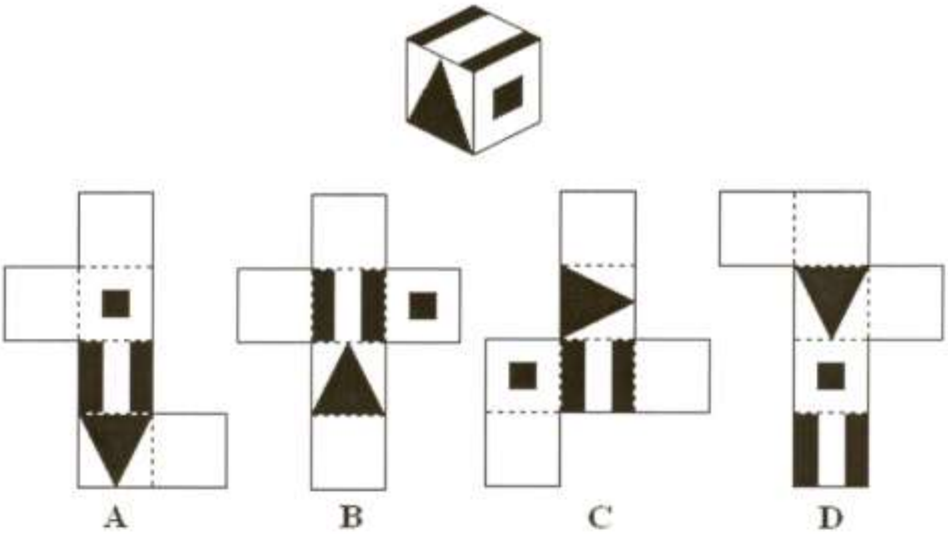
A B C D

38)



A B C D

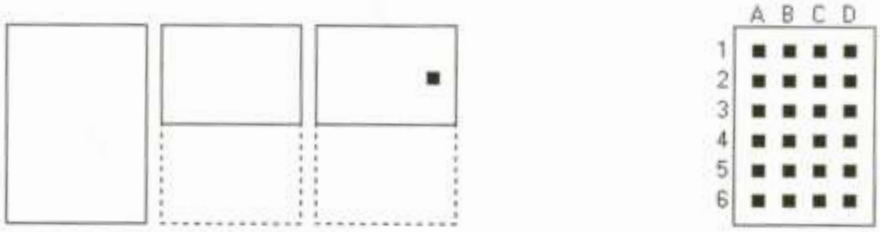
39)



A B C D

The drawings show a sheet of paper which has been folded. The dashed lines indicate the whole sheet, each drawing represents a single fold. The black square shows where a hole was punched. Where do the holes appear when the sheet is unfolded?

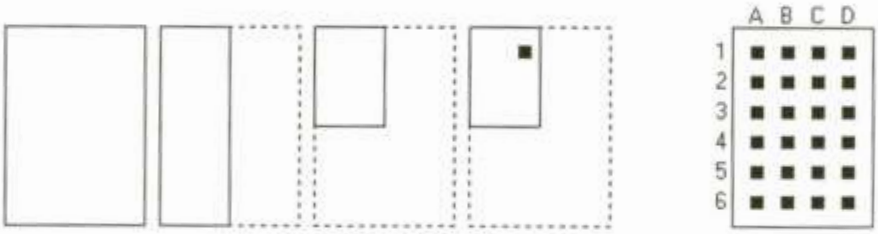
40)



A	B	C	D
2C,5C	2D,5D	3D,3D	2C,2D

A B C D

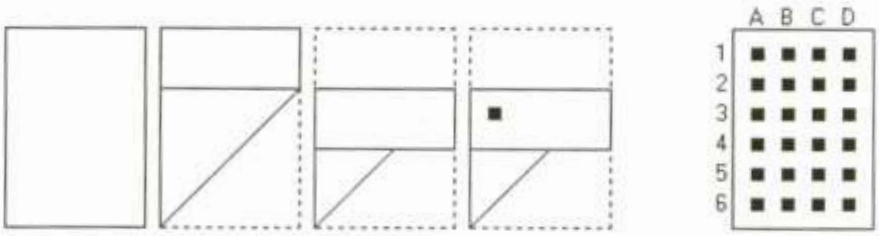
41)



A	B	C	D
1B,1C,5B,5C	2B,2C,5B,5C	1B,2C,6B,6C	1B,1C,6B,6C

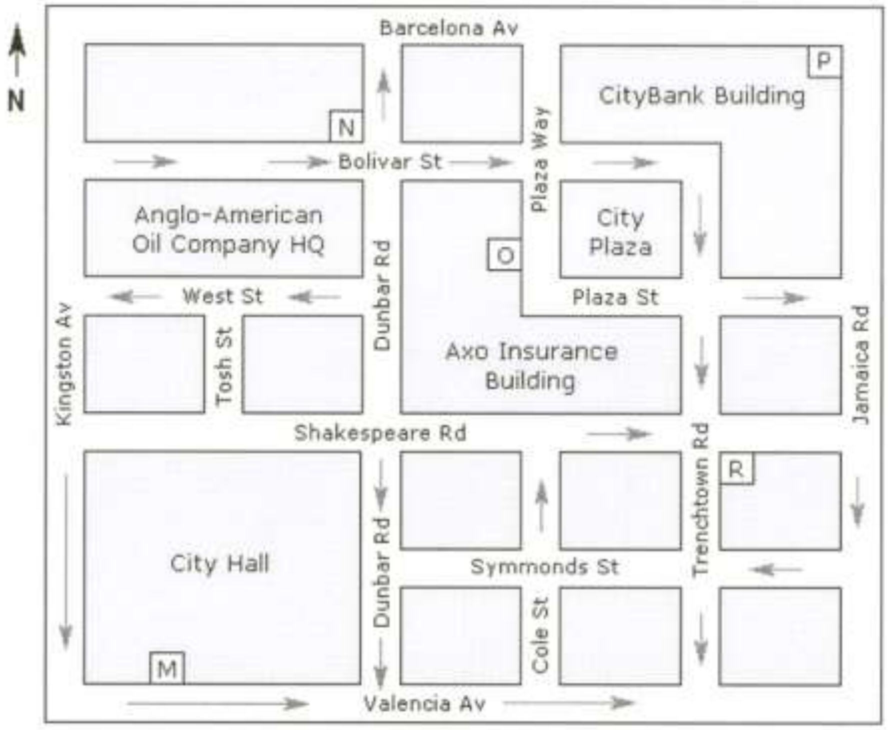
A B C D

42)



A	B	C	D
3A,2A,6D	3A,5A,6D	3A,5A,3D	3A,2A

A B C D



43) Officer Perez is in Tosh St with City Hall to her right. What direction is she facing?

A	B	C	D
North	South	East	West

44) She turns and walks to the junction with West St. She then turns right and walks to the next junction before turning left. Where is location 'O' in relation to her position?

A	B	C	D
North	South	East	West

45) Officer Martinez starts from location 'M' and proceeds as follows: left onto Valencia Av - heading East, second left - heading North, second right - heading East, second left - heading North. He proceeds North for two blocks. What is his location?

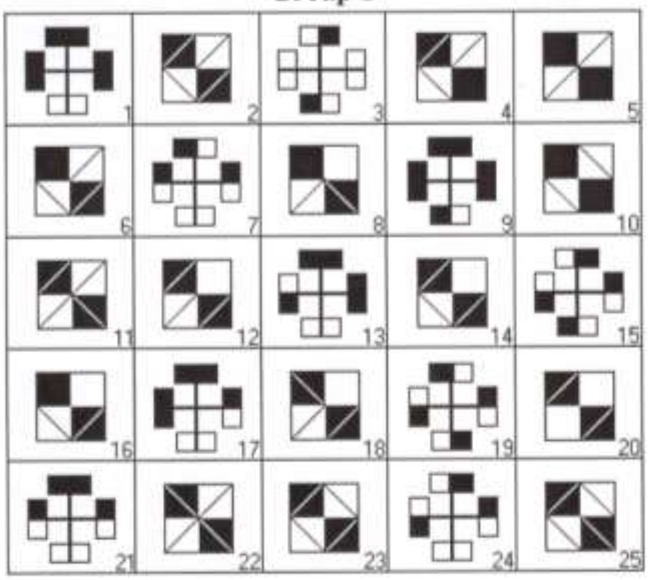
A	B	C	D
N	O	R	P

End of Spatial Ability - Test 1

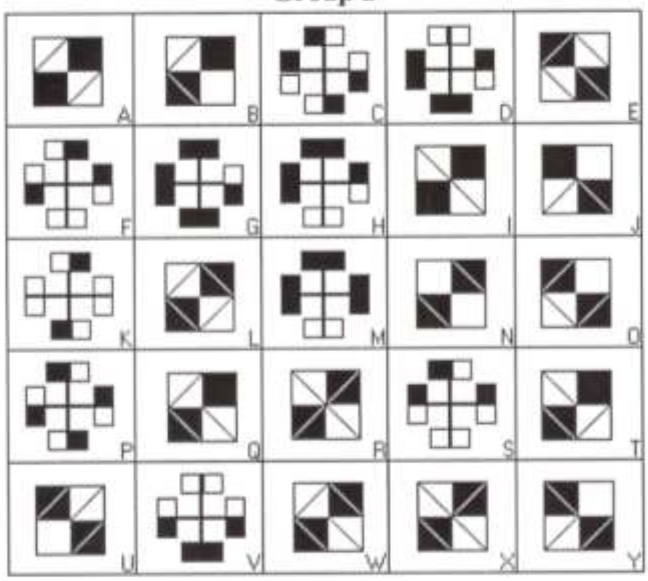
Spatial Ability Test 2: 45 Questions
Answer as many questions as you can in 20 minutes.

The shapes in Group 1 and Group 2 are identical, although some of them may be rotated. Which shape in Group 2 corresponds to the shapes (1 to 25) in Group 1?

Group 1



Group 2

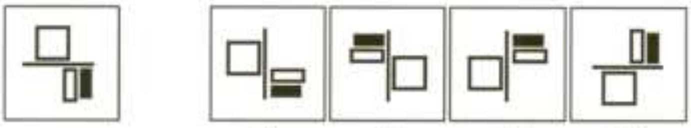


1)	2)	3)	4)	5)
6)	7)	8)	9)	10)
11)	12)	13)	14)	15)
16)	17)	18)	19)	20)
21)	22)	23)	24)	25)

Psychometric Success – Spatial Ability

In the figures shown below, one of the shapes (A-D) is identical to the first figure but has been rotated.

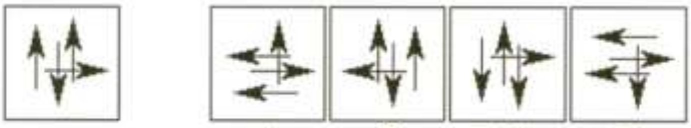
26) Which figure is identical to the first?



A B C D

A B C D

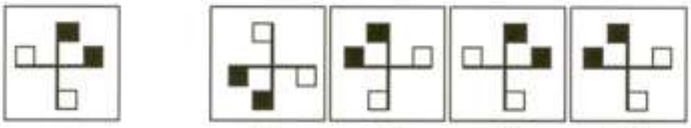
27) Which figure is identical to the first?



A B C D

A B C D

28) Which figure **not** is identical to the first?



A B C D

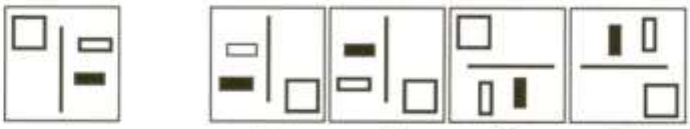
A B C D

29) Which figure is **not** identical to the first?

A B C D

A B C D

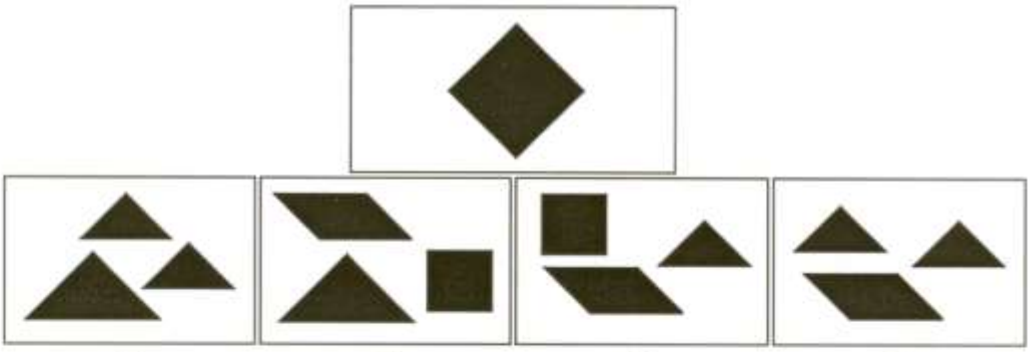
30) Which figure is identical to the first?



A B C D

A B C D

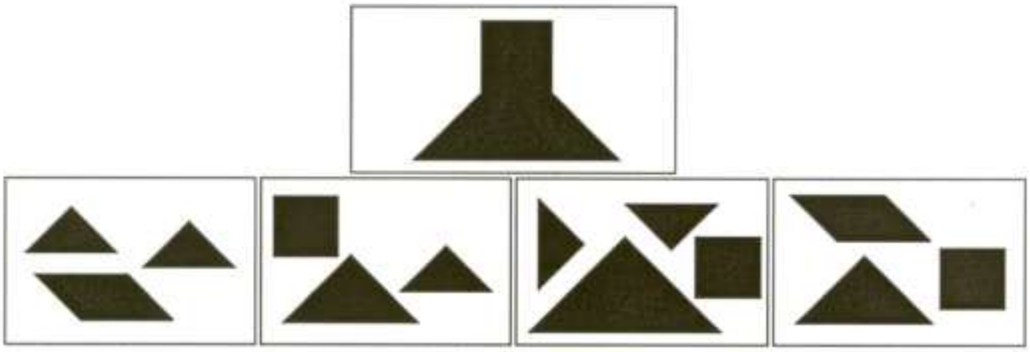
31) Which group of shapes can be assembled to make the shape shown?



A B C D

A B C D

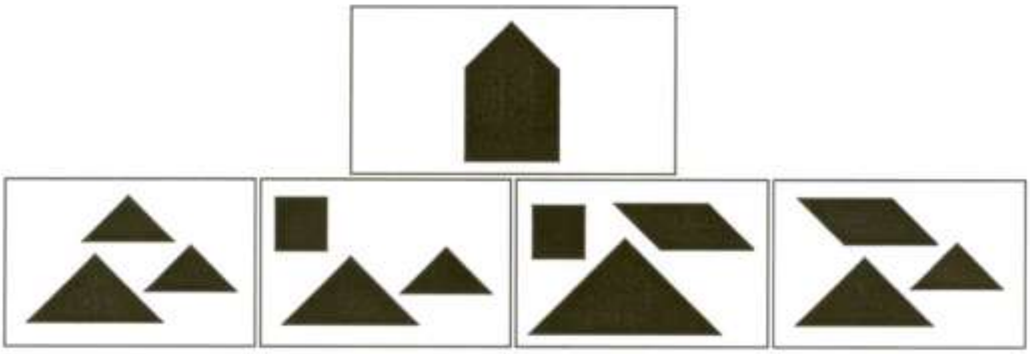
32) Which group of shapes can be assembled to make the shape shown?



A B C D

A B C D

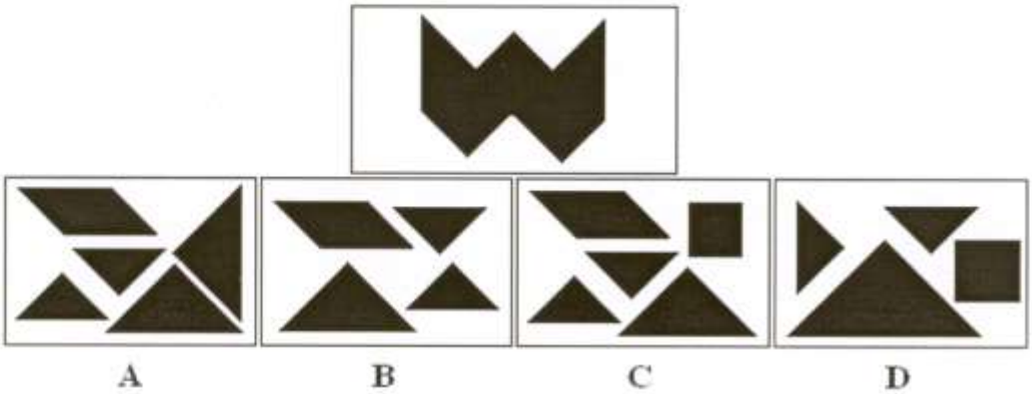
33) Which group of shapes can be assembled to make the shape shown?



A B C D

A B C D

34) Which shape can be assembled using all of the individual shapes shown?



A B C D

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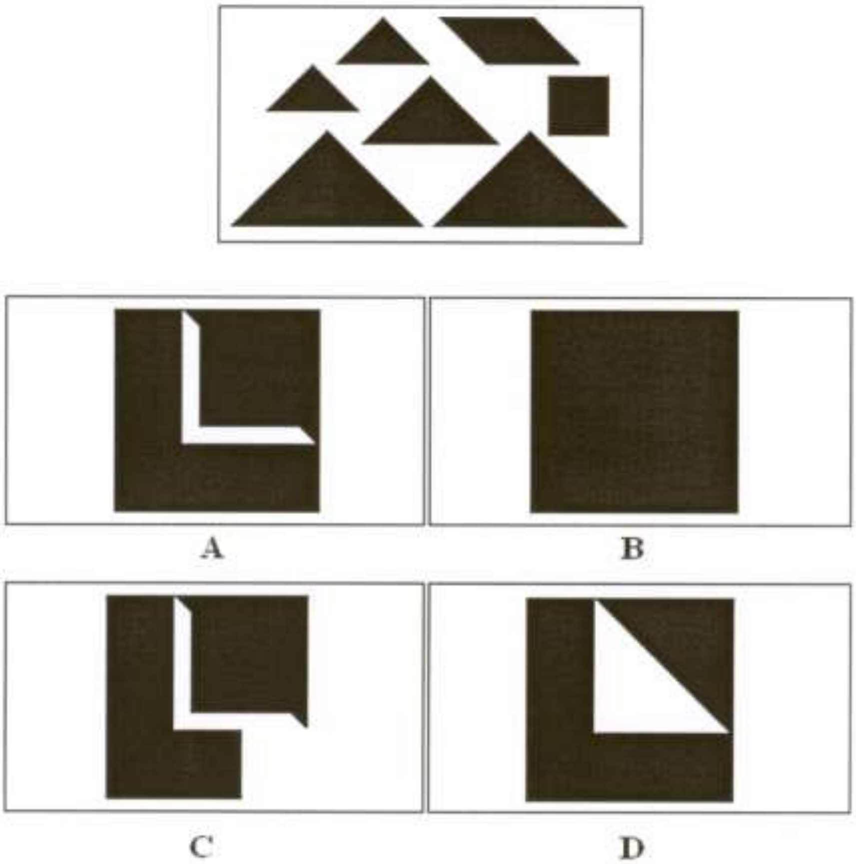
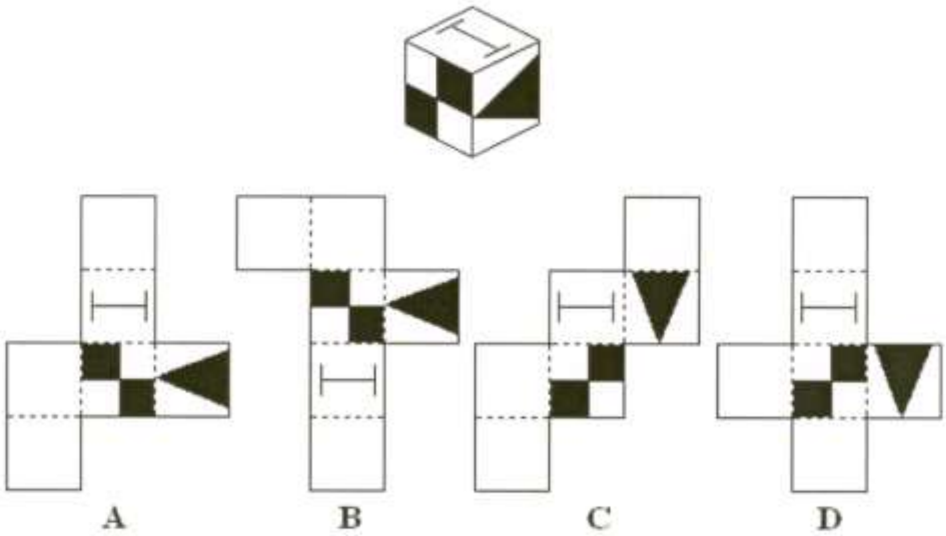


A B C D

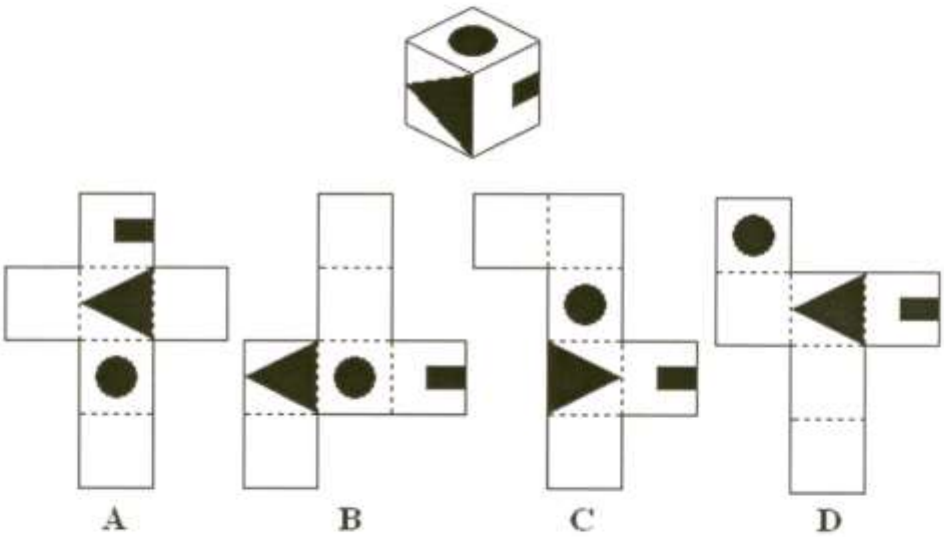
Which pattern can be folded to make the cube shown?

36)



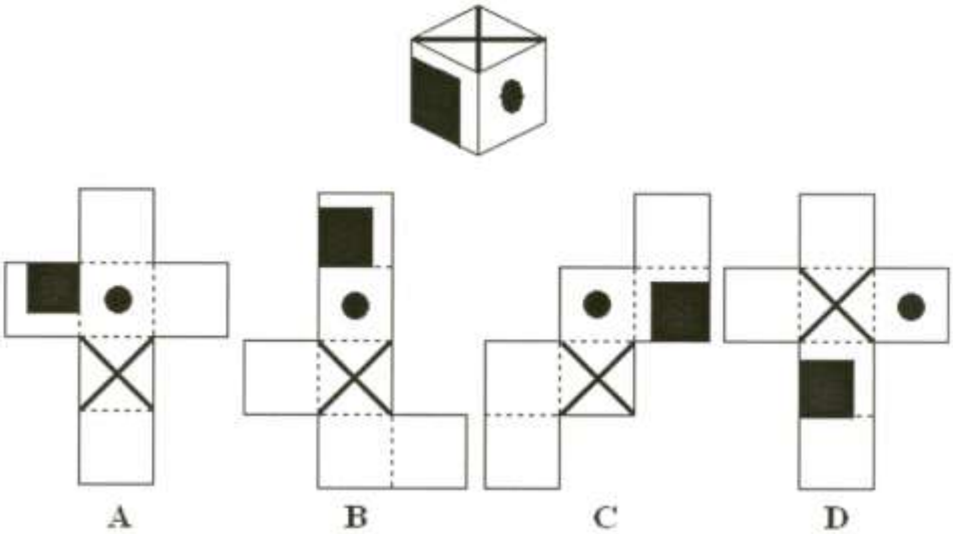
A B C D

37)



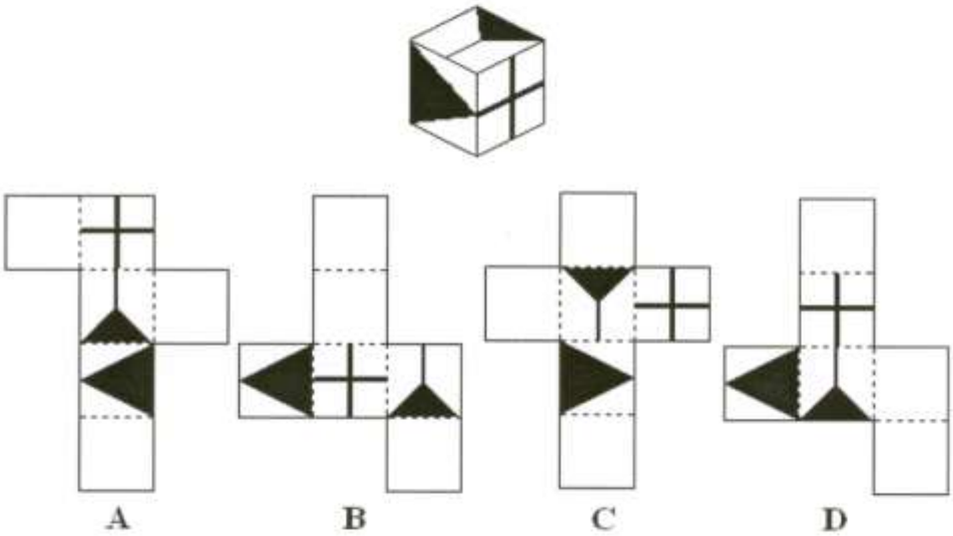
A B C D

38)



A B C D

39)



A B C D

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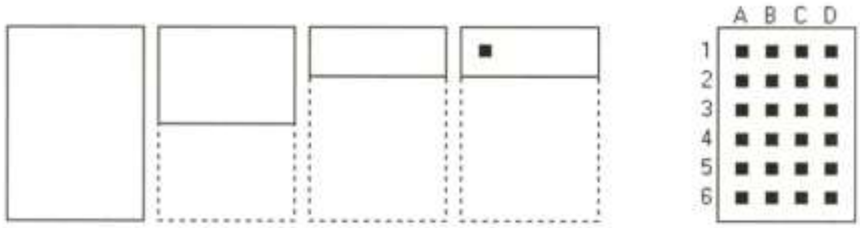
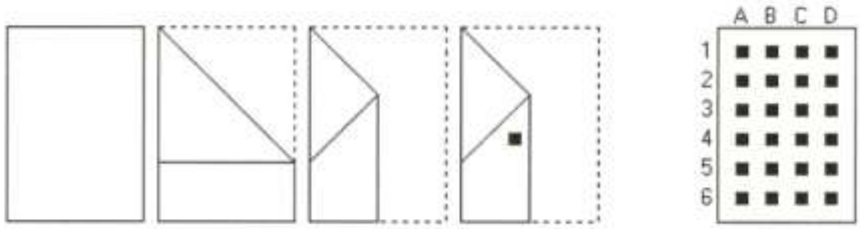
40)



A	B	C	D
1A,3B,4A,6B	1A,3A,4A,6A	1A,2A,4A,6A	1A,2A,4A,5A

A B C D

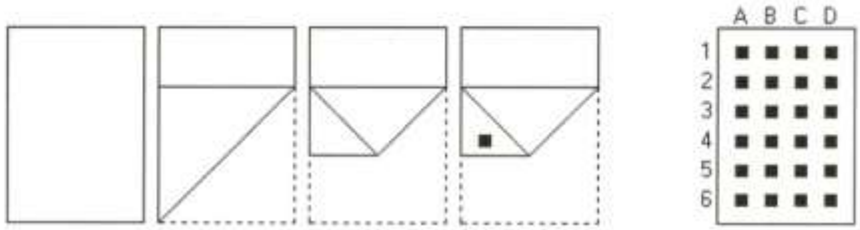
41)



A	B	C	D
4B,4C,3D,4D	4B,4C,2D,2D	4B,4D,2D,3D	4B,4C,2D,3D

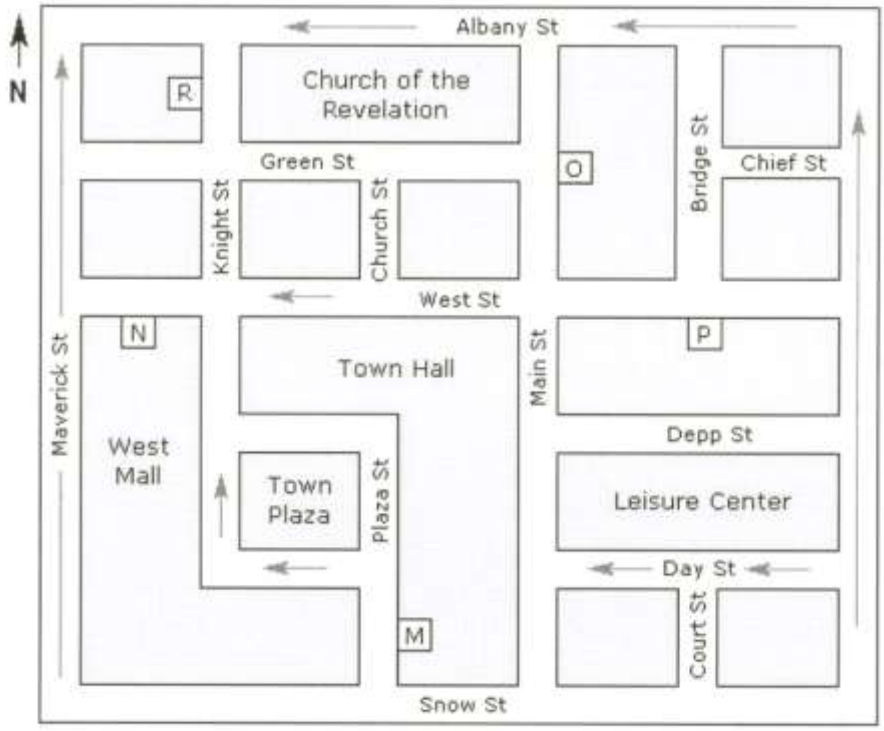
A B C D

42)



A	B	C	D
4A,5A,6B,6C	4A,5B,6B,6C	4A,5A,6C,6D	4A,5B,6C,6D

A B C D



43) Officer Wu is in Green St and can see the Town Hall to her right. What direction is location 'N' in relation to her position?

A	B	C	D
South	South East	South West	North East

44) She turns and walks to the junction with Main St. She turns right and proceeds four blocks before turning right and then taking the next right. Which location is nearest to her current position?

A	B	C	D
P	N	O	M

45) Officer Jones starts from location 'R' and proceeds as follows: right onto Knight St - heading South, first left - heading East, second right - heading South, second left - heading East. He proceeds East for one block. Where is location 'P' in relation to his current position?

A	B	C	D
North	North East	North West	East

End of Spatial Ability - Test 2

Questionnaires

Core Group

Name……………………………………………………………………………

Email……………………………………………………………………………

Telephone No…………………………………………………………………..

Date of Birth…………………………………………………………………

Sex………………………………………………………………………………

List any craft skills you have practical experience of, rating your ability in them on a scale of 1-5 (1 being beginner, 5 being expert):

Craft	No of years practised	Ability

List your previous experience with archaeological or replica flaked stone artefacts including university courses, handling museum collections or flintknapping demonstrations:

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Wider Group:

Name……………………………………………………………………………

Email……………………………………………………………………………

Telephone No…………………………………………………………………..

Date of Birth……………………………………………………………………

Sex………………………………………………………………………………

List any craft skills you have practical experience of, rating your ability in them on a scale of 1-5 (1 being beginner, 5 being expert):

Craft	No of years practised	Ability

List your previous experience with archaeological or replica flaked stone artefacts including university courses, handling museum collections or flintknapping demonstrations:

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Have you had any previous practical experience of flintknapping - Yes/No

If you answered yes to the last question how long is your practical flintknapping experience?

……………………………………………………………………………………………… ……………………………………………………………………………………………… …………

Please state the amount of time you have spent practising and rate your ability in the following 3 tasks/technologies on a scale of 0-5 (0 being no experience, 5 being expert):

Technology	Amount of experience	Ability
Flake production		
Acheulean Handaxe		
Levallois core technology		

Appendix 3 – Knapping Progress Forms.

Knapping Practice Forms

Name:……………………………   Date:……………………………

Technology:	Time practiced
Flake production	
Handaxe	
Levallois	
Other	

If other please specify:………………………………………………………………

………………………………………………………………………….

Received instruction: Yes/No   If Yes:

(Level of Instruction Given: 1-3, 1=verbal instruction, 2=demonstration, 3=physical intervention)

Name of instructor	Technology	Level of instruction

Assessment of Success (1-5, 1= very poor performance, worse than expected, 2=poor performance, at expected level but mistakes made, 3=average performance, at expected level, 4= good performance, better than expected, 5=excellent performance, far exceeds expectation):

Technology	Assessment of Success

Comments (e.g any breakthroughs made, closeness to original artefact, problems you may be having, perceived reasons for success/lack of success, tool/material flaws). Please continue on separate sheet if necessary:

Skill Evaluation Forms

Oldowan

Name: …………………………….   Date: …………………

Flakes:

Flake Number	**Connaissance comments**	**Savoir-Faire Comments**
1		
2		
3		
4		
5		

Comments:

Scores: Connaissance………………………….   Savoir-faire………………………

Acheulean Handaxe

Name: ………………………… Date: ………………………

Flake Number	Connaissance comments
1st Stage Flake 1	
1st Stage Flake 2	
2nd Stage Flake 1	
2nd Stage Flake 2	
3rd Stage Flake 1	
3rd Stage Flake 2	

Savoir-faire comments:

Scores: Connaissance……………………. Savoir-faire……………………………

Levallois

Name: ……………………….   Date: ………………………

Flake Number	**Connaissance comments**
1st Stage Flake 1	
1st Stage Flake 2	
2nd Stage Flake 1	
2nd Stage Flake 2	
Levallois Flake	

Savoir-faire comments:

Scores: Connaissance……………………. Savoir-faire……………………………

Appendix 4 – Evaluation Material Images.

Oldowan

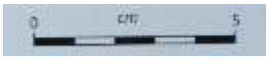
Evaluation 1

A **Dorsal** **Ventral**

B **Dorsal** **Ventral**

C **Dorsal** **Ventral**

D **Dorsal** **Ventral**



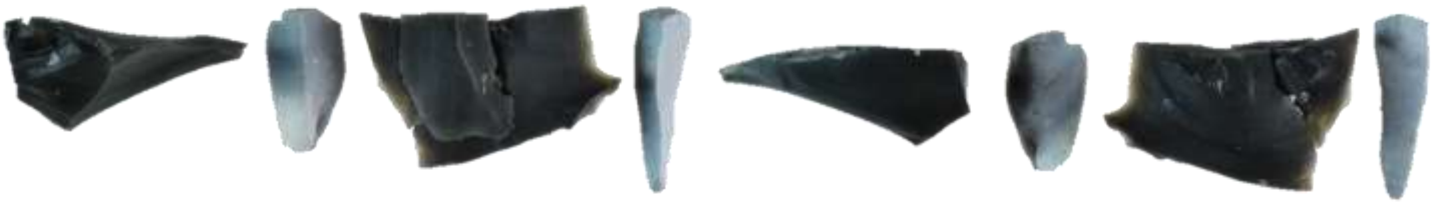
E **Dorsal** **Ventral**

F **Dorsal** **Ventral**

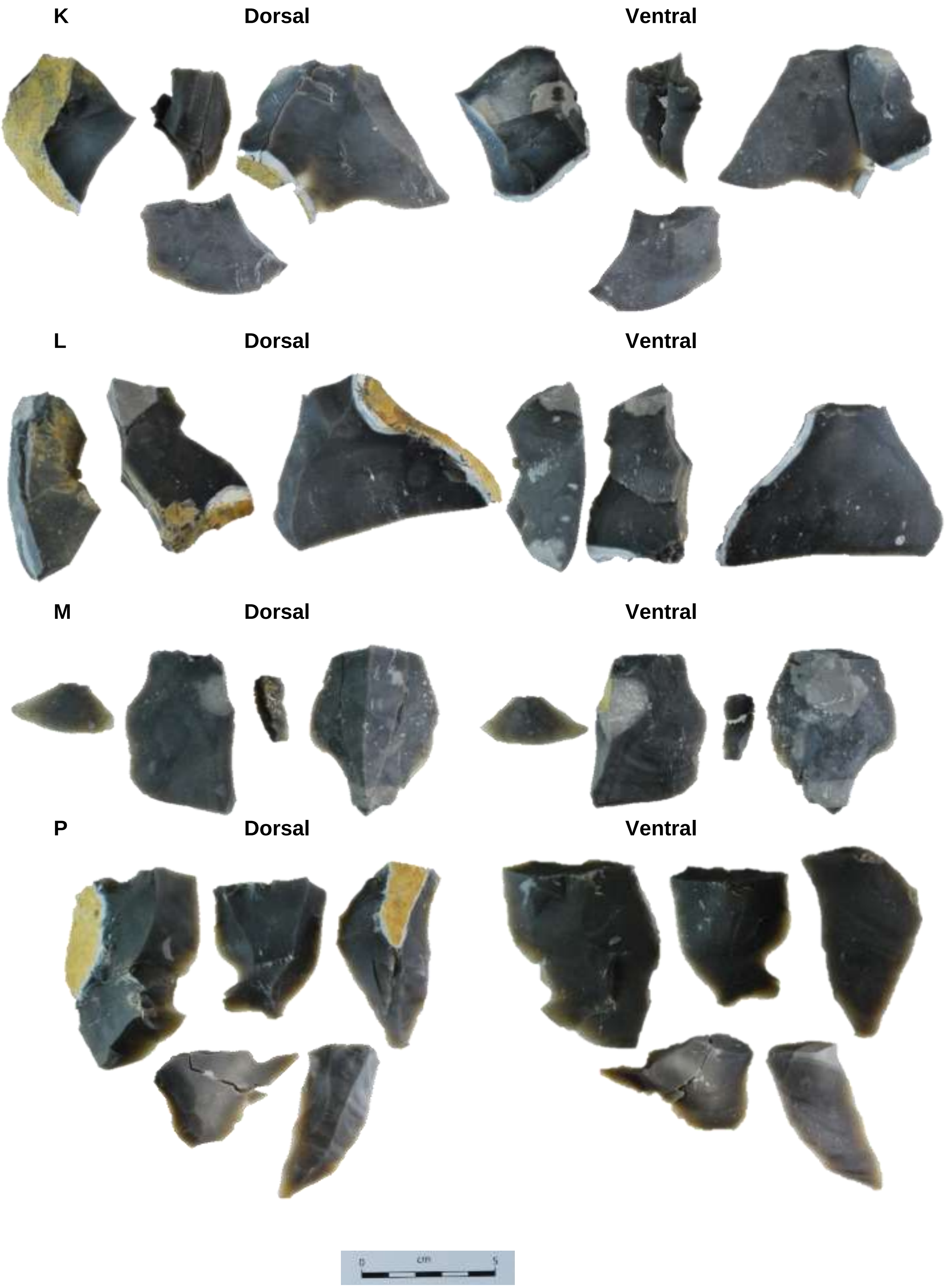
G **Dorsal** **Ventral**

H **Dorsal** **Ventral**

I **Dorsal** **Ventral**



J **Dorsal** **Ventral**


K
Dorsal
Ventral
L
Dorsal
Ventral
M
Dorsal
Ventral
P
Dorsal
Ventral
0
cm
5

R **Dorsal** **Ventral**

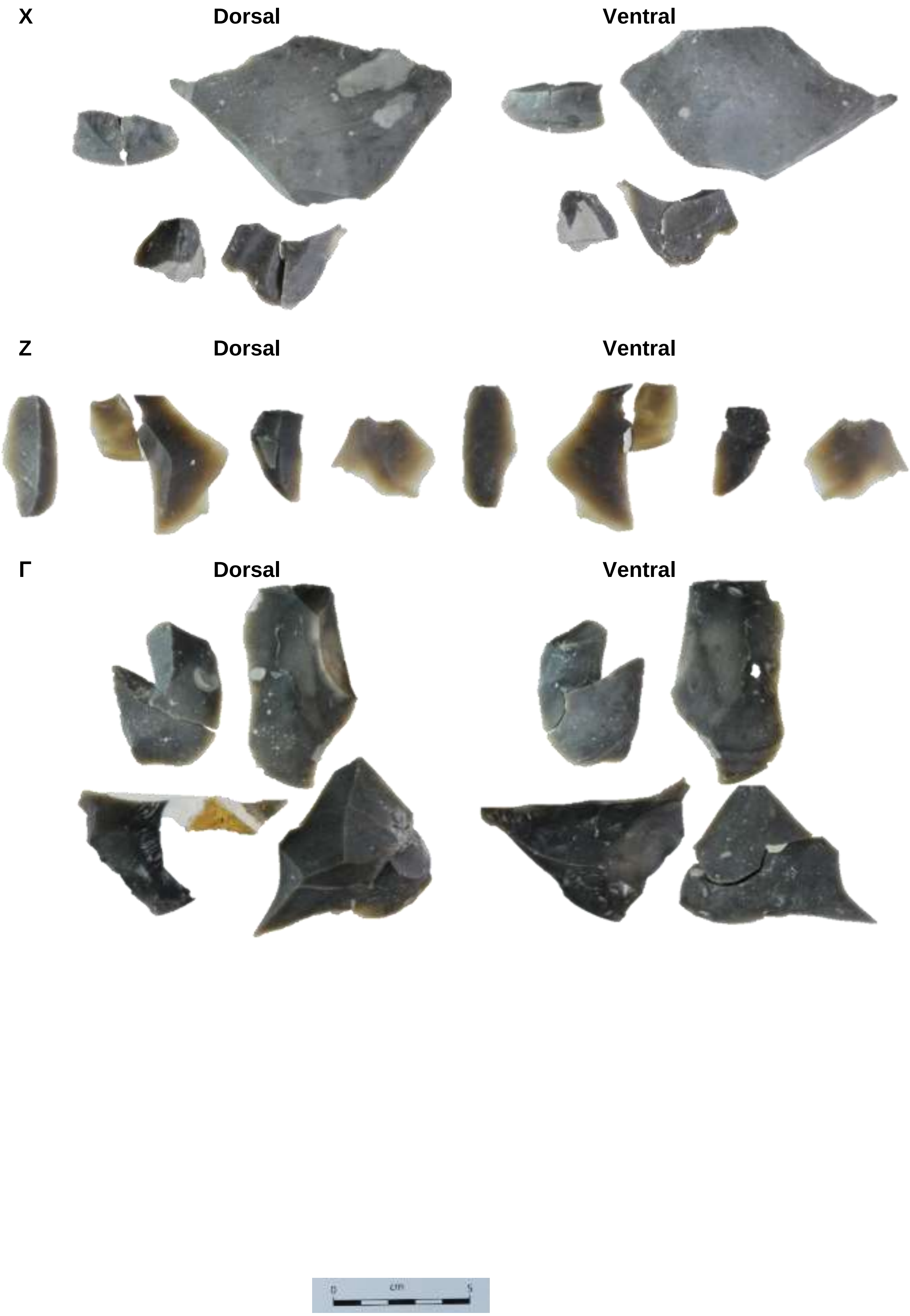
S **Dorsal** **Ventral**

T **Dorsal** **Ventral**

U **Dorsal** **Ventral**

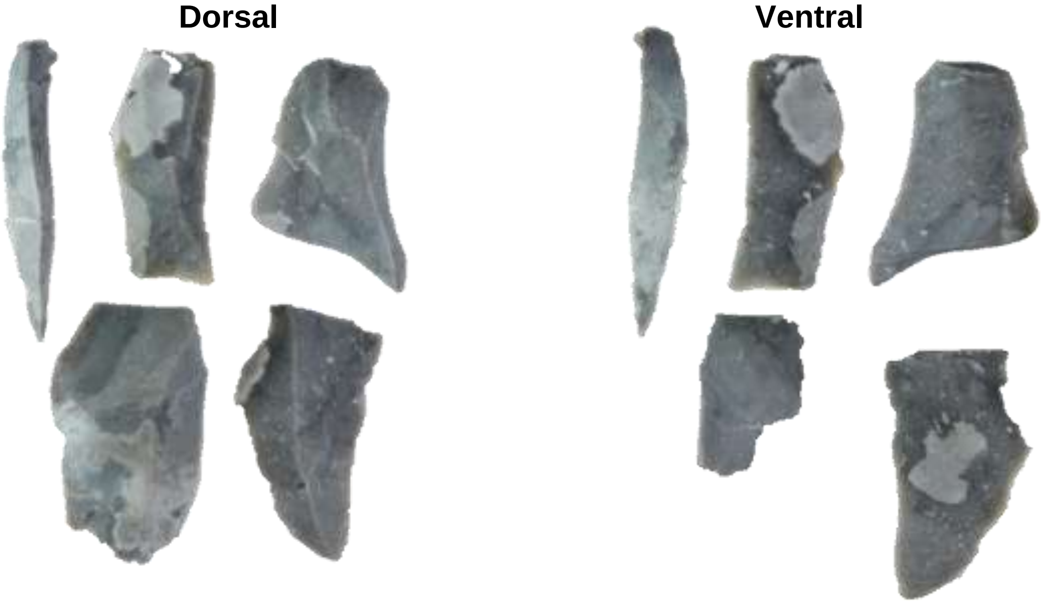
V **Dorsal** **Ventral**

W **Dorsal** **Ventral**


X
Dorsal
Ventral
Z
Dorsal
Ventral
Γ
Dorsal
Ventral
0
cm
5

Δ **Dorsal** **Ventral**

Θ **Dorsal** **Ventral**



Λ **Dorsal** **Ventral**

Ξ Dorsal Ventral

Evaluation 2

A **Dorsal** **Ventral**

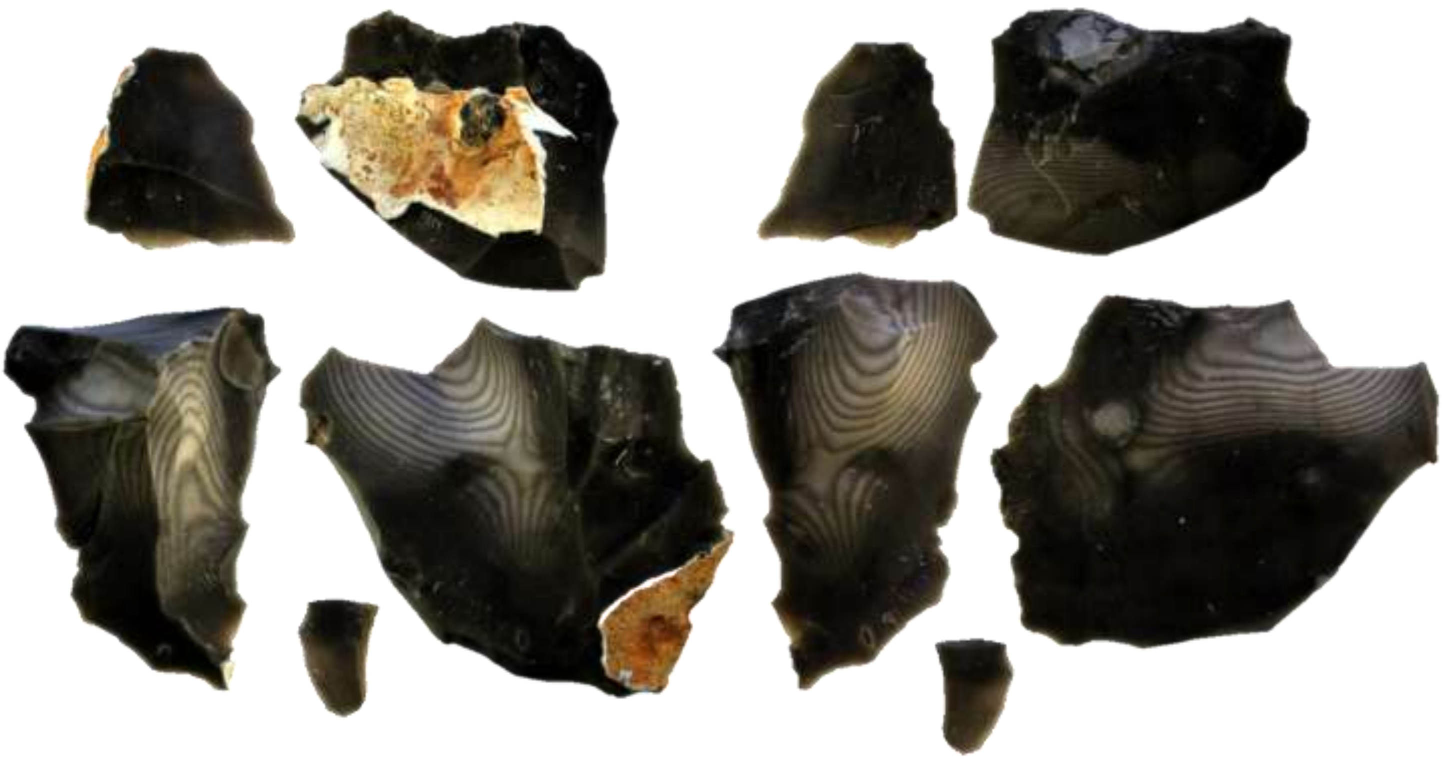
B **Dorsal** **Ventral**

C **Dorsal** **Ventral**

D **Dorsal** **Ventral**

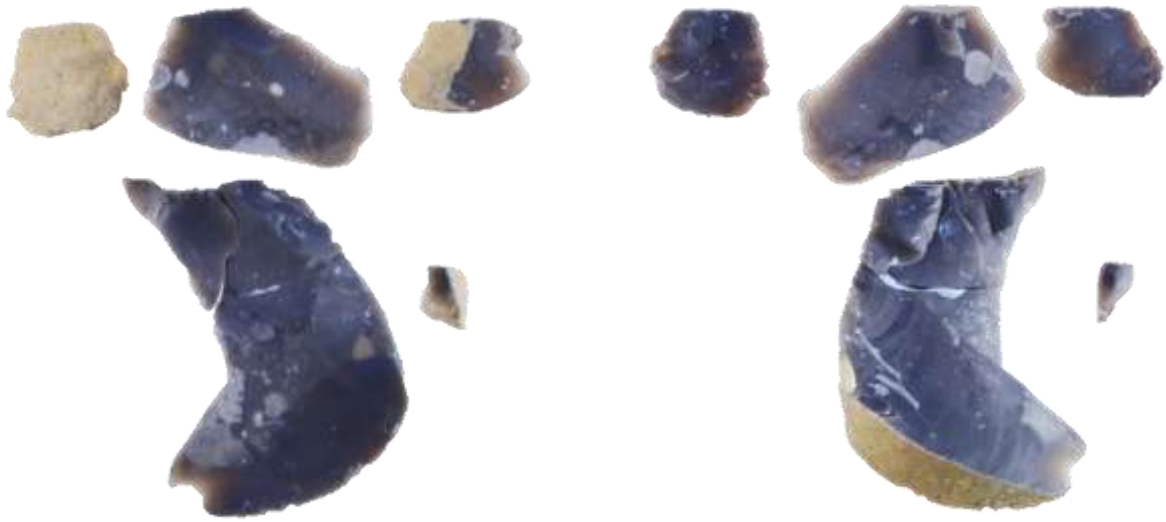
E **Dorsal** **Ventral**

F **Dorsal** **Ventral**



G **Dorsal** **Ventral**

I **Dorsal** **Ventral**



K **Dorsal** **Ventral**

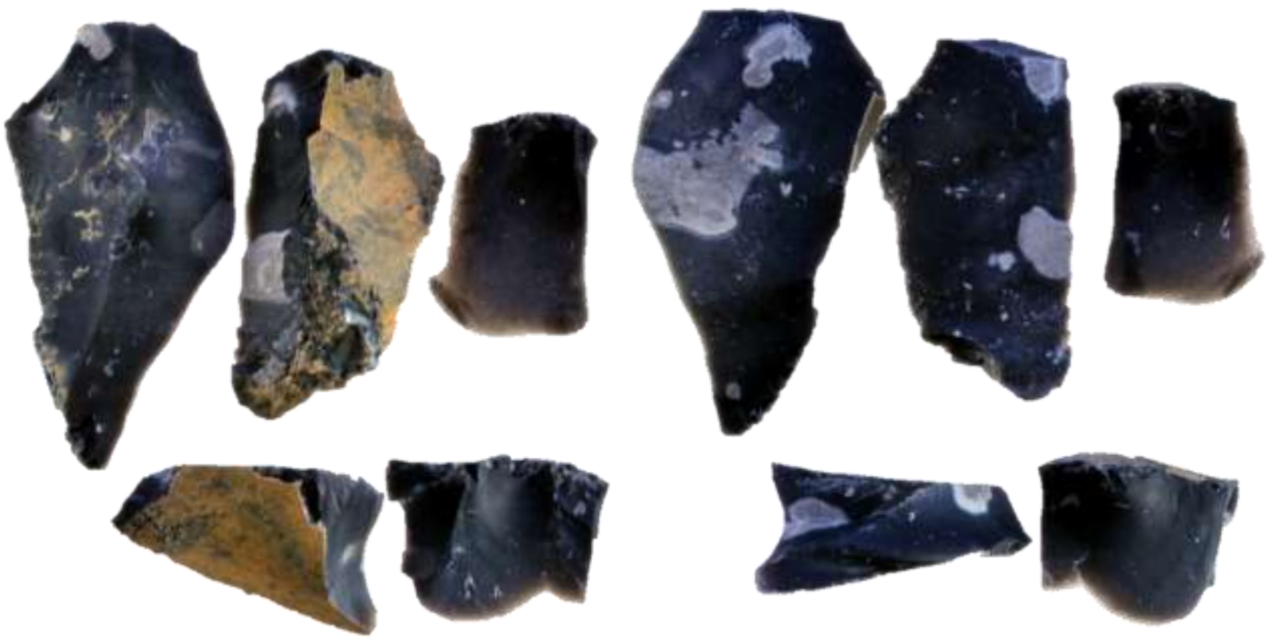
L **Dorsal** **Ventral**

M **Dorsal** **Ventral**

T **Dorsal** **Ventral**

V **Dorsal** **Ventral**

Θ **Dorsal** **Ventral**



Evaluation 3

A **Dorsal** **Ventral**

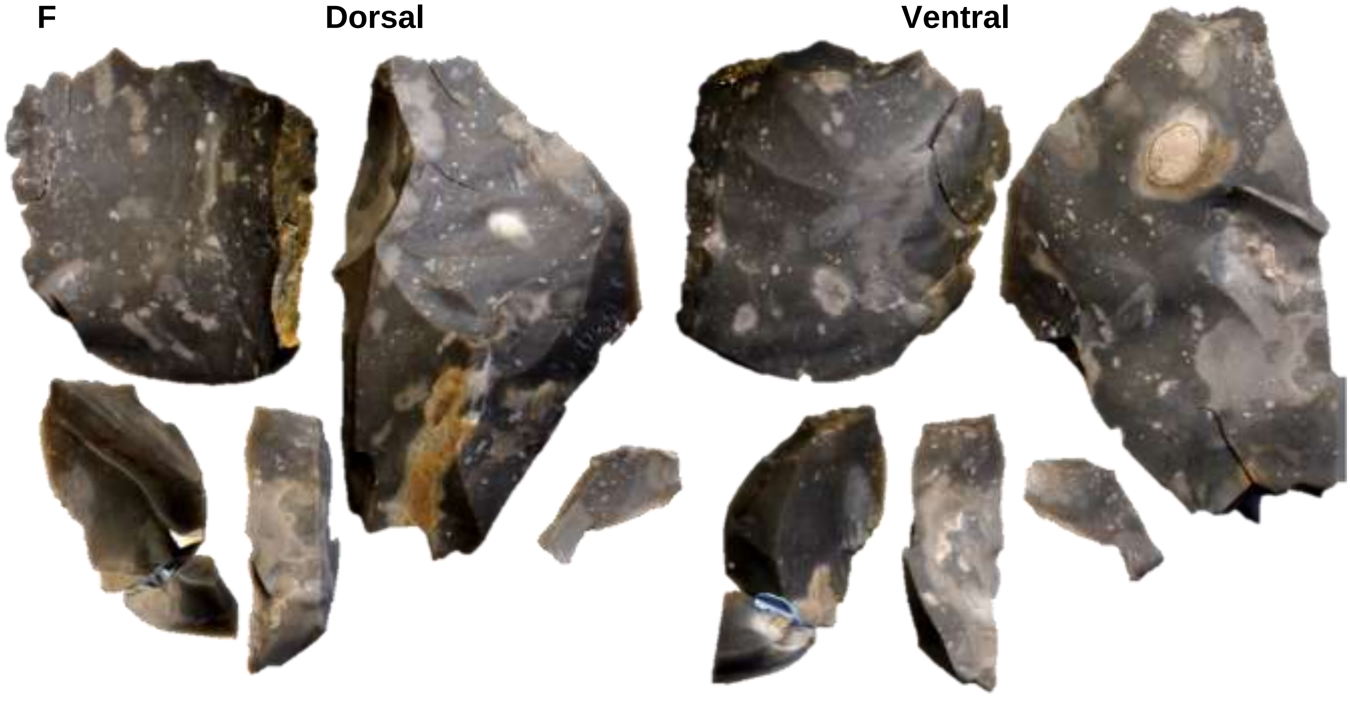
B **Dorsal** **Ventral**

C **Dorsal** **Ventral**

D **Dorsal** **Ventral**

E **Dorsal** **Ventral**

F **Dorsal** **Ventral**



G **Dorsal** **Ventral**

I **Dorsal** **Ventral**

L **Dorsal** **Ventral**

M **Dorsal** **Ventral**

T **Dorsal** **Ventral**

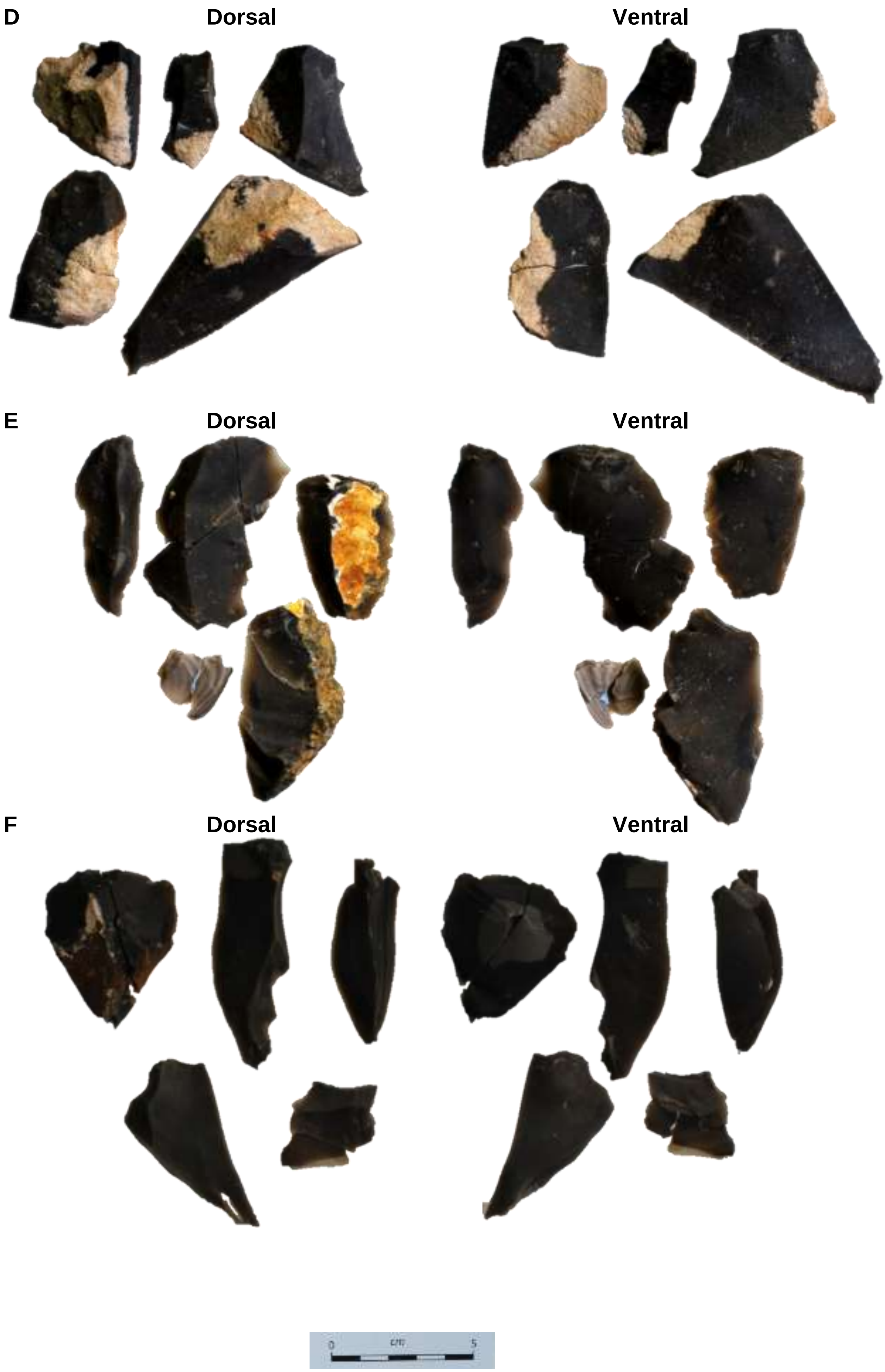
Θ **Dorsal** **Ventral**

Evaluation 4.

A **Dorsal** **Ventral**

B **Dorsal** **Ventral**

C **Dorsal** **Ventral**


D
Dorsal
Ventral
E
Dorsal
Ventral
F
Dorsal
Ventral
0
cm
5

G Dorsal Ventral

I Dorsal Ventral

K **Dorsal** **Ventral**

L **Dorsal** **Ventral**

M **Dorsal** **Ventral**

R **Dorsal** **Ventral**

T **Dorsal** **Ventral**

Θ **Dorsal** **Ventral**

Acheulean Handaxe

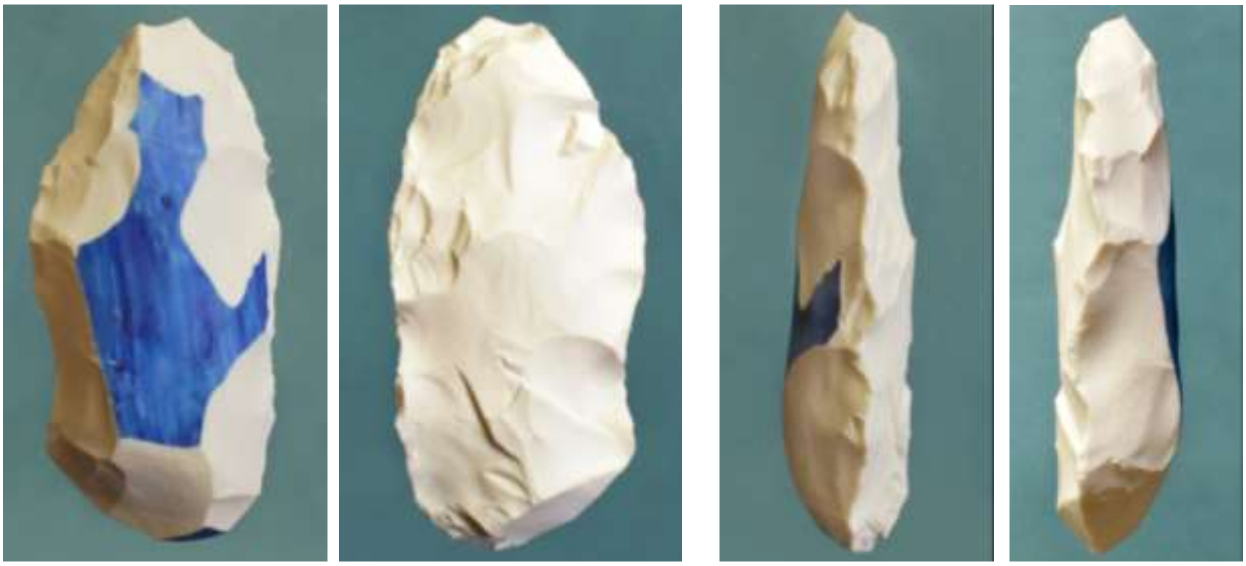
Evaluation 1

A **Plan** **Profile**

B **Plan** **Profile**

C **Plan** **Profile**

D **Plan** **Profile**

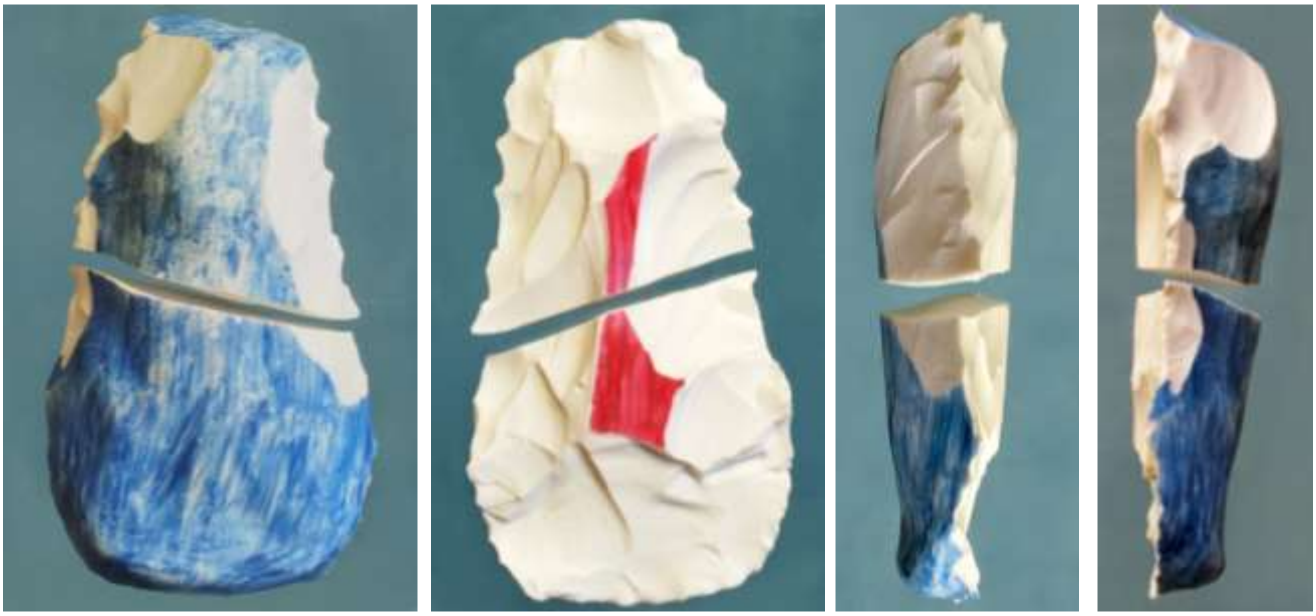


E **Plan** **Profile**

F **Plan** **Profile**

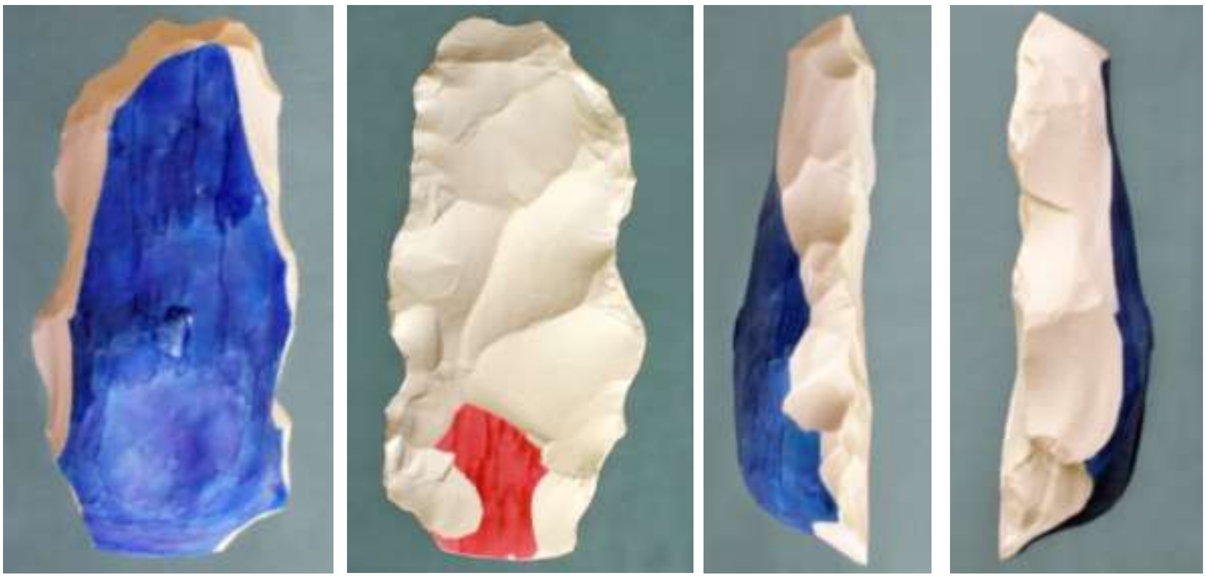
G Plan Profile

I Plan Profile



K **Plan** **Profile**

L **Plan** **Profile**



M **Plan** **Profile**

R **Plan** **Profile**

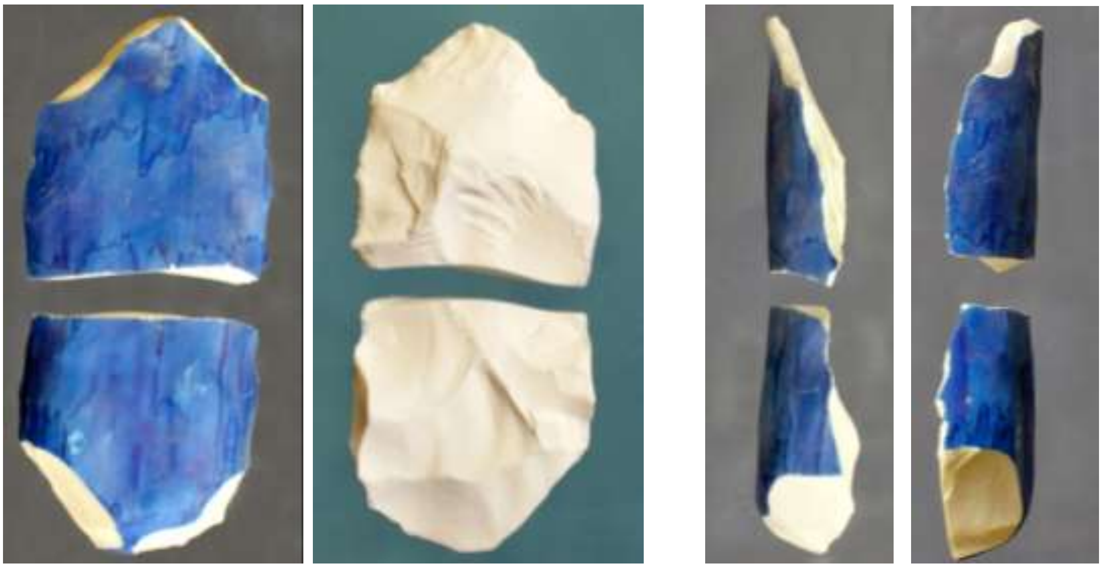
T **Plan** **Profile**

V **Plan** **Profile**

Θ **Plan** **Profile**

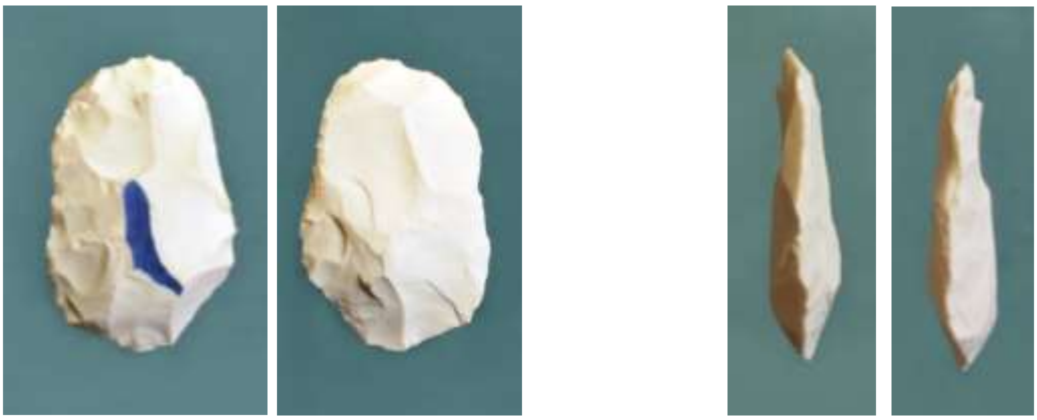
Evaluation 2

A **Plan** **Profile**



B **Plan** **Profile**

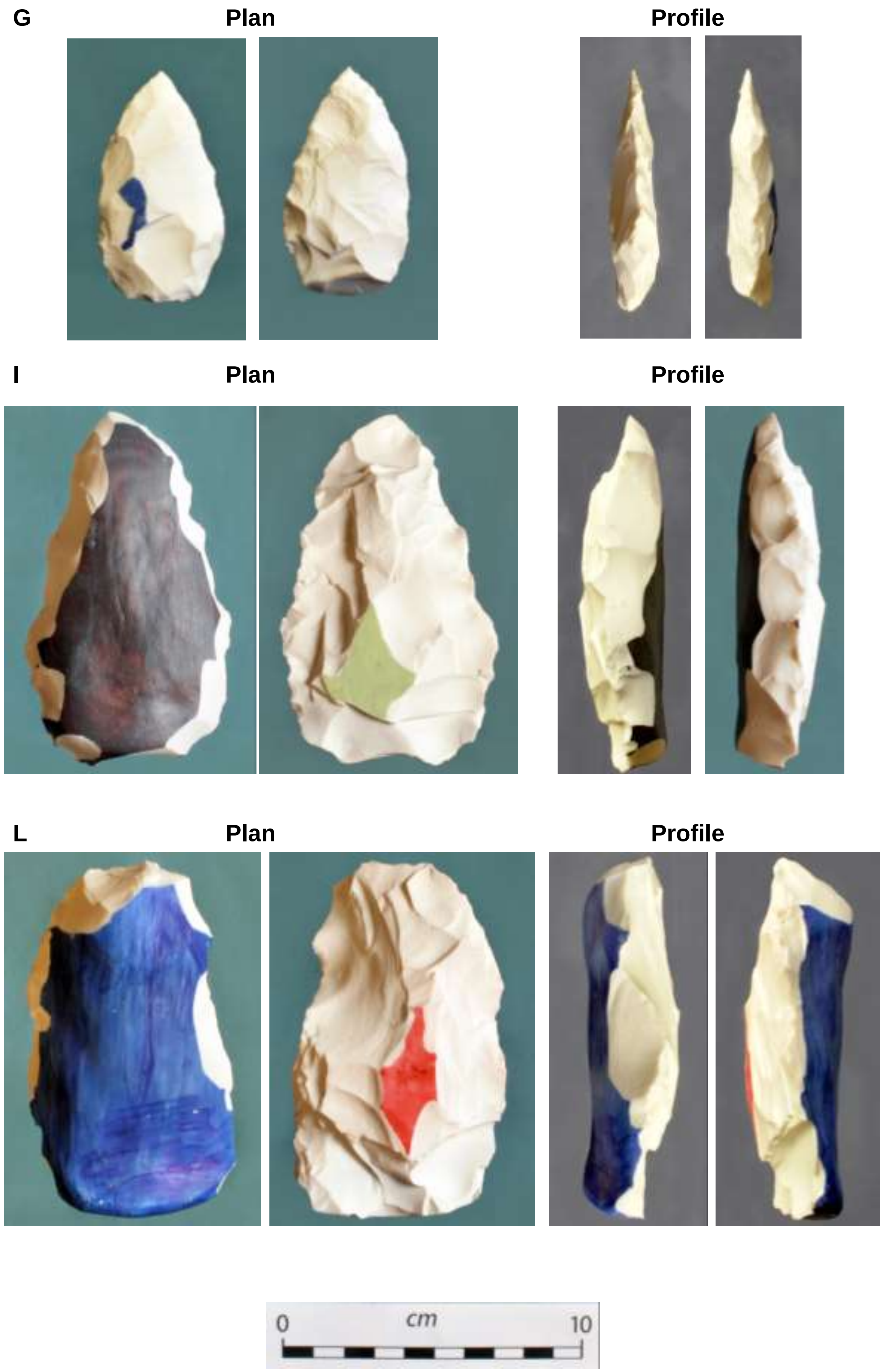
C **Plan** **Profile**



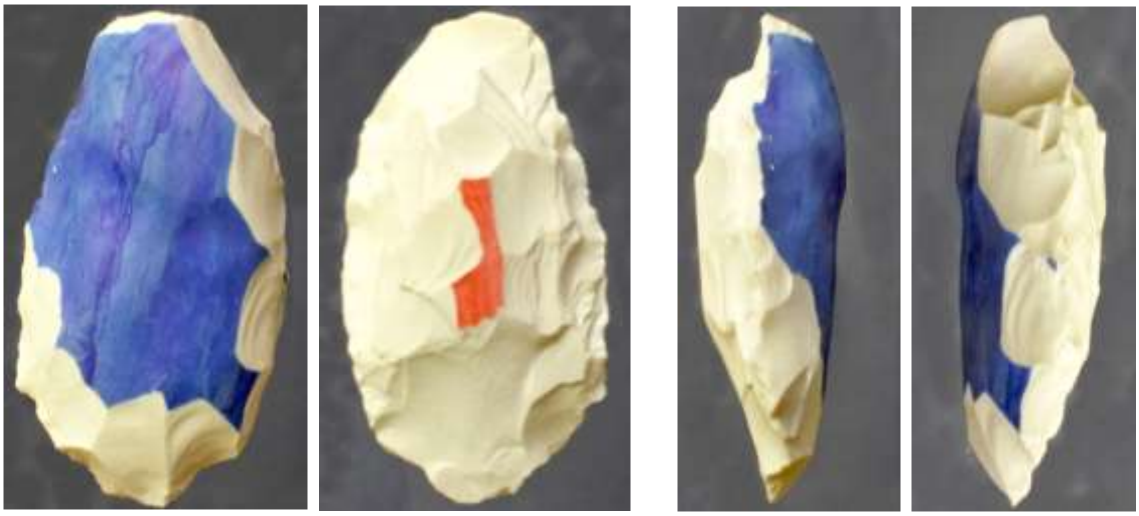
D **Plan** **Profile**

E **Plan** **Profile**

F **Plan** **Profile**


G
Plan
Profile
I
Plan
Profile
L
Plan
Profile
0
cm
10

M **Plan** **Profile**



R **Plan** **Profile**

T **Plan** **Profile**

Θ Plan Profile

Evaluation 3

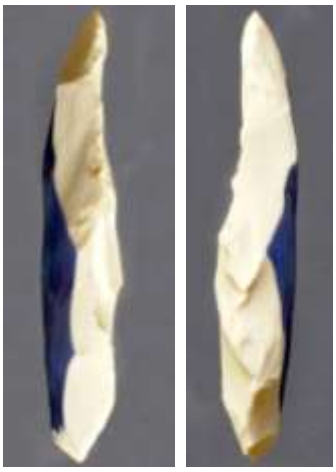
A **Plan** **Profile**

B **Plan** **Profile**

C **Plan** **Profile**

D **Plan** **Profile**

E **Plan** **Profile**

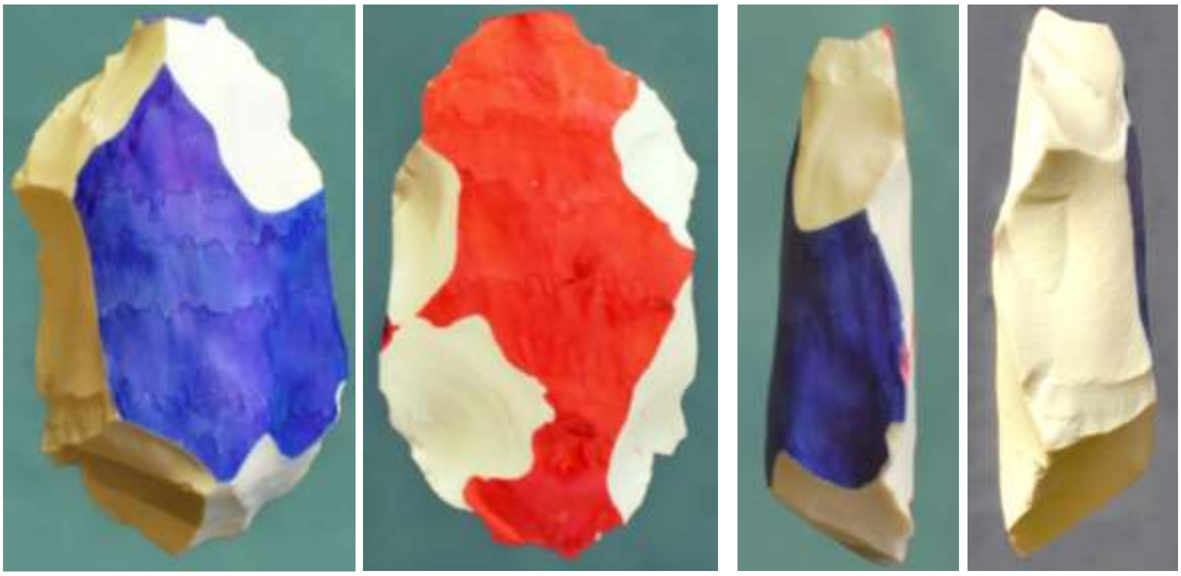


F **Plan** **Profile**

G **Plan** **Profile**

I **Plan** **Profile**

K **Plan** **Profile**

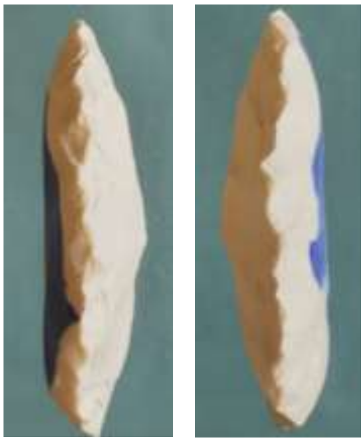


L **Plan** **Profile**

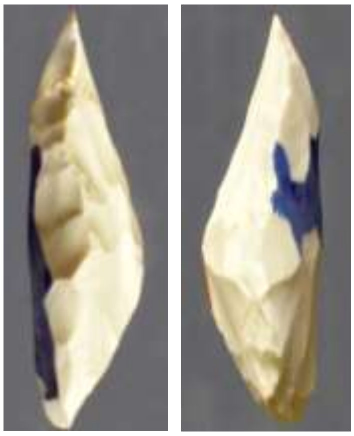
M **Plan** **Profile**

R **Plan** **Profile**

T **Plan** **Profile**



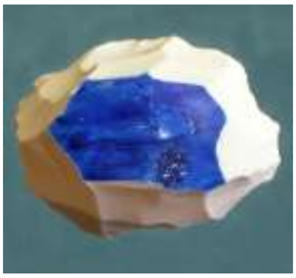
Θ **Plan** **Profile**



Levallois

Evaluation 1

A **Core** **Flake** **Platform**

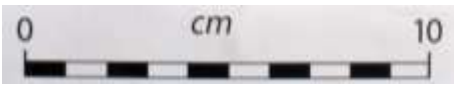



B **Core**



C **Core** **Flake** **Platform**

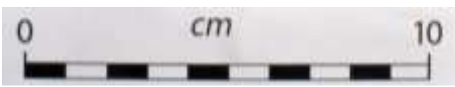


D **Core**

E **Core**

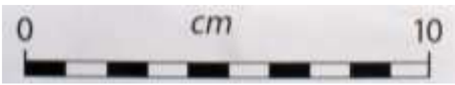
F **Core** **Flake** **Platform**



G **Core**

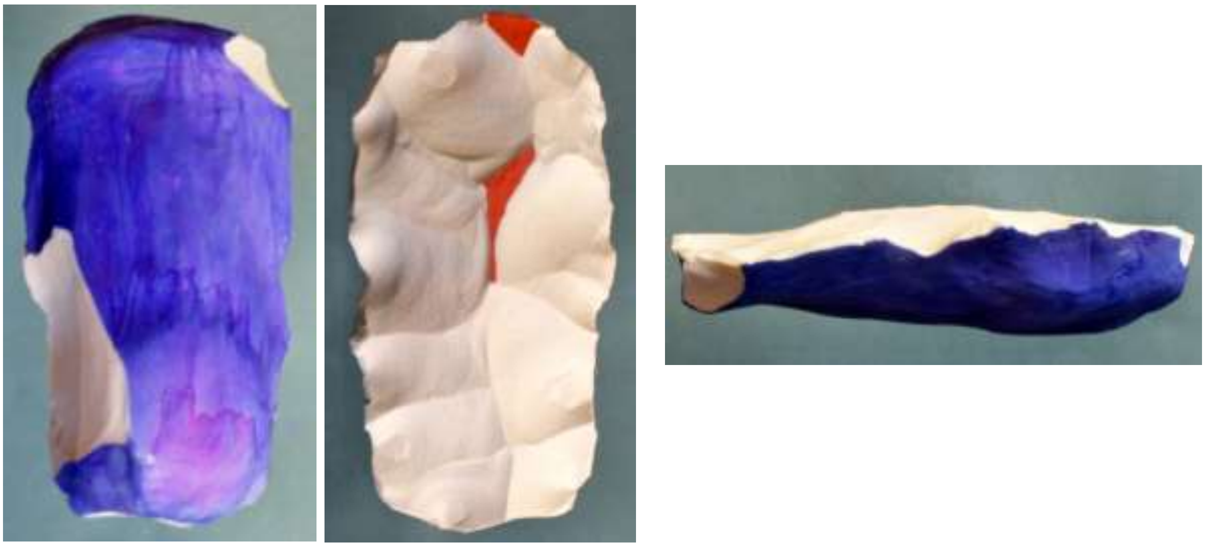
H **Core** **Flake** **Platform**

I **Core**

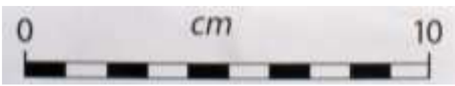


L **Core**

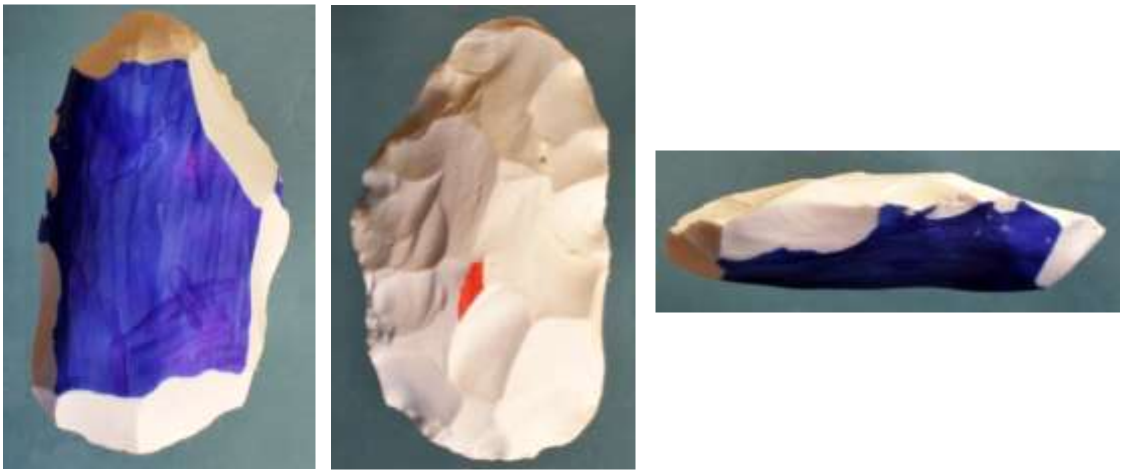
M **Core**



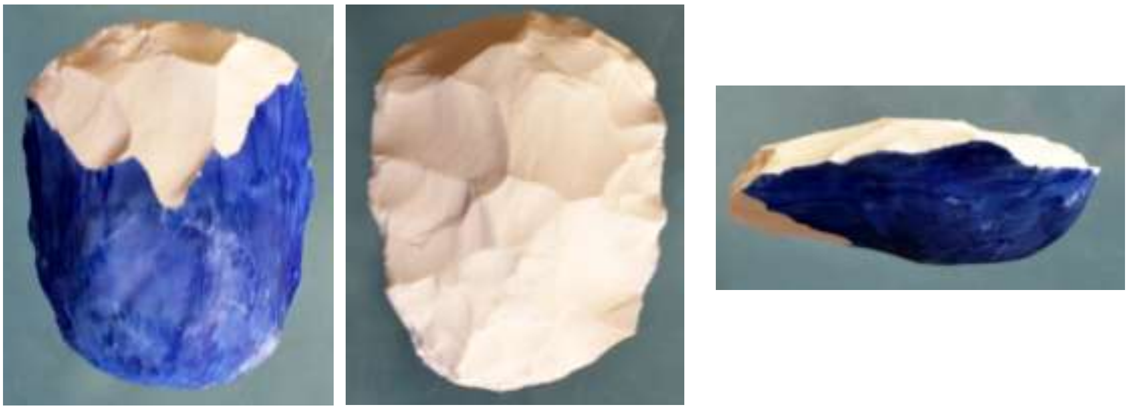
R **Core**

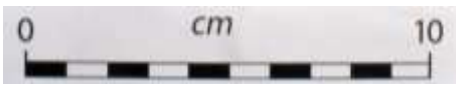


T **Core**



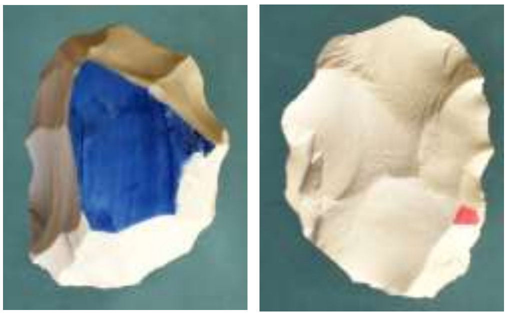
Θ **Core**





Evaluation 2

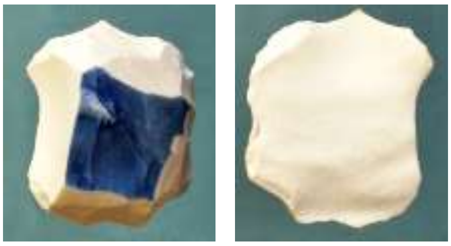
A **Core** **Flake** **Platform**



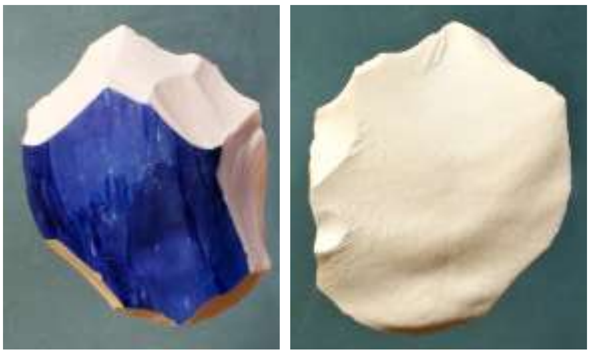
B **Core** **Flake** **Platform**

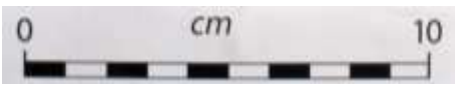


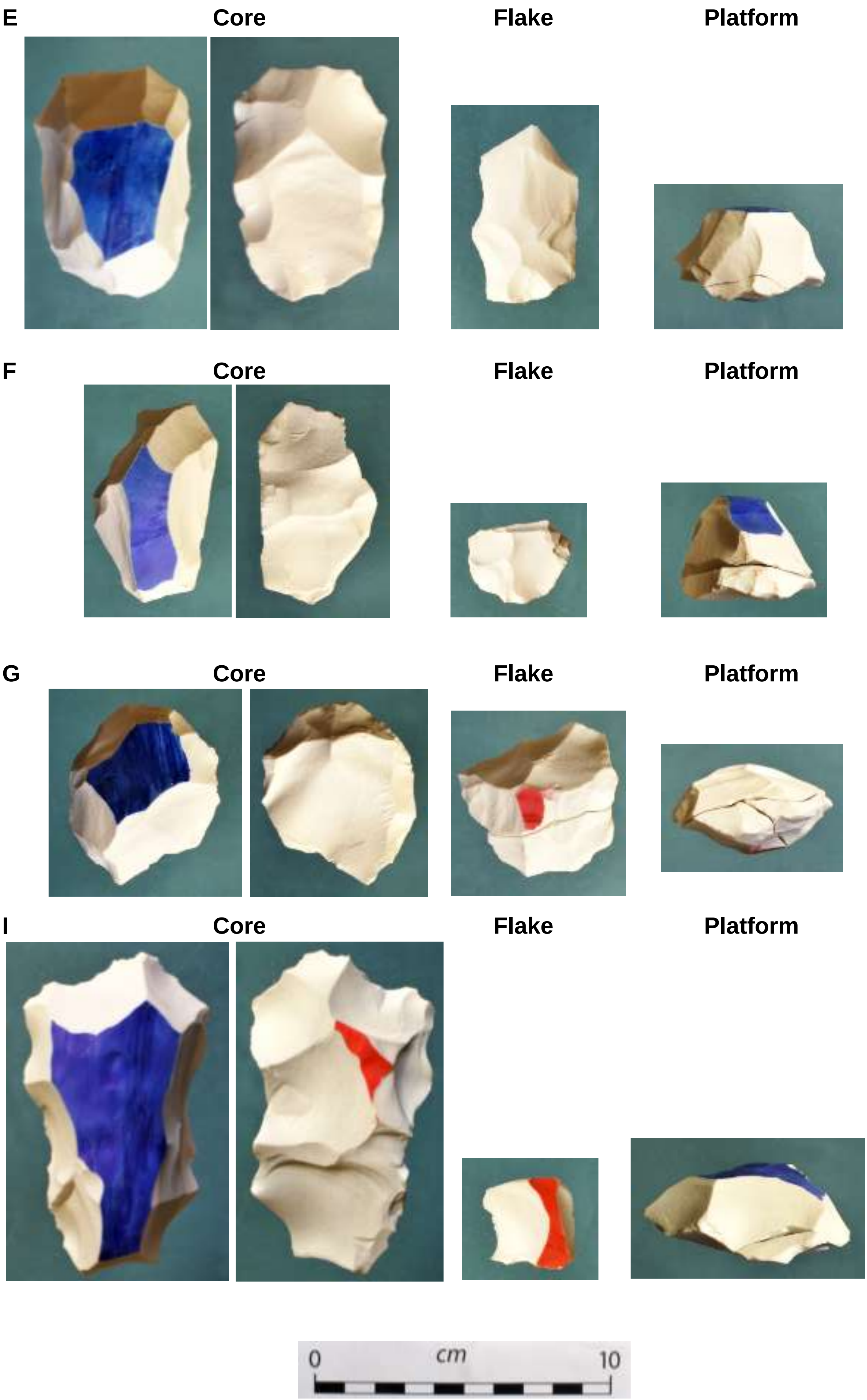
C **Core** **Flake** **Platform**



D **Core** **Flake** **Platform**

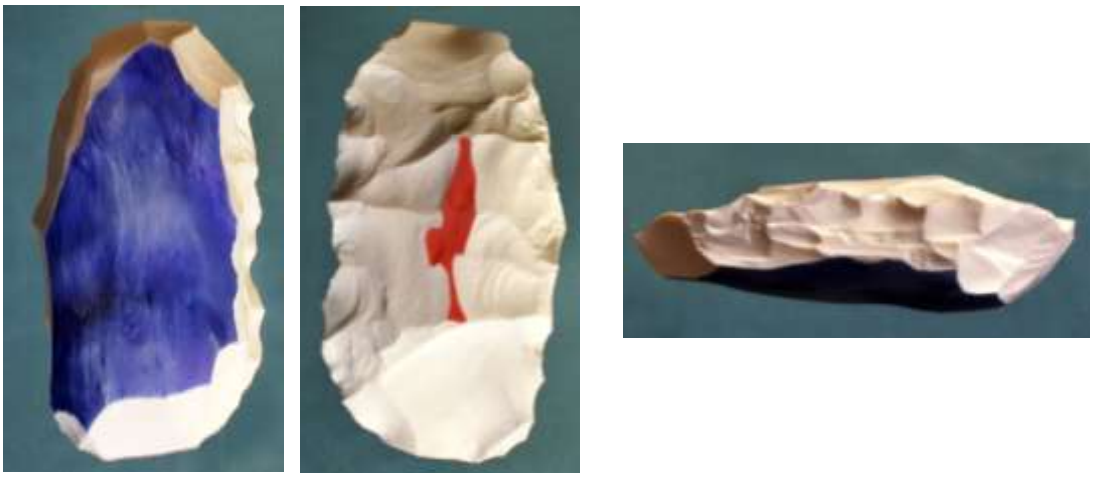




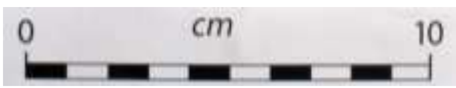

E
Core
Flake
Platform
F
Core
Flake
Platform
G
Core
Flake
Platform
I
Core
Flake
Platform
0
cm
10

L **Core**

M **Core**

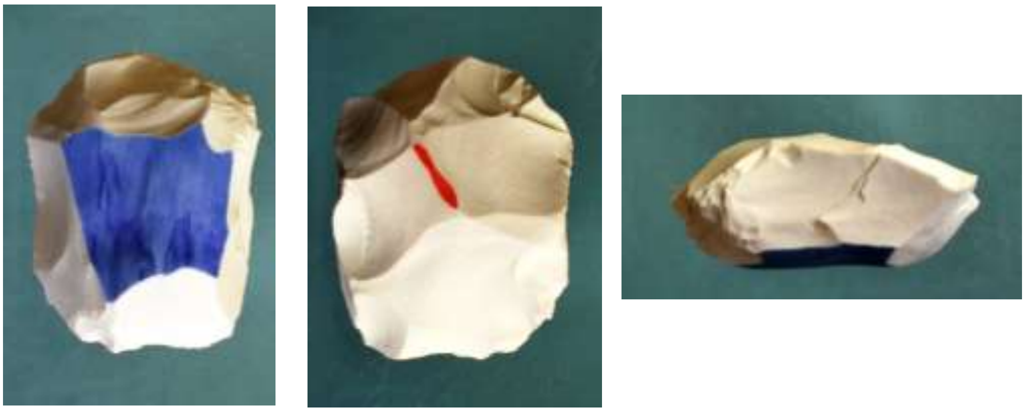


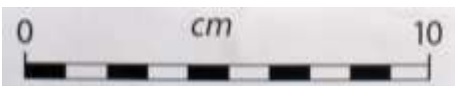
R **Core** **Flake** **Platform**



T Core

Θ Core

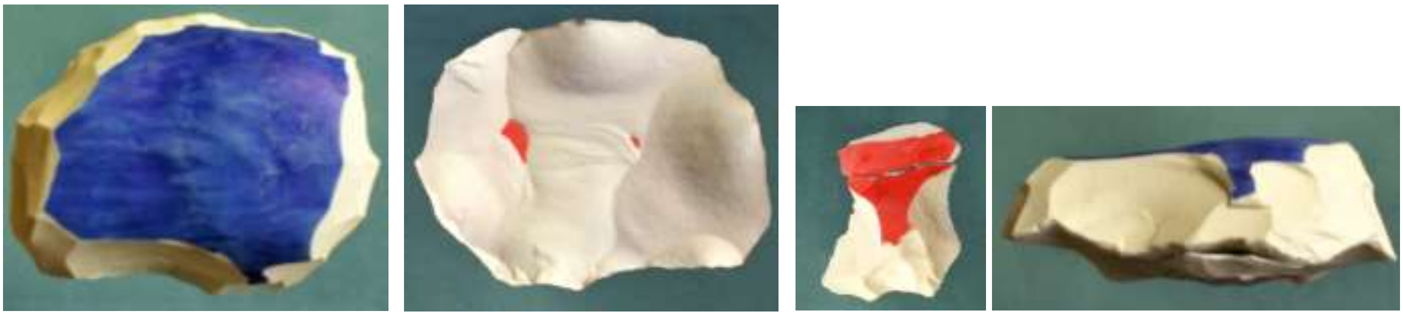




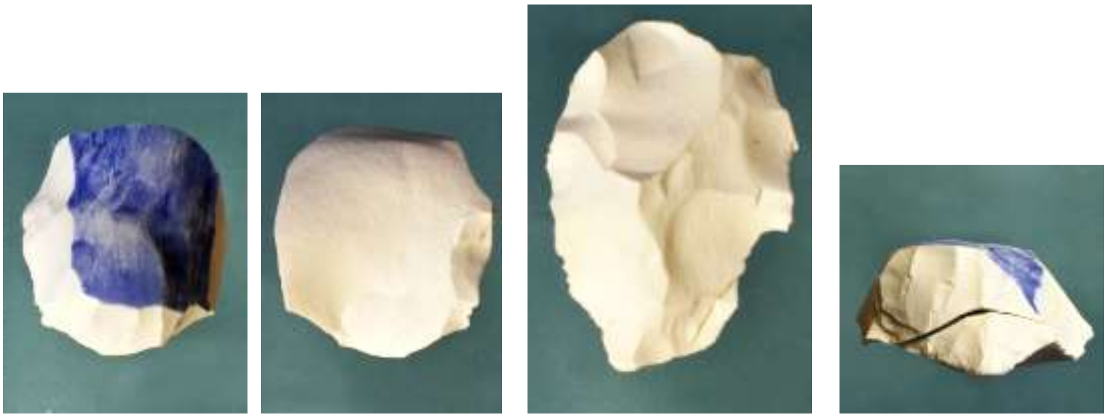
Evaluation 3

A **Core** **Flake** **Platform**

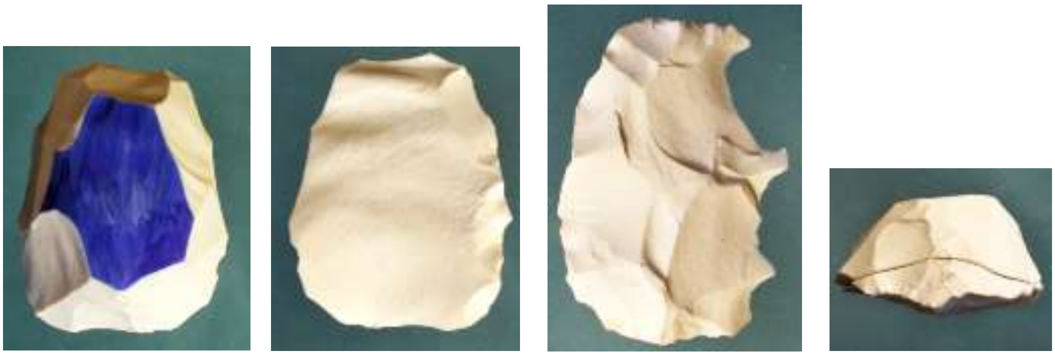
B **Core** **Flake** **Platform**

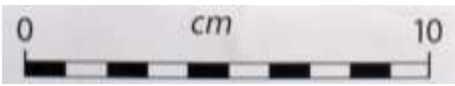


C **Core** **Flake** **Platform**

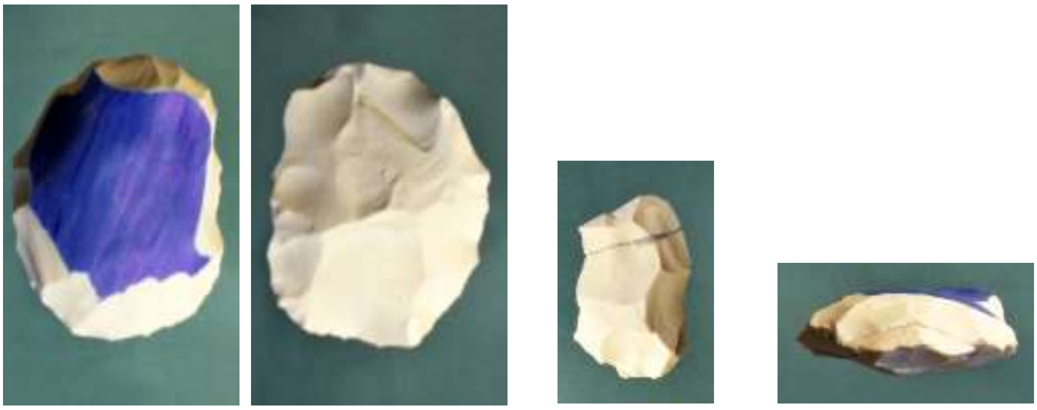


D **Core** **Flake** **Platform**



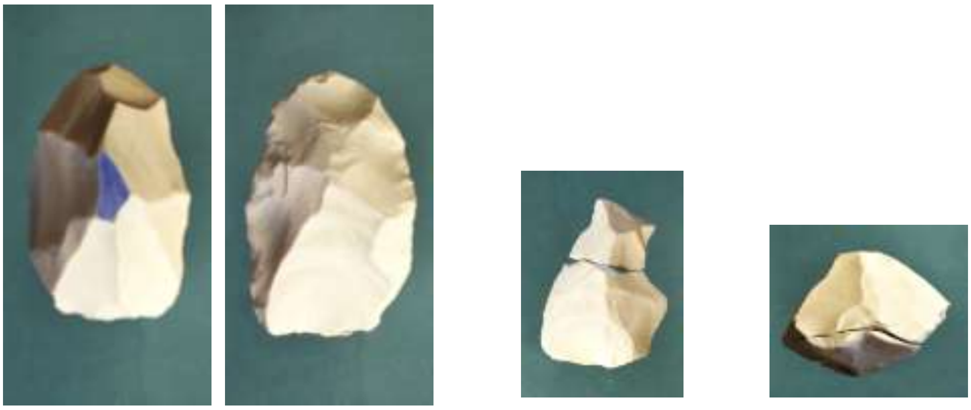


E | **Core** | **Flake** | **Platform**



F | **Core** | **Flake** | **Platform**

G | **Core** | **Flake** | **Platform**



Appendix 5 – Results Tables

Practice Hours

Group	Knapper	Date	Technology	Time Practiced	Instruction	Success
Core	A	02/02/2011	Flaking	1	0	2
Core	A	07/02/2011	Flaking	1	0	3
Core	A	11/02/2011	Flaking	2	0	2.5
Core	A	17/02/2011	Blade Production	1.5	0	3
Core	A	01/03/2011	Levallois	1.5	0	2
Core	A	18/03/2011	Levallois	1	0	3
Core	A	18/03/2011	Flaking	1	0	3
Core	A	23/03/2011	Levallois	1.5	0	3
Core	A	05/04/2011	Levallois	1	0	2
Core	A	05/04/2011	Blade Production	2	0	3
Core	A	06/04/2011	Handaxe	1	0	3
Core	A	07/04/2011	Levallois	2	0	3
Core	A	08/04/2011	Levallois	2	0	3
Core	A	09/04/2011	Levallois	1.5	1	3
Core	A	09/04/2011	Handaxe	1	0	2
Core	A	10/04/2011	Levallois	4	1	4
Core	A	12/04/2011	Levallois	2	0	4
Core	A	12/04/2011	Handaxe	0.5	0	3
Core	A	13/04/2011	Levallois	2	0	4
Core	A	13/04/2011	Handaxe	1	2	3
Core	A	14/04/2011	Handaxe	0.5	0	3
Core	A	16/04/2011	Levallois	2	1	3
Core	A	16/04/2011	Handaxe	2	0	3
Core	A	18/04/2011	Indirect Percussion	1	2	3
Core	A	20/04/2011	Handaxe	0.5	0	4
Core	A	20/04/2011	Levallois	0.5	0	3
Core	A	21/04/2011	Levallois	1	0	3
Core	A	21/04/2011	Handaxe	1	1	3
Core	A	23/04/2011	Handaxe	2	1	4
Core	A	24/04/2011	Handaxe	2.5	0	4
Core	A	25/04/2011	Handaxe	2	0	3
Core	A	26/04/2011	Handaxe	1	0	4
Core	A	26/04/2011	Levallois	1	0	4
Core	A	27/04/2011	Handaxe	2	0	4
Core	A	27/04/2011	Levallois	0.5	0	3
Core	A	28/04/2011	Handaxe	1.5	0	3
Core	A	29/04/2011	Handaxe	2	0	4

Group	Knapper	Date	Technology	Time Practiced	Instruction	Success
Core	A	30/04/2011	Handaxe	5	0	4
Core	A	16/05/2011	Blade Production	1	0	3
Core	A	24/05/2011	Levallois	1	0	3
Core	A	25/07/2011	Levallois	1.5	0	3
Core	A	08/08/2011	Levallois	1	0	2
Core	A	08/08/2011	Biface	1.5	0	4
Core	A	14/09/2011	Levallois	1.75	0	3
Core	A	15/09/2011	Handaxe	2	2	3
Core	A	15/09/2011	Levallois	2	2	4
Core	A	16/09/2011	Handaxe	2	0	3
Core	A	17/09/2011	Levallois	2	0	4
Core	A	17/09/2011	Handaxe	2	0	3
Core	A	19/09/2011	Handaxe	3	1	4
Core	A	19/09/2011	Levallois	2	0	3
Core	A	20/09/2011	Handaxe	3	1	4
Core	A	20/09/2011	Levallois	1	0	4
Core	A	21/09/2011	Handaxe	2	0	3
Core	A	21/09/2011	Levallois	2	0	3
Core	A	22/09/2011	Handaxe	1	1	3
Core	A	22/09/2011	Levallois	4	1	4
Core	A	23/09/2011	Handaxe	0.5	0	3
Core	A	23/09/2011	Levallois	3	0	4
Core	A	24/09/2011	Handaxe	3	0	3
Core	A	24/09/2011	Levallois	2	0	4
Core	A	15/10/2011	Handaxe	1	0	3
Core	A	18/10/2011	Levallois	2	0	4
Core	A	18/10/2011	Handaxe	1	0	3
Core	A	19/10/2011	Handaxe	2	0	3
Core	A	23/10/2011	Levallois	1	0	2
Core	A	28/10/2011	Levallois	1.5	0	3
Core	A	31/10/2011	Handaxe	0.75	0	4
Core	A	31/10/2011	Levallois	0.25	0	3
Core	A	22/11/2011	Handaxe	1	0	3
Core	A	26/11/2011	Handaxe	1.5	0	3
Core	A	30/11/2011	Handaxe	0.75	0	3
Core	A	30/11/2011	Levallois	0.5	0	4
Core	A	09/01/2012	Handaxe	0.75	0	4
Core	A	12/01/2012	Handaxe	0.5	0	3
Core	A	12/01/2012	Levallois	1.5	0	3
Core	A	13/01/2012	Handaxe	0.5	0	3
Core	A	16/01/2012	Handaxe	1	0	4
Core	A	17/01/2012	Handaxe	1	0	4

Group	Knapper	Date	Technology	Time Practiced	Instruction	Success
Core	A	09/02/2012	Handaxe	1.5	0	4
Core	A	12/03/2012	Levallois	0.75	0	2
Core	A	12/03/2012	Handaxe	1.5	0	3
Core	A	19/03/2012	Handaxe	0.75	0	3
Core	A	15/04/2012	Handaxe	1	0	2
Core	A	24/04/2012	Handaxe	1.5	0	3
Core	A	27/04/2012	Handaxe	1	0	3
Core	A	01/05/2012	Handaxe	0.75	0	4
Core	A	06/05/2012	Handaxe	1.5	0	4
Core	A	09/05/2012	Handaxe	0.75	0	4
Core	A	09/05/2012	Blade Production	0.5	0	3
Core	A	18/05/2012	Handaxe	1.5	0	3
Core	A	18/05/2012	Levallois	0.25	0	2
Core	A	20/05/2012	Levallois	0.75	0	3
Core	A	27/05/2012	Handaxe	0.75	0	3
Core	A	28/05/2012	Handaxe	1	0	3
Core	A	29/05/2012	Handaxe	0.75	0	4
Core	A	29/05/2012	Levallois	0.5	0	4
Core	A	09/06/2012	Handaxe	0.75	0	4
Core	B	25/01/2011	Levallois	0.5	0	1
Core	B	25/01/2011	Flaking	0.5	0	3.5
Core	B	25/01/2011	Retouch	0.5	0	3
Core	B	27/01/2011	Levallois	1.5	0	2
Core	B	27/01/2011	Flaking	1.5	0	3
Core	B	29/01/2011	Levallois	1	0	3
Core	B	24/02/2011	Flaking	0.5	0	3
Core	B	24/02/2011	Blade Production	0.5	0	3.5
Core	B	24/02/2011	Levallois	0.5	0	2
Core	B	07/03/2011	Blade Production	0.5	0	3
Core	B	07/03/2011	Flaking	0.25	0	3
Core	B	08/03/2011	Blade Production	0.75	0	2.5
Core	B	24/03/2011	Blade Production	0.25	0	4
Core	B	24/03/2011	Flaking	0.5	0	4
Core	B	25/03/2011	Levallois	0.5	0	4
Core	B	25/03/2011	Blade Production	0.5	0	3
Core	B	25/03/2011	Flaking	0.5	0	3
Core	B	05/04/2011	Flaking	0.5	0	3
Core	B	06/04/2011	Flaking	0.75	0	4
Core	B	06/04/2011	Handaxe	0.75	0	1
Core	B	07/04/2011	Flaking	0.25	0	4
Core	B	07/04/2011	Levallois	0.25	0	3
Core	B	07/04/2011	Handaxe	2	0	2

Group	Knapper	Date	Technology	Time Practiced	Instruction	Success
Core	B	08/04/2011	Levallois	0.5	3	2
Core	B	08/04/2011	Handaxe	1.25	2	3
Core	B	08/04/2011	Flaking	0.5	0	4
Core	B	09/04/2011	Handaxe	1	0	3
Core	B	09/04/2011	Flaking	0.25	0	3
Core	B	12/04/2011	Levallois	0.5	1	2
Core	B	12/04/2011	Handaxe	0.75	0	2
Core	B	13/04/2011	Handaxe	1.25	1	1.5
Core	B	16/04/2011	Levallois	0.5	0	2
Core	B	16/04/2011	Flaking	0.5	0	4
Core	B	16/04/2011	Handaxe	0.5	0	2
Core	B	18/04/2011	Indirect Percussion	2.5	2	4
Core	B	19/04/2011	Handaxe	2	0	2
Core	B	20/04/2011	Handaxe	0.5	0	2
Core	B	20/04/2011	Flaking	0.5	0	3
Core	B	21/04/2011	Levallois	0.25	0	1
Core	B	21/04/2011	Handaxe	0.75	0	2
Core	B	25/04/2011	Flaking	0.5	0	4
Core	B	25/04/2011	Levallois	0.5	0	4
Core	B	25/04/2011	Handaxe	1.5	0	2
Core	B	28/04/2011	Flaking	0.5	0	3.5
Core	B	28/04/2011	Levallois	0.75	0	2
Core	B	29/04/2011	Levallois	0.25	3	3
Core	B	29/04/2011	Handaxe	0.5	3	2
Core	B	19/05/2011	Levallois	1	0	4
Core	B	19/05/2011	Blade Production	0.5	0	3
Core	B	01/08/2011	Levallois	2	0	3
Core	B	01/08/2011	Flaking	4	0	4
Core	B	24/10/2011	Flaking	1	0	3
Core	B	03/04/2012	Biface	1	2	4
Core	B	03/04/2012	Levallois	2.5	0	3
Core	B	04/04/2012	Handaxe	5	1	5
Core	B	05/04/2012	Levallois	2	0	4
Core	B	05/04/2012	Handaxe	3	0	2
Core	B	06/04/2012	Handaxe	2.5	1	3
Core	B	07/04/2012	Handaxe	2	0	2
Core	B	09/04/2012	Handaxe	2	0	3
Core	B	24/09/2012	Handaxe	0.75	0	4
Core	C	25/01/2011	Flaking	1	0	3
Core	C	25/01/2011	Pressure Flaking	1	0	3
Core	C	03/02/2011	Handaxe	1	0	2

Group	Knapper	Date	Technology	Time Practiced	Instruction	Success
Core	C	03/02/2011	Levallois	1	0	2
Core	C	03/02/2011	Flaking	0.25	0	3
Core	C	10/02/2011	Handaxe	1	0	3
Core	C	10/02/2011	Blade Production	1	0	3
Core	C	10/02/2011	Pressure Flaking	1	0	2
Core	C	14/02/2011	Handaxe	2	0	4
Core	C	17/02/2011	Handaxe	1	0	2
Core	C	07/03/2011	Pressure Flaking	1	0	4
Core	C	07/03/2011	Handaxe	1	0	3
Core	C	21/03/2011	Blade Production	0.5	0	2
Core	C	21/03/2011	Levallois	0.5	0	2
Core	C	04/04/2011	Biface	2	0	2
Core	C	06/04/2011	Handaxe	4	0	3
Core	C	06/04/2011	Levallois	1	0	2
Core	C	06/04/2011	Pressure Flaking	3	0	4
Core	C	07/04/2011	Biface	1	0	3
Core	C	07/04/2011	Levallois	2	0	3
Core	C	08/04/2011	Biface	3	1	3
Core	C	10/04/2011	Adze Manufacture	2.5	2	4
Core	C	10/04/2011	Handaxe	1.5	0	3
Core	C	10/04/2011	Levallois	0.5	0	3
Core	C	12/04/2011	Adze Manufacture	2	0	4
Core	C	13/04/2011	Adze Manufacture	0.5	0	4
Core	C	13/04/2011	Levallois	0.5	0	3
Core	C	15/04/2011	Adze Manufacture	0.5	0	3
Core	C	15/04/2011	Levallois	0.5	0	3
Core	C	16/04/2011	Levallois	2	0	4
Core	C	18/04/2011	Indirect Percussion	2	2	4
Core	C	19/04/2011	Handaxe	2	0	3
Core	C	23/04/2011	Handaxe	1.5	0	4
Core	C	24/04/2011	Handaxe	1	0	4
Core	C	24/04/2011	Levallois	1	0	4
Core	C	28/04/2011	Handaxe	2	0	4
Core	C	29/04/2011	Handaxe	3	0	4
Core	C	30/04/2011	Pressure Flaking	1	0	4
Core	C	30/04/2011	Handaxe	3	0	4
Core	C	19/06/2011	Blade Production	2	0	3
Core	C	28/06/2011	Handaxe	1	0	3
Core	C	28/06/2011	Blade Production	1	0	3
Core	C	14/09/2011	Levallois	1	2	4
Core	C	15/09/2011	Levallois	3.5	0	4

Group	Knapper	Date	Technology	Time Practiced	Instruction	Success
Core	C	16/09/2011	Handaxe	2	0	3
Core	C	17/09/2011	Handaxe	3	0	3
Core	C	19/09/2011	Handaxe	3	0	4
Core	C	21/09/2011	Square Axe Manufacture	2.5	1	2
Core	C	21/09/2011	Punch Blade Production	2.5	0	4
Core	C	22/09/2011	Punch Blade Production	4	0	3
Core	C	23/09/2011	Handaxe	1.5	0	3
Core	C	24/09/2011	Blade Production	2	0	4
Core	C	14/10/2011	Levallois	1.5	0	2
Core	C	27/10/2011	Levallois	1	0	3
Core	C	23/11/2011	Levallois	0.5	0	2
Core	C	07/12/2011	Handaxe	2	0	4
Core	C	21/02/2012	Handaxe	1	0	3
Core	C	03/04/2012	Levallois	1.5	0	4
Core	C	03/04/2012	Handaxe	1	0	3
Core	C	03/04/2012	Blade Production	0.5	0	3
Core	C	04/04/2012	Handaxe	1.5	0	3
Core	C	04/04/2012	Levallois	1	0	2
Core	C	04/04/2012	Blade Production	0.5	0	1
Core	C	05/04/2012	Blade Production	1	1	4
Core	C	06/04/2012	Blade Production	1	0	3
Core	C	06/04/2012	Levallois	0.5	0	3
Core	C	15/06/2012	Levallois	1	0	3
Core	C	23/11/2012	Handaxe	0.5	0	3
Core	D	25/01/2011	Flaking	0.5	0	3
Core	D	25/01/2011	Levallois	0.5	0	2
Core	D	25/01/2011	Retouch	0.5	0	3
Core	D	02/02/2011	Flaking	1	0	3
Core	D	02/02/2011	Levallois	1	0	1
Core	D	03/02/2011	Flaking	1.5	0	3
Core	D	03/02/2011	Pressure Flaking	0.75	0	2
Core	D	03/02/2011	Blade Production	0.75	0	3
Core	D	22/02/2011	Levallois	0.25	0	4
Core	D	22/02/2011	Blade Production	0.75	0	2
Core	D	24/02/2011	Levallois	0.5	0	2
Core	D	24/02/2011	Blade Production	1	0	2
Core	D	02/03/2011	Retouch	0.5	0	3
Core	D	02/03/2011	Blade Production	0.75	0	4
Core	D	02/03/2011	Levallois	0.5	0	1
Core	D	24/03/2011	Retouch	0.25	0	3

Group	Knapper	Date	Technology	Time Practiced	Instruction	Success
Core	D	24/03/2011	Levallois	0.5	0	2
Core	D	24/03/2011	Blade Production	0.25	0	4
Core	D	04/04/2011	Retouch	1	0	1
Core	D	04/04/2011	Flaking	1	0	1
Core	D	06/04/2011	Handaxe	1.5	1, 3	4
Core	D	06/04/2011	Blade Production	0.5	0	2
Core	D	07/04/2011	Levallois	0.25	1	2
Core	D	07/04/2011	Blade Production	2.75	0	3
Core	D	08/04/2011	Handaxe	1.5	1, 2	1
Core	D	08/04/2011	Blade Production	2	1	4
Core	D	08/04/2011	Biface	0.25	0	3
Core	D	09/04/2011	Levallois	2	1	5
Core	D	09/04/2011	Blade Production	1	0	2
Core	D	12/04/2011	Handaxe	1.5	1, 2, 3	4
Core	D	12/04/2011	Blade Production	1.25	0	1
Core	D	12/04/2011	Pressure Flaking	1.25	0	3
Core	D	13/04/2011	Levallois	0.25	0	2
Core	D	13/04/2011	Pressure Flaking	0.5	1, 2, 3	3
Core	D	13/04/2011	Blade Production	1.5	1	4
Core	D	14/04/2011	Handaxe	0.5	0	2
Core	D	14/04/2011	Levallois	2	0	2
Core	D	16/04/2011	Levallois	2	0	2
Core	D	18/04/2011	Levallois	0.5	0	3
Core	D	18/04/2011	Indirect Percussion	2	1, 2	2
Core	D	18/04/2011	Pressure Flaking	2	0	3
Core	D	19/04/2011	Levallois	0.5	0	2
Core	D	19/04/2011	Pressure Flaking	2.5	1	2
Core	D	20/04/2011	Handaxe	2	1	4
Core	D	21/04/2011	Levallois	0.75	1	3
Core	D	23/04/2011	Levallois	2	1	5
Core	D	24/04/2011	Handaxe	0.5	1	2
Core	D	28/04/2011	Flaking	0.5	0	3
Core	D	29/04/2011	Handaxe	1	0	1
Core	D	01/05/2011	Handaxe	2	1	2
Core	D	05/05/2011	Pressure Flaking	1	0	3
Core	D	12/05/2011	Handaxe	1	0	4
Core	D	12/05/2011	Levallois	1	0	4
Core	D	19/05/2011	Handaxe	1	0	2
Core	D	19/05/2011	Levallois	0.5	0	4
Core	D	25/05/2011	Handaxe	0.5	0	1
Core	D	25/05/2011	Blade Production	1	0	3

Group	Knapper	Date	Technology	Time Practiced	Instruction	Success
Core	D	31/05/2011	Blade Production	1.75	0	4
Core	D	31/05/2011	Handaxe	0.25	0	3
Core	D	06/06/2011	Handaxe	1	0	4
Core	D	06/06/2011	Blade Production	0.5	0	3
Core	D	08/06/2011	Handaxe	0.25	0	3
Core	D	08/06/2011	Flaking	0.5	0	4
Core	D	24/06/2011	Levallois	0.5	0	5
Core	D	24/06/2011	Handaxe	1	0	4
Core	D	14/09/2011	Blade Production	0.25	0	3
Core	D	14/09/2011	Levallois	1.25	0	1
Core	D	15/09/2011	Handaxe	5	0	5
Core	D	16/09/2011	Levallois	0.25	0	1
Core	D	16/09/2011	Handaxe	1.25	1, 2	2
Core	D	17/09/2011	Biface	4	0	1
Core	D	19/09/2011	Square Axe Manufacture	5	1	4
Core	D	19/09/2011	Levallois	1	1	3.5
Core	D	19/09/2011	Handaxe	2	0	2
Core	D	20/09/2011	Square Axe Manufacture	6	0	3
Core	D	20/09/2011	Handaxe	1	0	2
Core	D	21/09/2011	Square Axe Manufacture	5	0	2
Core	D	21/09/2011	Pressure Flaking	2	0	4
Core	D	21/09/2011	Handaxe	1	0	2
Core	D	22/09/2011	Handaxe	1	0	3
Core	D	22/09/2011	Pressure Flaking	1	0	3
Core	D	22/09/2011	Levallois	2	1	3
Core	D	23/09/2011	Square Axe Manufacture	3.25	0	4
Core	D	23/09/2011	Pressure Flaking	3.25	0	4
Core	D	24/09/2011	Handaxe	1	0	2
Core	D	24/09/2011	Pressure Flaking	3	2, 3	4
Core	D	29/09/2011	Levallois	1	0	4
Core	D	29/09/2011	Handaxe	1	0	4
Core	D	29/09/2011	Biface	0.75	0	4
Core	D	07/10/2011	Handaxe	1	0	4
Core	D	07/10/2011	Levallois	1	0	5
Core	D	10/10/2011	Pressure Flaking	1	0	3
Core	D	13/10/2011	Pressure Flaking	0.5	0	3
Core	D	13/10/2011	Levallois	1	0	3
Core	D	17/10/2011	Levallois	0.5	0	3
Core	D	24/10/2011	Handaxe	2.5	0	4

Group	Knapper	Date	Technology	Time Practiced	Instruction	Success
Core	D	25/10/2011	Pressure Flaking	0.5	0	3
Core	D	25/10/2011	Square Axe Manufacture	0.5	0	3
Core	D	03/11/2011	Handaxe	0.75	0	2
Core	D	09/11/2011	Pressure Flaking	1.5	0	4
Core	D	10/11/2011	Handaxe	1	0	4
Core	D	23/11/2011	Square Axe Manufacture	1	0	3
Core	D	24/11/2011	Pressure Flaking	1.5	0	4
Core	D	25/11/2011	Pressure Flaking	1	0	4
Core	D	05/12/2011	Handaxe	1	0	3
Core	D	17/01/2012	Handaxe	0.5	0	3
Core	D	20/01/2012	Handaxe	0.75	0	3
Core	D	30/01/2012	Handaxe	1	0	3
Core	D	06/02/2012	Pressure Flaking	0.75	0	3
Core	D	16/02/2012	Handaxe	1	0	3
Core	D	21/02/2012	Handaxe	2	0	4
Core	D	22/02/2012	Handaxe	1	0	4
Core	D	29/02/2012	Handaxe	1	0	3
Core	D	02/03/2012	Blade Production	0.25	0	3
Core	D	02/03/2012	Handaxe	2.75	0	3
Core	D	29/03/2012	Blade Production	1	0	3
Core	D	30/03/2012	Blade Production	1.5	0	3.5
Core	D	03/04/2012	Blade Production	1	0	3
Core	D	03/04/2012	Handaxe	3	3	2
Core	D	03/04/2012	Levallois	1	0	3
Core	D	04/04/2012	Handaxe	1	0	3
Core	D	05/04/2012	Handaxe	5.5	1	4
Core	D	06/04/2012	Blade Production	0.5	0	2
Core	D	06/04/2012	Levallois	0.25	0	5
Core	D	06/04/2012	Handaxe	4.25	0	4
Core	D	07/04/2012	Pressure Flaking	1	0	3
Core	D	07/04/2012	Handaxe	5	0	3
Core	D	08/04/2012	Handaxe	3	1, 2	5
Core	D	09/04/2012	Handaxe	1	1	4
Core	D	09/04/2012	Pressure Flaking	4	0	4.5
Core	D	10/04/2012	Handaxe	1	0	3
Core	D	11/04/2012	Handaxe	0.5	0	2
Core	D	01/05/2012	Handaxe	3	0	3
Core	D	19/05/2012	Handaxe	2	0	3
Core	D	25/05/2012	Handaxe	2.25	1	4
Core	D	28/05/2012	Blade Production	0.5	0	1
Core	D	28/05/2012	Handaxe	1.75	1	3

Group	Knapper	Date	Technology	Time Practiced	Instruction	Success
Core	D	05/06/2012	Handaxe	2	0	3.5
Core	D	18/06/2012	Handaxe	1.25	0	4
Core	D	20/06/2012	Pressure Flaking	2	0	4
Core	D	05/07/2012	Blade Production	2	0	1
Core	D	12/07/2012	Blade Production	2	0	1
Core	D	13/07/2012	Pressure Flaking	3	0	3
Core	D	18/09/2012	Handaxe	2.5	0	4
Core	D	20/09/2012	Handaxe	1.75	0	3
Core	D	21/09/2012	Handaxe	2	1	3
Core	D	27/09/2012	Pressure Flaking	1.5	0	2
Core	D	10/10/2012	Handaxe	1.5	0	3
Core	D	10/10/2012	Levallois	1	0	4
Core	E	03/02/2011	Levallois	2.25	0	2
Core	E	03/02/2011	Flaking	0.5	0	3
Core	E	17/02/2011	Levallois	1	0	2
Core	E	21/02/2011	Blade Production	0.5	0	3.5
Core	E	21/02/2011	Levallois	0.5	0	2
Core	E	25/02/2011	Levallois	0.75	0	3
Core	E	25/02/2011	Blade Production	0.5	0	3
Core	E	03/03/2011	Flaking	1	0	4
Core	E	04/03/2011	Blade Production	1	0	2.5
Core	E	07/03/2011	Levallois	0.75	0	3
Core	E	07/03/2011	Retouch	0.5	0	3
Core	E	08/03/2011	Levallois	1	0	2.5
Core	E	08/03/2011	Blade Production	1	0	3
Core	E	21/03/2011	Levallois	1	0	2
Core	E	21/03/2011	Blade Production	0.25	0	2
Core	E	23/03/2011	Levallois	0.5	0	3
Core	E	23/03/2011	Blade Production	0.5	0	4
Core	E	04/04/2011	Retouch	0.5	0	3
Core	E	04/04/2011	Flaking	0.5	0	3
Core	E	04/04/2011	Blade Production	0.75	0	3
Core	E	06/04/2011	Retouch	0.5	0	3.5
Core	E	06/04/2011	Blade Production	0.25	0	2
Core	E	06/04/2011	Handaxe	2.25	0	2
Core	E	06/04/2011	Levallois	4	0	2
Core	E	07/04/2011	Handaxe	1.25	0	2
Core	E	07/04/2011	Levallois	1.5	0	2
Core	E	08/04/2011	Handaxe	2	1	3
Core	E	08/04/2011	Levallois	1	0	2
Core	E	09/04/2011	Handaxe	1	0	3
Core	E	12/04/2011	Levallois	1.25	0	4

Group	Knapper	Date	Technology	Time Practiced	Instruction	Success
Core	E	12/04/2011	Handaxe	1	0	3.5
Core	E	13/04/2011	Handaxe	1	0	3
Core	E	14/04/2011	Levallois	1	0	3
Core	E	16/04/2011	Levallois	6	0	2
Core	E	18/04/2011	Indirect Percussion	4	1, 2	2.5
Core	E	19/04/2011	Handaxe	1	0	2
Core	E	19/04/2011	Levallois	1	0	2
Core	E	20/04/2011	Handaxe	0.5	0	2
Core	E	20/04/2011	Levallois	0.5	0	2
Core	E	21/04/2011	Handaxe	3.75	1	4
Core	E	23/04/2011	Levallois	0.5	0	3
Core	E	23/04/2011	Biface	3.5	1, 2	3
Core	E	24/04/2011	Levallois	1.5	0	2
Core	E	27/04/2011	Levallois	1	0	3
Core	E	28/04/2011	Handaxe	1.5	0	4
Core	E	29/04/2011	Levallois	1	0	3
Core	E	14/09/2011	Levallois	1	2	2
Core	E	15/09/2011	Handaxe	1	2	2.5
Core	E	15/09/2011	Levallois	2	0	3
Core	E	16/09/2011	Handaxe	3	0	3
Core	E	17/09/2011	Handaxe	3	0	3
Core	E	19/09/2011	Levallois	1.5	0	3
Core	E	19/09/2011	Handaxe	3	0	3
Core	E	21/09/2011	Handaxe	4	0	3.5
Core	E	21/09/2011	Pressure Flaking	1	2	1.5
Core	E	22/09/2011	Handaxe	3	0	3.5
Core	E	22/09/2011	Levallois	0.5	0	3
Core	E	22/09/2011	Pressure Flaking	0.5	0	1.5
Core	E	23/09/2011	Handaxe	1.5	0	3.5
Core	E	23/09/2011	Levallois	0.5	0	3
Core	E	24/09/2011	Levallois	0.5	0	2.5
Core	E	24/09/2011	Handaxe	2	0	3
Core	E	07/10/2011	Pressure Flaking	2	0	1.5
Core	E	14/10/2011	Handaxe	1	0	2.5
Core	E	14/10/2011	Levallois	0.5	0	2.5
Core	E	14/10/2011	Blade Production	0.5	0	3
Core	E	19/10/2011	Handaxe	1	0	3
Core	E	19/10/2011	Levallois	0.5	0	3
Core	E	19/10/2011	Blade Production	0.5	0	3
Core	E	27/10/2011	Handaxe	0.5	0	4
Core	E	27/10/2011	Levallois	1	0	3

Group	Knapper	Date	Technology	Time Practiced	Instruction	Success
Core	E	03/11/2011	Handaxe	1.5	0	3
Core	E	03/11/2011	Blade Production	0.5	0	3
Core	E	08/11/2011	Handaxe	1	0	3
Core	E	22/11/2011	Handaxe	2	0	3
Core	E	24/11/2011	Handaxe	0.75	0	4
Core	E	24/11/2011	Levallois	0.5	0	4
Core	E	30/11/2011	Levallois	0.5	0	4
Core	E	30/11/2011	Handaxe	1	0	3
Core	E	30/11/2011	Handaxe	0.5	0	3.5
Core	E	16/01/2012	Handaxe	1	0	3
Core	E	17/01/2012	Handaxe	1	0	4
Core	E	27/01/2012	Levallois	1.5	0	3
Core	E	02/02/2012	Levallois	0.75	0	2
Core	E	02/02/2012	Handaxe	1.5	0	2
Core	E	06/02/2012	Levallois	0.5	0	4
Core	E	06/02/2012	Handaxe	0.5	0	4
Core	E	07/02/2012	Handaxe	1	0	3
Core	E	08/02/2012	Handaxe	1	0	4
Core	E	21/02/2012	Blade Production	0.75	0	3
Core	E	21/02/2012	Handaxe	0.75	0	3.5
Core	E	29/02/2012	Handaxe	1	0	3
Core	E	15/03/2012	Levallois	0.5	0	2
Core	E	15/03/2012	Biface	3	0	2
Core	E	15/03/2012	Handaxe	0.5	0	3
Core	E	03/04/2012	Levallois	2	1, 2	4
Core	E	03/04/2012	Handaxe	1	0	3
Core	E	04/04/2012	Levallois	4	0	4
Core	E	04/04/2012	Handaxe	1.5	0	4
Core	E	05/04/2012	Levallois	1	0	1
Core	E	06/04/2012	Levallois	2	0	4
Core	E	06/04/2012	Handaxe	1	0	4
Core	E	07/04/2012	Handaxe	4.5	1	5
Core	E	23/05/2012	Levallois	1.5	0	3.5
Core	E	12/06/2012	Handaxe	1	0	3
Core	E	12/06/2012	Levallois	1	0	4
Core	E	04/10/2012	Handaxe	1.5	0	3.5
Core	F	31/01/2011	Flaking	2.5	0	3
Core	F	07/02/2011	Flaking	2.75	0	2
Core	F	16/02/2011	Flaking	1	0	3
Core	F	16/02/2011	Levallois	1	0	1
Core	F	02/03/2011	Flaking	0.75	0	2
Core	F	02/03/2011	Levallois	0.5	0	1

Group	Knapper	Date	Technology	Time Practiced	Instruction	Success
Core	F	12/03/2011	Levallois	0.5	0	2
Core	F	12/03/2011	Flaking	1	0	4
Core	F	19/03/2011	Flaking	1	0	3
Core	F	19/03/2011	Levallois	1	0	2
Core	F	04/04/2011	Flaking	4	0	4
Core	F	06/04/2011	Handaxe	3	0	3
Core	F	06/04/2011	Levallois	2	0	3
Core	F	06/04/2011	Blade Production	2	0	2
Core	F	07/04/2011	Handaxe	3	1	4
Core	F	08/04/2011	Levallois	2	1, 3	4
Core	F	08/04/2011	Handaxe	1	1	3
Core	F	09/04/2011	Levallois	2	1	4
Core	F	12/04/2011	Blade Production	2	2	2
Core	F	13/04/2011	Levallois	2	1	1
Core	F	13/04/2011	Blade Production	1	0	1
Core	F	14/04/2011	Handaxe	1	2	3
Core	F	14/04/2011	Levallois	1	0	4
Core	F	16/04/2011	Handaxe	1	0	1
Core	F	16/04/2011	Levallois	2	0	2
Core	F	16/04/2011	Blade Production	1	0	1
Core	F	18/04/2011	Indirect Percussion	3	2	3
Core	F	18/04/2011	Indirect Percussion	2	1, 2, 3	4
Core	F	18/04/2011	Blade Production	2	0	4
Core	F	19/04/2011	Indirect Percussion	3	0	3
Core	F	20/04/2011	Handaxe	1	0	2
Core	F	20/04/2011	Levallois	2	0	2
Core	F	20/04/2011	Blade Production	2	0	2
Core	F	21/04/2011	Levallois	1	0	1
Core	F	21/04/2011	Handaxe	1	1	1
Core	F	23/04/2011	Handaxe	1	0	1
Core	F	23/04/2011	Blade Production	1	0	1
Core	F	30/04/2011	Handaxe	1	0	3
Core	F	11/05/2011	Handaxe	1	0	2
Core	F	11/05/2011	Levallois	1	0	1
Core	F	11/05/2011	Blade Production	1	0	4
Core	F	12/05/2011	Handaxe	0.5	0	1
Core	F	12/05/2011	Levallois	2	0	2
Core	F	31/05/2011	Blade Production	1	0	2
Core	F	07/06/2011	Blade Production	1	0	2
Core	F	14/06/2011	Blade Production	1	0	4

Group	Knapper	Date	Technology	Time Practiced	Instruction	Success
Core	F	01/08/2011	Handaxe	4	0	3
Core	F	01/08/2011	Blade Production	2	0	2
Core	F	14/09/2011	Handaxe	0.75	0	4
Core	F	14/09/2011	Levallois	1	1	4
Core	F	15/09/2011	Handaxe	2	0	2
Core	F	15/09/2011	Blade Production	1	0	2
Core	F	16/09/2011	Flaking	0.25	0	4
Core	F	17/09/2011	Handaxe	2	1	2
Core	F	19/09/2011	Handaxe	2.5	0	3
Core	F	19/09/2011	Levallois	2.5	0	3
Core	F	20/09/2011	Handaxe	2	1	3
Core	F	20/09/2011	Levallois	1	0	3
Core	F	21/09/2011	Handaxe	2	1	4
Core	F	21/09/2011	Blade Production	3	3	5
Core	F	22/09/2011	Handaxe	2	1	5
Core	F	22/09/2011	Blade Production	2	3	4
Core	F	23/09/2011	Levallois	0.5	0	2
Core	F	23/09/2011	Blade Production	1	3	3
Core	F	23/09/2011	Handaxe	4	0	3
Core	F	24/09/2011	Handaxe	1.5	0	3
Core	F	24/09/2011	Blade Production	2	0	4
Core	F	03/10/2011	Handaxe	2	0	3
Core	F	04/10/2011	Handaxe	2	0	3
Core	F	04/10/2011	Levallois	1	0	4
Core	F	06/10/2011	Handaxe	3	2	4
Core	F	30/11/2011	Flaking	0.5	0	5
Core	F	30/11/2011	Blade Production	0.5	0	2
Core	F	01/02/2012	Levallois	1	0	3
Core	F	01/02/2012	Blade Production	0.5	0	2
Core	F	01/02/2012	Handaxe	0.75	0	3
Core	F	03/04/2012	Levallois	1	1	2
Core	F	03/04/2012	Handaxe	1.5	1	2
Core	F	06/04/2012	Handaxe	1.5	0	4
Core	F	06/04/2012	Blade Production	0.5	0	3
Core	F	06/04/2012	Pressure Flaking	0.5	0	2
Core	F	07/04/2012	Pressure Flaking	0.5	0	3
Core	F	07/04/2012	Handaxe	2.5	1	4
Core	F	07/04/2012	Blade Production	0.5	0	2
Core	F	08/04/2012	Pressure Flaking	1.5	0	4
Core	F	08/04/2012	Blade Production	1.5	0	3
Core	F	09/04/2012	Pressure Flaking	1.5	0	3
Core	F	09/04/2012	Blade Production	1.5	0	2

Group	Knapper	Date	Technology	Time Practiced	Instruction	Success
Core	F	25/04/2012	Flaking	1	3	4
Core	F	25/04/2012	Handaxe	2	1, 3	4
Core	F	27/04/2012	Handaxe	2	1	4
Core	F	28/04/2012	Handaxe	3	0	4
Core	F	10/05/2012	Handaxe	1	0	4
Core	F	10/05/2012	Blade Production	2	0	3
Core	F	12/05/2012	Handaxe	1	0	3
Core	F	12/05/2012	Blade Production	1	0	3
Core	F	27/05/2012	Handaxe	1	0	3
Core	F	30/07/2012	Blade Production	1	0	5
Core	F	30/07/2012	Handaxe	2	0	4
Core	F	02/08/2012	Handaxe	1	0	3
Core	F	09/08/2012	Handaxe	0.5	0	2
Core	F	09/08/2012	Blade Production	1	0	3
Core	F	16/08/2012	Notching	5.5	0	5
Core	F	16/08/2012	Handaxe	2	0	4
Core	F	23/08/2012	Handaxe	1	0	4
Core	F	23/08/2012	Blade Production	1	0	4
Core	F	30/08/2012	Handaxe	2	0	4
Core	F	20/09/2012	Handaxe	3	0	4
Core	F	27/09/2012	Blade Production	2	0	3
Core	F	04/10/2012	Blade Production	1	0	3
Core	F	04/10/2012	Handaxe	2	0	3
Core	G	04/04/2011	Biface	2	0	3
Core	G	07/04/2011	Biface	3	1	4
Core	G	08/04/2011	Flaking	2	3	2
Core	G	09/04/2011	Biface	3	1	4
Core	G	12/04/2011	Retouch	2	0	3
Core	G	13/04/2011	Handaxe	3	1	4
Core	G	16/04/2011	Handaxe	2	2, 3	4
Core	G	16/04/2011	Levallois	1	2, 3	2
Core	G	20/04/2011	Indirect Percussion	1.5	1	4
Core	G	20/04/2011	Levallois	1.5	1	3
Core	G	21/04/2011	Flaking	1	0	5
Core	G	21/04/2011	Handaxe	1	0	4
Core	G	23/04/2011	Biface	2	0	3
Core	G	24/04/2011	Biface	2	0	4
Core	G	29/04/2011	Handaxe	4	1, 2	4
Core	G	30/04/2011	Biface	4	1	5
Core	G	30/04/2011	Flaking	1	0	3
Core	G	30/04/2011	Handaxe	2	2	4

Group	Knapper	Date	Technology	Time Practiced	Instruction	Success
Core	G	15/06/2011	Flaking	1	0	4
Core	G	22/06/2011	Handaxe	0.5	0	3
Core	G	22/06/2011	Levallois	0.5	0	3
Core	G	07/07/2011	Biface	6	0	3
Core	G	19/07/2011	Biface	5	0	3
Core	G	05/08/2011	Biface	2	0	2
Core	G	15/08/2011	Biface	4	0	1
Core	G	14/09/2011	Biface	0.5	0	3
Core	G	14/09/2011	Flaking	0.25	0	4
Core	G	14/09/2011	Levallois	2	0	3
Core	G	15/09/2011	Flaking	0.25	0	3
Core	G	15/09/2011	Handaxe	3	1	4
Core	G	15/09/2011	Levallois	2	0	2
Core	G	16/09/2011	Biface	2	1	5
Core	G	17/09/2011	Handaxe	3	0	3
Core	G	19/09/2011	Handaxe	5	0	2
Core	G	20/09/2011	Biface	4	1	3
Core	G	21/09/2011	Biface	6	1	4
Core	G	22/09/2011	Biface	5	0	4
Core	G	23/09/2011	Biface	5	0	2.5
Core	G	24/09/2011	Biface	4	0	4
Core	G	12/10/2011	Biface	5	0	4
Core	G	13/10/2011	Biface	5	0	4
Core	G	02/11/2011	Biface	1.25	0	3.5
Core	G	06/11/2011	Biface	1.25	0	3
Core	G	19/11/2011	Biface	1.25	0	4
Core	G	20/11/2011	Biface	1	0	3
Core	G	20/03/2012	Biface	3	0	3
Core	G	25/03/2012	Biface	3	0	3
Core	G	30/03/2012	Biface	3	0	4
Core	G	03/04/2012	Biface	5	1	4
Core	G	04/04/2012	Biface	0.25	0	3
Core	G	04/04/2012	Levallois	0.25	0	2
Core	G	05/04/2012	Biface	5	0	3
Core	G	06/04/2012	Biface	5	0	4
Core	G	07/04/2012	Handaxe	2	2	4
Core	G	07/04/2012	Biface	3	0	3
Core	G	08/04/2012	Biface	3	0	3
Core	G	08/04/2012	Handaxe	2	1	3
Core	G	09/04/2012	Biface	3	1	3
Core	G	10/04/2012	Retouch	3	0	4
Core	G	11/04/2012	Biface	5	0	3

Group	Knapper	Date	Technology	Time Practiced	Instruction	Success
Core	G	15/04/2012	Biface	3	0	3
Core	G	16/04/2012	Biface	4	0	5
Core	G	17/04/2012	Biface	4	0	5
Core	G	18/04/2012	Biface	2.5	0	3
Core	G	18/04/2012	Levallois	0.5	0	3
Core	G	24/04/2012	Levallois	0.5	0	3
Core	G	24/04/2012	Biface	3	0	3
Core	G	25/04/2012	Biface	3	0	3
Core	G	28/04/2012	Biface	3	1	3.5
Core	G	29/04/2012	Biface	4	0	4
Core	G	02/05/2012	Levallois	2	0	2
Core	G	02/05/2012	Biface	3	0	3
Core	G	05/05/2012	Biface	4	0	3
Core	G	10/05/2012	Levallois	0.5	0	3
Core	G	10/05/2012	Biface	3	0	4.5
Core	G	11/05/2012	Biface	5	0	5
Core	G	17/06/2012	Biface	3	0	4
Core	G	17/06/2012	Flaking	1	0	3.5
Core	G	20/06/2012	Biface	1	0	3
Core	G	15/07/2012	Flaking	0.5	0	3
Core	G	15/07/2012	Biface	4	0	4
Core	G	20/07/2012	Biface	3	0	5
Core	G	25/07/2012	Biface	3	0	4
Core	G	29/07/2012	Biface	1	0	5
Core	G	02/09/2012	Biface	5	0	3.5
Core	H	01/03/2011	Flaking	1.5	0	4
Core	H	04/04/2011	Flaking	1.25	1	3
Core	H	06/04/2011	Flaking	1	1	3
Core	H	07/04/2011	Flaking	2	0	2
Core	H	07/04/2011	Blade Production	1.5	1, 2, 3	4
Core	H	08/04/2011	Blade Production	1.5	1, 2, 3	4
Core	H	08/04/2011	Flaking	1.5	0	3
Core	H	13/04/2011	Handaxe	2	1, 2	4
Core	H	13/04/2011	Flaking	0.5	0	3
Core	H	16/04/2011	Flaking	0.5	0	3
Core	H	16/04/2011	Handaxe	2	0	3
Core	H	16/04/2011	Levallois	0.5	2	3
Core	H	18/04/2011	Levallois	0.25	1	4
Core	H	19/04/2011	Levallois	0.5	1	3
Core	H	21/04/2011	Handaxe	0.25	1	2
Core	H	21/04/2011	Levallois	0.25	1	2
Core	H	23/04/2011	Levallois	0.75	1	4

Group	Knapper	Date	Technology	Time Practiced	Instruction	Success
Core	H	11/05/2011	Levallois	2	0	3
Core	H	31/05/2011	Flaking	0.5	0	3
Core	H	03/06/2011	Blade Production	2	0	3
Core	H	06/06/2011	Blade Production	0.75	0	4
Core	H	07/06/2011	Levallois	0.75	0	2
Core	H	07/06/2011	Flaking	1	0	3
Core	H	19/06/2011	Flaking	1	0	3
Core	H	10/07/2011	Handaxe	1	0	2
Core	H	10/07/2011	Flaking	0.5	0	3
Core	H	08/08/2011	Levallois	1	0	4
Core	H	10/08/2011	Handaxe	1.25	0	4
Core	H	24/08/2011	Handaxe	1	1	4.5
Core	H	24/08/2011	Handaxe	1	1, 3	4
Core	H	14/09/2011	Levallois	1.75	1, 2	2
Core	H	15/09/2011	Handaxe	2.75	0	3
Core	H	26/09/2011	Handaxe	0.5	0	3
Core	H	26/09/2011	Levallois	0.25	0	3
Core	H	11/10/2011	Levallois	0.25	0	2
Core	H	02/11/2011	Handaxe	1	1, 2, 3	3
Core	H	11/01/2012	Handaxe	0.5	0	2
Wider Beginners	I	09/02/2011	Flaking	1	0	2
Wider Beginners	I	15/02/2011	Flaking	1	0	3
Wider Beginners	I	24/02/2011	Flaking	1	1, 2	3
Wider Beginners	I	04/03/2011	Flaking	1	0	3
Wider Beginners	I	11/03/2011	Flaking	1	0	3.5
Wider Beginners	I	24/03/2011	Flaking	1	0	4
Wider Beginners	I	15/06/2012	Handaxe	0.75	0	2.5
Wider Beginners	J	09/02/2011	Flaking	0.75	1, 2	3
Wider Beginners	J	11/02/2011	Flaking	2	1, 2	3
Wider Beginners	J	17/02/2011	Flaking	1.5	1, 2	3
Wider Beginners	J	01/03/2011	Flaking	1	0	3
Wider Beginners	J	02/03/2011	Flaking	0.5	0	3

Group	Knapper	Date	Technology	Time Practiced	Instruction	Success
Wider Beginners	J	03/03/2011	Flaking	1	0	4
Wider Beginners	J	04/03/2011	Flaking	1	0	4
Wider Beginners	J	09/03/2011	Flaking	0.5	0	2
Wider Beginners	J	12/03/2011	Flaking	1.25	0	5
Wider Beginners	J	24/03/2011	Flaking	1	0	2
Wider Beginners	J	03/05/2011	Flaking	2.5	0	2.5
Wider Beginners	J	12/05/2011	Flaking	3	0	3
Wider Beginners	J	24/05/2011	Flaking	3	0	3
Wider Beginners	J	25/05/2011	Flaking	1.5	0	3.5
Wider Beginners	J	27/05/2011	Flaking	1.25	0	3.5
Wider Beginners	J	31/05/2011	Flaking	1	0	3
Wider Beginners	K	04/02/2011	Flaking	0.75	0	2
Wider Beginners	K	10/02/2011	Flaking	1	0	3
Wider Beginners	K	11/02/2011	Flaking	1	0	3
Wider Beginners	K	12/02/2011	Flaking	1	0	3
Wider Beginners	K	24/02/2011	Flaking	1	0	3
Wider Beginners	K	25/02/2011	Flaking	1	0	3
Wider Beginners	K	04/03/2011	Flaking	1	0	3
Wider Beginners	K	10/03/2011	Flaking	1	0	3
Wider Beginners	K	11/03/2011	Flaking	1	0	3
Wider Beginners	L	10/02/2011	Flaking	1	0	3
Wider Beginners	L	11/02/2011	Flaking	1	0	3
Wider Beginners	L	24/02/2011	Flaking	1	0	3
Wider	L	25/02/2011	Flaking	1	0	2

Group	Knapper	Date	Technology	Time Practiced	Instruction	Success
Beginners						
Wider Beginners	L	11/03/2011	Flaking	1	0	2.5
Wider Beginners	L	08/10/2012	Retouch	2	1, 2	3
Wider Beginners	L	15/10/2012	Retouch	2	0	3
Wider Beginners	M	03/02/2011	Flaking	1	1	3
Wider Beginners	M	09/02/2011	Flaking	1	1, 2	3.5
Wider Beginners	M	22/02/2011	Handaxe	0.5	0	2
Wider Beginners	M	22/02/2011	Flaking	1	2, 3	4.5
Wider Beginners	M	02/03/2011	Flaking	1	0	5
Wider Beginners	M	03/03/2011	Flaking	1	0	3
Wider Beginners	M	09/03/2011	Retouch	0.5	0	3
Wider Beginners	M	09/03/2011	Flaking	1.5	3	5
Wider Beginners	M	24/03/2011	Flaking	2	2	3.5
Wider Beginners	M	05/04/2011	Blade Production	0.5	0	3
Wider Beginners	M	05/04/2011	Flaking	1	0	3
Wider Beginners	M	21/04/2011	Flaking	1.5	0	4
Wider Beginners	M	28/04/2011	Flaking	1.5	0	3.5
Wider Beginners	M	06/05/2011	Flaking	1	0	3
Wider Beginners	M	16/05/2011	Flaking	1	0	3
Wider Beginners	M	31/10/2011	Handaxe	2	1, 2, 3	3
Wider Beginners	M	13/11/2011	Handaxe	2	1, 2, 3	3.5
Wider Beginners	M	25/11/2011	Handaxe	2	1, 2, 3	2
Wider Beginners	M	16/02/2012	Handaxe	2	0	3
Wider Beginners	M	20/02/2012	Handaxe	1	0	2

Group	Knapper	Date	Technology	Time Practiced	Instruction	Success
Wider Beginners	N	04/02/2011	Flaking	1	0	4
Wider Beginners	N	10/02/2011	Flaking	1	0	3
Wider Beginners	N	17/02/2011	Flaking	1	0	4
Wider Beginners	N	24/02/2011	Flaking	1.5	0	3
Wider Beginners	N	25/02/2011	Flaking	1.5	0	3
Wider Beginners	N	10/03/2011	Flaking	1	0	3
Wider Beginners	N	11/03/2011	Flaking	1	0	3
Wider Beginners	O	03/02/2011	Flaking	1.25	0	2
Wider Beginners	P	04/02/2011	Flaking	0.75	0	3
Wider Beginners	P	10/02/2011	Flaking	1	0	4
Wider Beginners	P	17/02/2011	Flaking	1	0	3
Wider Beginners	P	24/02/2011	Flaking	1.5	0	3.5
Wider Beginners	P	25/02/2011	Flaking	1.5	0	3
Wider Beginners	P	04/03/2011	Flaking	1	0	3
Wider Beginners	P	10/03/2011	Flaking	1	0	4
Wider Beginners	P	11/03/2011	Flaking	1	0	3.5
Wider Experienced	R	11/03/2011	Flaking	1.5	0	2
Wider Experienced	R	11/03/2011	Biface	0.5	0	3
Wider Experienced	R	01/04/2011	Flaking	1	0	4
Wider Experienced	R	01/04/2011	Levallois	1	0	3
Wider Experienced	S	08/02/2011	Flaking	0.75	0	3
Wider Experienced	S	08/02/2011	Blade Production	0.25	2	4
Wider Experienced	S	11/02/2011	Blade Production	0.5	0	2
Wider	S	11/02/2011	Flaking	0.5	0	3

Group	Knapper	Date	Technology	Time Practiced	Instruction	Success
Experienced						
Wider Experienced	S	21/02/2011	Flaking	2.5	0	3.5
Wider Experienced	S	21/02/2011	Handaxe	0.5	0	2
Wider Experienced	S	18/05/2011	Levallois	2	0	4
Wider Experienced	T	08/02/2011	Flaking	0.5	0	3
Wider Experienced	T	08/02/2011	Handaxe	0.75	1, 3	2
Wider Experienced	T	16/02/2011	Handaxe	0.25	0	2
Wider Experienced	T	16/02/2011	Flaking	1	0	3
Wider Experienced	T	22/02/2011	Handaxe	1.25	0	2.5
Wider Experienced	T	22/02/2011	Flaking	0.5	0	3
Wider Experienced	T	25/02/2011	Handaxe	1.5	0	2.5
Wider Experienced	T	25/02/2011	Flaking	0.5	0	3
Wider Experienced	T	28/02/2011	Handaxe	1	1	2.5
Wider Experienced	T	28/02/2011	Flaking	0.25	0	3
Wider Experienced	T	03/03/2011	Flaking	0.25	0	3
Wider Experienced	T	03/03/2011	Handaxe	1	0	2
Wider Experienced	T	07/03/2011	Handaxe	1.25	1	2.5
Wider Experienced	T	07/03/2011	Flaking	0.25	0	3
Wider Experienced	T	09/03/2011	Handaxe	3.5	0	3
Wider Experienced	T	16/03/2011	Handaxe	1	0	3.5
Wider Experienced	T	21/03/2011	Handaxe	1	0	2.5
Wider Experienced	T	30/03/2011	Levallois	1.5	0	2
Wider Experienced	T	30/03/2011	Handaxe	1.25	0	2.5
Wider Experienced	T	01/04/2011	Handaxe	2	0	3

Group	Knapper	Date	Technology	Time Practiced	Instruction	Success
Wider Experienced	T	01/04/2011	Levallois	1	0	2
Wider Experienced	T	05/04/2011	Levallois	0.75	0	2
Wider Experienced	T	05/04/2011	Handaxe	1.75	0	3
Wider Experienced	T	12/04/2011	Flaking	0.5	0	3
Wider Experienced	T	12/04/2011	Handaxe	1.5	0	3
Wider Experienced	T	27/04/2011	Flaking	0.5	0	3
Wider Experienced	T	27/04/2011	Handaxe	1.5	0	3
Wider Experienced	T	06/05/2011	Handaxe	1	0	3.5
Wider Experienced	T	17/05/2011	Handaxe	2	0	3.5
Wider Experienced	T	19/05/2011	Handaxe	1.5	0	3.5
Wider Experienced	T	25/05/2011	Levallois	0.5	0	2
Wider Experienced	T	25/05/2011	Handaxe	1	0	3
Wider Experienced	T	03/06/2011	Blade Production	0.5	0	3
Wider Experienced	T	03/06/2011	Handaxe	0.75	0	2.5
Wider Experienced	T	03/06/2011	Flaking	0.25	0	3
Wider Experienced	T	27/06/2011	Handaxe	1	0	3
Wider Experienced	T	27/06/2011	Flaking	0.25	0	3
Wider Experienced	T	27/06/2011	Levallois	0.75	0	2
Wider Experienced	T	01/12/2011	Handaxe	1.25	1, 2	3.5
Wider Experienced	T	22/02/2012	Handaxe	1	0	3
Wider Experienced	T	22/02/2012	Levallois	0.5	0	2
Wider Experienced	T	11/04/2012	Microlith manufacture	1.25	2	2
Wider Experienced	T	11/04/2012	Pressure Flaking	2	2	1
Wider	T	26/04/2012	Handaxe	1	0	3

Group	Knapper	Date	Technology	Time Practiced	Instruction	Success
Experienced						
Wider Experienced	T	26/04/2012	Microlith manufacture	0.75	0	2
Wider Experienced	T	08/06/2012	Flaking	0.25	0	3
Wider Experienced	T	08/06/2012	Handaxe	1.25	0	3.5
Wider Experienced	T	11/06/2012	Handaxe	3	1, 2	3.5
Wider Experienced	V	09/03/2011	Flaking	2	0	2
Wider Experienced	V	10/03/2011	Flaking	1.25	0	3
Wider Experienced	V	16/03/2011	Biface	1	0	3
Wider Experienced	V	18/03/2011	Blade Production	1	0	3
Wider Experienced	V	18/03/2011	Flaking	1	0	3
Wider Experienced	V	18/03/2011	Levallois	1	0	3
Wider Experienced	V	21/03/2011	Levallois	1	1, 2	4
Wider Experienced	V	23/03/2011	Levallois	1	0	3
Wider Experienced	V	01/04/2011	Biface	2.25	0	3
Wider Experienced	V	04/04/2011	Biface	2	0	3
Wider Experienced	V	04/04/2011	Levallois	1	0	4
Wider Experienced	V	05/04/2011	Biface	1	0	3
Wider Experienced	V	05/04/2011	Flaking	1	0	4
Wider Experienced	V	18/11/2011	Handaxe	3	1, 3	4
Wider Experienced	V	19/11/2011	Flaking	2	0	3
Wider Experienced	V	19/11/2011	Handaxe	6	0	3
Wider Experienced	Θ	22/02/2011	Biface	1	0	3.5
Wider Experienced	Θ	22/02/2011	Flaking	0.5	0	3
Wider Experienced	Θ	23/02/2011	Flaking	0.75	2, 3	3

Group	Knapper	Date	Technology	Time Practiced	Instruction	Success
Wider Experienced	Θ	23/02/2011	Biface	0	1	2
Wider Experienced	Θ	01/03/2011	Biface	0.75	0	3
Wider Experienced	Θ	18/03/2011	Biface	2	0	2
Wider Experienced	Θ	23/03/2011	Flaking	1	0	3
Wider Experienced	Θ	09/04/2011	Flaking	1	0	4
Wider Experienced	Θ	16/04/2011	Pressure Flaking	1	0	3
Wider Experienced	Θ	18/04/2011	Pressure Flaking	0.5	0	3
Wider Experienced	Θ	18/04/2011	Indirect Percussion	2	2	4
Wider Experienced	Θ	19/04/2011	Indirect Percussion	2	3	4
Wider Experienced	Θ	19/04/2011	Flaking	1	0	3
Wider Experienced	Θ	20/04/2011	Biface	2.5	0	5
Wider Experienced	Θ	21/04/2011	Biface	2	0	4
Wider Experienced	Θ	21/04/2011	Flaking	0.25	0	3
Wider Experienced	Θ	03/06/2011	Flaking	1.5	0	3
Wider Experienced	Θ	15/06/2011	Biface	1	0	3
Wider Experienced	Θ	21/06/2011	Biface	1	0	3
Wider Experienced	Θ	24/06/2011	Pressure Flaking	10	0	4
Wider Experienced	Θ	20/07/2011	Pressure Flaking	0.25	0	3
Wider Experienced	Θ	27/07/2011	Pressure Flaking	0.25	0	3
Wider Experienced	Θ	27/07/2011	Flaking	0.25	0	3
Wider Experienced	Θ	19/10/2011	Biface	0.5	0	3.5
Wider Experienced	Θ	19/10/2011	Handaxe	0.5	2	3.5
Wider Experienced	Θ	11/11/2011	Handaxe	0.75	0	3
Wider	Θ	15/11/2011	Handaxe	0.75	0	2

Group	Knapper	Date	Technology	Time Practiced	Instruction	Success
Experienced						
Wider Experienced	Θ	11/01/2012	Handaxe	0.5	0	2.5
Wider Experienced	Θ	15/03/2012	Handaxe	1	0	4.5
Wider Experienced	Θ	29/05/2012	Handaxe	1.5	1, 2, 3	4
Wider Experienced	Θ	11/06/2012	Biface	0.5	0	3.5
Wider Experienced	Θ	12/06/2012	Handaxe	1.5	1	3.5

Instruction: 0= no instruction, 1=verbal instruction, 2= demonstration, 3= physical intervention

Evaluation Materials

Oldowan Core

Knapper	Evaluation	Maximum Length (mm)	Maximum Width (mm)	Maximum Thickness (mm)
A	1	125	128	56
B	1	151	130	47
C	1	120	86	64
D	1	201	159	89
E	1	107	68	35
F	1	193	118	91
G	1	291	197	119
H	1	165	94	85
I	1	110	68	35
J	1	144	115	105
K	1	187	178	92
L	1	222	144	95
M	1	196	147	88
P	1	134	117	103
R	1	106	103	61
S	1	139	88	38
T	1	145	112	49
U	1	205	149	82

Knapper	Evaluation	Maximum Length (mm)	Maximum Width (mm)	Maximum Thickness (mm)
V	1	115	80	44
W	1	78	51	42
X	1	92	89	44
Z	1	137	120	79
Γ	1	221	183	70
Δ	1	163	112	61
Θ	1	107	108	98
Λ	1	140	82	122
Ξ	1	191	120	64
A	2	155	104	50
B	2	163	74	49
C	2	157	139	66
D	2	154	99	57
E	2	131	79	48
F	2	163	134	122
G	2	173	109	83.8
I	2	121	87	55
K	2	118	112	39
L	2	197	126	102
R	2	172	115	89
T	2	120	91	60
V	2	173	93	108
Θ	2	153	119	71
A	3	121	86	48
B	3	117	104	79
C	3	140	97	75
D	3	93	72	49
E	3	152	125	81
F	3	140	116	81
G	3	161	103	46
I	3	150	109	78
L	3	200	130	125
M	3	159	82	65
T	3	123	93	88
Θ	3	108	71	87
A	4	190	106	49
B	4	108	95	36
C	4	188	139	122
D	4	164	102	45
E	4	106	103	84
F	4	105	54	56
G	4	233	158	146

Knapper	Evaluation	Maximum Length (mm)	Maximum Width (mm)	Maximum Thickness (mm)
I	4	169	135	87
K	4	115	73	42
L	4	218	98	53
M	4	142	124	76
R	4	88	67	44
T	4	175	104	42
Θ	4	130	118	76

Oldowan Flake

Knapper	Evaluation	No of Flakes	Flake	Maximum Length (mm)	Max. width (mm)	Max. thickness (mm)	Termination	Platform thickness (mm)
A	1	3	1	32.6	18.5	4.2	H	2.4
			2	28.7	44.9	4.6	H	4.2
			3	14.5	18.7	2.3	S	M
B	1	2	1	44.2	48.4	15.8	F	17.2
			2	28.2	68.8	8.9	F	14.2
C	1	4	1	47.4	35.1	10.8	H	11.8
			2	16.2	27	6.7	M	0.2
			3	46.5	44.8	10	F	10.9
			4	37.9	21.3	7.7	F	6.2
D	1	3	1	66.2	37	8.3	H	3.9
			2	52.2	37.6	13.9	F	7.4
			3	47.1	38.1	12.4	H	7.1
E	1	4	1	50.9	26.4	10.8	H	12.9
			2	61.2	35.6	12.1	F	9
			3	43.2	40.6	14.2	F	15.2
			4	27.5	50.8	7.2	F	7.4
F	1	5	1	59.6	45	16.6	M	17.8
			2	79.9	55.9	19.6	H	21.9
			3	89	46.2	15.1	H	20.4
			4	69.9	51.6	15.8	H	18.1
			5	59.3	30	19.4	M	11.9
G	1	4	1	67.6	127.2	28.9	F	4
			2	33.3	62.9	9	F	8.4
			3	29.3	35.1	5.9	F	4.3
			4	72.1	29.2	1.1	F	6.9

Knapper	Evaluation	No of Flakes	Flake	Maximum Length (mm)	Max. width (mm)	Max. thickness (mm)	Termination	Platform thickness (mm)
H	1	5	1	72.8	27.4	12.9	F	7.4
			2	53.2	49.1	14.2	F	14.2
			3	39.6	22.6	6.4	F	13.8
			4	66.1	28.6	15.2	F	13.9
			5	50.2	47	12.3	F	9.3
I	1	4	1	23.1	59.9	39.3	F	35.9
			2	36.4	20	7.9	F	6.1
			3	34.2	55.2	13.5	F	10
			4	47	14.1	12.9	F	8.9
J	1	4	1	103.4	36.3	15.9	F	2.9
			2	98.8	76.2	25.1	F	5.8
			3	81.8	55.8	30.1	F	4.2
			4	15.9	21.1	4.9	H	2
K	1	4	1	42.1	56.2	57.4	F	35.4
			2	41.2	14.7	9.4	F	M
			3	62.4	66.7	13.4	F	11.9
			4	54.9	39.8	12	F	11.8
L	1	3	1	70.8	33.5	17.1	H	16.7
			2	50.5	28.1	12.7	M	7.8
			3	58.2	88.2	21.2	F	16
M	1	4	1	19.9	42.7	3.9	F	3.2
			2	60.5	43.9	13.2	H	9.2
			3	10.1	12.2	4.3	M	3.8
			4	61.8	48.8	8.9	F	6.6
P	1	5	1	82.1	51.8	16.5	F	13.7
			2	52	44.3	12.2	F	12
			3	71.4	37.5	23.2	H	6

Knapper	Evaluation	No of Flakes	Flake	Maximum Length (mm)	Max. width (mm)	Max. thickness (mm)	Termination	Platform thickness (mm)
P			4	39	31.6	9.6	F	10.7
			5	69.4	29.4	12.8	F	12
R	1	3	1	58.5	41.4	13.8	M	8.9
			2	44.2	50.4	24.2	F	10
			3	118.6	95.9	27.4	OS	8.8
S	1	4	1	28.8	50.1	11.8	M	8.8
			2	45.4	28	12.5	F	12.3
			3	27.5	30.9	5.2	F	4.2
			4	47.6	33.9	11.1	S	8.3
T	1	3	1	36.4	55.8	8.2	F	9
			2	21.4	32.5	5.7	F	0.7
			3	15	15.1	3.4	F	3.6
U	1	4	1	72.1	45.7	19.7	H	22
			2	40.3	73.2	35.6	S	19.5
			3	70.4	49	23.1	F	25.2
			4	66.2	75.1	11.9	H	14.4
V	1	5	1	13	26.5	3.9	F	0.7
			2	16.7	29.2	4	H	1
			3	30.1	44	11.4	H	7.8
			4	34	17.9	10.6	H	M
			5	40.1	47.6	9.9	F	8.8
W	1	2	1	58.2	21.9	12.2	H	12.1
			2	23.6	18.2	7.3	M	3.9
X	1	4	1	20.5	21.2	7.1	H	6.7
			2	64.6	113.2	20	F	6.2
			3	24.2	27	7.6	S	3.9
			4	25.7	30.1	8.2	F	7.4

Knapper	Evaluation	No of Flakes	Flake	Maximum Length (mm)	Max. width (mm)	Max. thickness (mm)	Termination	Platform thickness (mm)
Z	1	4	1	47.2	21.6	6.2	H	4.8
			2	56.5	32.5	6	F	M
			3	36.2	19.2	9	H	8.1
			4	28.8	39.7	3.4	F	1.1
Γ	1	4	1	46.2	28.3	12.2	M	14.5
			2	78.4	41	10.4	F	9.2
			3	46.2	83.7	20	H	31.1
			4	42	46	12.9	M	3
Δ	1	4	1	26.5	29	7.1	H	8.5
			2	26.8	52.6	10.2	F	9.9
			3	59.9	23.9	10	F	11.2
			4	81	45.7	19.4	F	21.9
Θ	1	5	1	48.4	13.9	8.4	M	1.8
			2	60.8	25.2	6.3	F	2.3
			3	59.8	37.2	10.1	H	9
			4	67.6	41	9.9	F	7.1
			5	63.9	35	8	F	6.1
Λ	1	5	1	109.7	28.2	20.4	F	12.1
			2	26.9	13.1	5	M	1.4
			3	63.1	29	11.7	H	7.3
			4	62.5	25.5	5	H	M
			5	126.2	40	32.7	F	M
Ξ	1	5	1	64.4	67.2	17	F	M
			2	68.5	74.8	16.6	F	14.2
			3	42.3	33.9	10.6	M	4.2
			4	79.3	45.8	20.9	F	19
			5	60.1	57	17.2	M	12.3

Knapper	Evaluation	No of Flakes	Flake	Maximum Length (mm)	Max. width (mm)	Max. thickness (mm)	Termination	Platform thickness (mm)
A	2	4	1	41.6	15.9	5	S	M
			2	18	24.7	7	H	2.9
			3	19.2	27	4.9	F	1.3
			4	31.3	58.2	12.1	S	12.9
B	2	5	1	50.8	25.5	13	F	10
			2	41.8	46.9	18	F	21.8
			3	47.8	29.7	10.9	F	12.3
			4	43.8	31.6	8.4	F	2.9
			5	102.3	23	12.1	F	6.8
C	2	5	1	62	32.7	11.4	F	8.1
			2	20	38.7	4.1	H	M
			3	52.7	32.6	7.3	F	5.8
			4	57.8	38.2	6.9	S	1
			5	55	64.1	15	F	12.9
D	2	5	1	58.2	16.9	10	F	1
			2	25	11.6	3.1	F	0.5
			3	57.7	22.2	7.9	F	4
			4	30.9	19.2	4	F	2.1
			5	52.8	31.6	9.1	H	4.1
E	2	5	1	34.4	28.9	10.7	F	9.1
			2	79.6	32.3	14.9	F	14.7
			3	17.2	8.2	2	H	M
			4	41.2	30.4	6.2	F	4.1
			5	72.2	41.9	12	F	6.7
F	2	5	1	61.9	58.1	13	S	4.9
			2	74.2	96.8	35.7	H	30.8
			3	117	85	52.1	F	116.4

Knapper	Evaluation	No of Flakes	Flake	Maximum Length (mm)	Max. width (mm)	Max. thickness (mm)	Termination	Platform thickness (mm)
F			4	100.1	123.8	31.5	F	22.2
			5	33.3	21.6	8.2	F	8.2
G	2	5	1	58.2	33.2	12.9	F	15.2
			2	36.2	37.9	11.1	F	14
			3	58.9	44.1	15.6	F	13.8
			4	33.8	28.9	6.4	H	M
			5	76.3	48.2	14	F	10.8
I	2	5	1	29.9	31.9	5.7	S	5.8
			2	60	42.1	9	H	6.3
			3	25.6	35.6	7.4	S	7
			4	93	64	14	F	6
			5	17	14	4	S	3.7
K	2	3	1	23.2	52.2	63.8	F	57
			2	7.9	23.8	3.6	F	3.9
			3	25.9	25.8	5.8	F	9.2
L	2	5	1	38.4	69.2	64.8	H	64.8
			2	42.1	47.8	48.8	F	48.8
			3	36.2	67.9	18.4	H	18.1
			4	89.4	38.9	15.9	F	9.9
			5	78.2	31.8	14.1	H	5.4
R	2	4	1	104.6	55.2	24.6	H	18.3
			2	88.4	70.3	26.2	F	18.8
			3	105.5	81.6	24.8	F	15.3
			4	86.1	87.3	11.9	F	12.6
T	2	5	1	57	22.2	9.9	F	3.9
			2	48	32.8	11.4	H	5
			3	46.1	77.6	54.8	F	38.1

Knapper	Evaluation	No of Flakes	Flake	Maximum Length (mm)	Max. width (mm)	Max. thickness (mm)	Termination	Platform thickness (mm)
T			4	21.1	17.9	4.9	S	M
			5	43.1	48	8.7	H	6.6
V	2	3	1	118.2	74.1	12.4	F	12.5
			2	91	55.8	13.9	F	13.3
			3	48.7	76.3	5.8	F	6.2
Θ	2	5	1	107.8	56.9	22.1	F	19.7
			2	93.8	49	20.9	F	17.1
			3	57.8	41	14.5	F	12.3
			4	32.2	68.1	42	H	33.4
			5	42.2	60.8	14.9	F	12.4
A	3	5	1	55.5	33.2	13.3	H	14.3
			2	30.8	35.5	8.6	F	6.7
			3	54.9	60.2	12.7	H	13.2
			4	62.3	69.1	21.1	OS	11.7
			5	21.3	26.8	6.4	F	6.1
B	3	5	1	25.1	30.7	6.3	H	6.3
			2	45.8	32.5	6.9	H	7.3
			3	51.4	70.5	14.8	H	13
			4	57.9	29.5	10.8	S	8
			5	18.3	6.9	2.4	S	1.1
C	3	5	1	77	32.6	13.9	OS	5
			2	97.9	43.1	14.1	OS	5.6
			3	67	18.5	7.7	F	5.5
			4	33.9	23.9	5.8	S	3.1
			5	17.4	1.1	4.2	S	4
D	3	5	1	51.4	24.1	11.8	OS	M
			2	45.6	35.4	6.8	F	3.4

Knapper	Evaluation	No of Flakes	Flake	Maximum Length (mm)	Max. width (mm)	Max. thickness (mm)	Termination	Platform thickness (mm)
D			3	54.1	24.6	9.8	F	7.8
			4	28.4	13.1	3.9	F	3.3
			5	43	28.2	5.5	F	4.9
E	3	5	1	62.8	43.1	14.4	F	14.9
			2	72.7	74.6	13.7	F	16.8
			3	95.8	41.1	19.8	F	13.6
			4	69.6	36.9	11.2	F	11.7
			5	60.2	30.7	21.9	S	20.6
F	3	5	1	84.1	39.9	13.3	H	9.2
			2	88.9	83.1	20.6	S	17.7
			3	133.3	82.5	35.3	OS	22.8
			4	73.3	27	13	F	7.4
			5	33.5	30	6.7	H	8.8
G	3	4	1	107.9	46.7	13.9	F	9.1
			2	124.9	72.1	21.9	F	19.4
			3	130	95.1	28.7	OS	17.4
			4	73.7	44.9	10.3	H	1.6
I	3	5	1	18.3	27.3	6.5	F	8
			2	19.3	24.5	7.1	F	7.1
			3	23.8	23.4	6.9	F	9.1
			4	23.9	16.8	4.4	F	5.5
			5	35.9	19.4	8.4	F	9.4
L	3	5	1	66.7	44.4	15	F	14.5
			2	27	28.7	6.6	H	8.9
			3	125.8	56.8	20.7	OS	20.1
			4	78.3	30.4	13.1	H	13.3
			5	50.3	43.4	5.6	H	4.3

Knapper	Evaluation	No of Flakes	Flake	Maximum Length (mm)	Max. width (mm)	Max. thickness (mm)	Termination	Platform thickness (mm)
M	3	5	1	56.4	32.3	8.4	F	4.7
			2	20.3	23.2	6.2	H	3.1
			3	47.1	34.9	14.4	F	14.7
			4	23.7	41.7	10.9	H	2.5
			5	40.4	21.7	8.9	F	10.2
T	3	3	1	69.9	19.9	17.9	F	3.6
			2	43.9	25.6	6.4	H	2.3
			3	24.4	18.3	4.2	F	2.5
Θ	3	5	1	83	31.5	17.4	F	3.6
			2	47.2	17.9	8.7	F	5
			3	88.4	42.5	10.8	F	5.3
			4	75.1	35.9	16.2	OS	4.3
			5	98.6	53.8	18.3	F	12.5
A	4	5	1	35	22.1	10.2	H	10.5
			2	36.9	39.2	9.9	F	9.2
			3	56.9	41.6	11.4	S	9
			4	48.5	48.1	13.3	F	17.5
			5	44.5	53.6	7.7	F	11.1
B	4	5	1	33.1	25.9	5.9	F	M
			2	20.4	21.6	5.5	F	1.6
			3	34.9	41.2	17	F	8.3
			4	53.9	27.1	6.8	S	5.2
			5	89.4	45.7	17.7	F	17.9
C	4	5	1	90.5	57.3	14.3	H	11.9
			2	115	52.2	9.6	F	4.9
			3	79.4	53.4	9.5	F	5.9
			4	59.6	23.1	6.9	F	6.1

Knapper	Evaluation	No of Flakes	Flake	Maximum Length (mm)	Max. width (mm)	Max. thickness (mm)	Termination	Platform thickness (mm)
			5	74.6	79.3	15.4	H	6.5
D	4	5	1	47.3	40	19.4	F	21.1
			2	44.8	19.4	9.9	F	3.4
			3	51.8	43.9	22.7	F	13.5
			4	59.2	36.5	15.9	F	8.6
			5	92.8	48.1	30	F	3.3
E	4	5	1	66.6	26.8	10.1	F	9.4
			2	71	42.2	14.3	F	11.4
			3	54	33.9	13.9	S	13.4
			4	25	22.1	3.6	F	2.5
			5	68.7	41.6	14.6	F	13.9
F	4	5	1	57.6	46.4	16.9	H	16.5
			2	82.4	26.2	13.3	F	14.9
			3	63.4	21.9	18.5	F	9.6
			4	59.7	34.2	14.3	F	10
			5	29.4	30.5	10.8	F	8.8
G	4	5	1	79.8	69.5	17.3	H	12.6
			2	97.4	46.1	9.5	F	4.2
			3	174.4	137.2	34.5	F	10.9
			4	104.4	55.3	14.4	F	17.3
			5	83.6	43.6	17.3	H	6.2
I	4	5	1	59.2	74.3	22.7	H	27.6
			2	43.3	35	11.7	S	15.3
			3	50.4	69.2	17.6	F	10
			4	80.9	56.9	24.2	F	6.3
			5	33.7	32.2	11.4	S	15.3
K	4	5	1	33.3	26.2	7.4	H	7.9

Knapper	Evaluation	No of Flakes	Flake	Maximum Length (mm)	Max. width (mm)	Max. thickness (mm)	Termination	Platform thickness (mm)
K			2	36.3	53.7	14.9	F	15.4
			3	31.4	45.3	12	F	8
			4	37.6	62.9	21.3	S	11.3
			5	27.6	21.7	5.2	F	6.1
L	4	5	1	66.1	87.4	18.8	F	19.9
			2	59.7	77.4	18.5	H	19
			3	39.5	35.1	7.2	F	8.7
			4	21.4	40.3	3.4	H	2.3
			5	28.2	18.9	3.5	F	3.3
M	4	4	1	55.5	37.1	11.7	H	10.7
			2	25.8	11.1	2.2	F	2
			3	58.5	56.8	16.9	H	15.4
			4	80.9	41.1	16.1	F	7.6
R	4	5	1	87.5	46.3	20.3	F	18.4
			2	23.2	20.9	8.3	S	8.3
			3	104	72	22.9	OS	9.2
			4	103.4	29.9	43.4	OS	11.2
			5	26.1	6.3	1.9	F	1.3
T	4	5	1	13.5	8.4	2.1	S	0.5
			2	44.9	50.3	9.5	F	7
			3	24.3	25.1	3.9	F	3.8
			4	38	62.7	9.3	F	9.9
			5	48.2	45.4	10.9	F	12.1
Θ	4	5	1	85.2	68.3	20.9	F	11.9
			2	80.9	40.8	18.4	H	17.4
			3	23.8	28.4	6.7	S	6.5
			4	27.9	24.9	6.3	F	1.8

Knapper	Evaluation	No of Flakes	Flake	Maximum Length (mm)	Max. width (mm)	Max. thickness (mm)	Termination	Platform thickness (mm)
Θ			5	64.1	42.2	18.6	F	14.3

Handaxe Tool

Knapper	Evaluation	Completion	Maximum Length (mm)	Maximum Width (mm)	Maximum Thickness (mm)	Mass (g)
A	1	Completed	106.2	55.4	22.6	101.6
B	1	Completed	100.1	67.3	32.3	226.4
C	1	Broken - one piece reworked:	80.1	58.9	26.9	127.7
		Discarded piece:	67.5	71.7	38.2	223.1
D	1	Completed	140.1	67.2	31.8	300.9
E	1	Completed	131.4	67.9	26.1	229.6
F	1	Completed	115.9	37.8	17.7	76.7
G	1	Completed	100.1	61.7	26.8	130.3
I	1	Broken & abandoned	148.9	87.2	38.7	443.2
K	1	Abandoned	145.9	85.3	37.2	498.7
L	1	Completed	144.3	68.9	35.1	410.7
M	1	Completed	114.5	67.2	33.9	212.9
R	1	Completed	117.8	60.9	26.6	150.6
T	1	Completed	127.8	68.8	27.5	241.3
V	1	Completed	129.4	61.4	30.1	250.4
Θ	1	Completed	129.4	70.9	36.2	278.4
A	2	Broken and abandoned	132.9	64.1	24.1	196.4
B	2	Completed	105.7	65.3	35.2	271
C	2	Broken - one piece reworked	79.8	52.7	18.3	65.5
		Discarded piece	63.9	84.4	28.9	166
D	2	Completed	94	34.1	14.5	57.7
E	2	Completed	117	55.4	31.2	155.2

Knapper	Evaluation	Completion	Maximum Length (mm)	Maximum Width (mm)	Maximum Thickness (mm)	Mass (g)
F	2	Completed	89.9	47.7	25.8	107.3
G	2	Completed	80.2	43.6	16.8	50.1
I	2	Completed	129.4	77.5	31.3	300.4
L	2	Completed	126.8	72.7	31.1	337.4
M	2	Completed	128.6	69.2	39.9	327.7
R	2	Completed	101.1	58.3	27.2	136.1
T	2	Completed	122.6	54.6	30.4	179.7
Θ	2	Completed	126.3	65.3	19.4	180.9
A	3	Completed	93.2	44.9	19.7	74.7
B	3	Completed	109	63.8	30.5	225.6
C	3	Broken and Abandonned	117.1	67.7	29.6	201.4
D	3	Completed	96.2	41.5	27.5	85.8
E	3	Completed	123.4	56	21.2	143.2
F	3	Broken and Abandonned	115.1	56.7	25.8	158.5
G	3	Completed	99.5	65.9	21.4	117.7
I	3	Completed	122.7	68.2	37.1	300.1
K	3	Completed	144.2	82.8	38.6	495.5
L	3	Completed	136	74.5	38.2	407.3
M	3	Completed	109.6	64.4	28.3	224.1
R	3	Completed	104.9	52.9	23.8	122.9
T	3	Completed	109.4	57.1	26.2	159.9
Θ	3	Completed	109.3	65.2	29.9	180.2

Handaxe Debitage

Knapper	Evaluation	Mass (g)	No of Flakes	Platform			Termination				
				Flat	Faceted	Undetermined	Feather	Hinge	Step	Undetermined	Overshot
A	1	530.9	71	37	28	6	64	2	5	0	0
B	1	432.2	59	35	15	9	57	1	1	0	0
C	1	330.4	33	28	5	0	28	3	2	0	0
D	1	334.4	65	15	38	12	58	1	6	0	0
E	1	422.6	53	25	23	5	49	3	1	0	0
F	1	587.5	72	21	31	20	63	1	7	1	0
G	1	523.1	59	33	19	7	52	3	3	1	0
I	1	223.3	40	36	4	0	23	7	4	3	0
K	1	167.7	33	33	0	0	30	2	1	0	0
L	1	244.4	54	37	15	2	50	1	3	0	0
M	1	435.5	84	33	36	15	73	2	7	2	0
R	1	485.3	115	47	45	23	108	2	5	0	0
T	1	400.9	73	43	19	11	64	5	4	0	0
V	1	375.3	64	29	30	5	55	3	3	3	0
Θ	1	374.2	66	33	24	9	56	2	3	5	0
A	2	458.1	60	38	21	1	44	4	12	0	0
B	2	390.4	125	67	56	2	90	13	22	0	0
C	2	407.6	93	43	45	5	71	6	16	0	0
D	2	594.9	172	45	114	13	125	14	32	1	0
E	2	510	75	32	38	5	60	7	8	0	0
F	2	590.6	99	44	54	1	76	5	18	0	0
G	2	607.3	120	46	69	5	83	10	26	0	1
I	2	334.7	71	41	30	0	37	13	21	0	0
L	2	326.7	83	36	45	2	43	15	25	0	0
M	2	369.8	94	42	50	2	53	6	35	0	0
R	2	515.1	179	102	71	6	134	7	38	0	0

Knapper	Evaluation	Mass (g)	No of Flakes	Platform			Termination				
				Flat	Faceted	Undetermined	Feather	Hinge	Step	Undetermined	Overshot
T	2	497.4	142	69	67	6	107	8	27	0	0
Θ	2	460.8	120	64	54	2	90	11	19	0	0
A	3	566.1	122	77	41	4	98	5	19	0	0
B	3	477.3	106	54	40	12	90	5	11	0	0
C	3	472.1	95	62	25	8	72	7	16	0	0
D	3	606.3	139	53	77	9	119	2	18	0	0
E	3	517.9	91	57	31	3	80	4	7	0	0
F	3	520.3	142	77	60	5	105	9	28	0	0
G	3	511.5	131	50	71	10	104	6	21	0	0
I	3	343.8	98	64	33	1	80	4	14	0	0
K	3	212.6	31	28	3	0	26	2	3	0	0
L	3	281.2	86	59	24	3	55	16	15	0	0
M	3	440.8	168	92	71	5	109	14	45	0	0
R	3	533	184	115	67	2	144	5	35	0	0
T	3	526.8	174	100	64	10	126	9	39	0	0
Θ	3	489.9	136	66	62	8	102	10	22	2	0

Levallois Core

Knapper	Evaluation	Levallois Flake Produced	Maximum length (mm) (inc. flake)	Maximum width (mm) (inc. flake)	Maximum depth (mm) (inc. flake)	Core Mass (g) (inc. flake)	Core Mass (g) (ex. flake)
A	1	Yes	72	54.1	36.6	149.1	132.1
B	1	No	107.4	49.6	29.2	~	164.3
C	1	Yes	59.2	48.6	14.1	52.2	44
D	1	No	112.8	66.3	30	~	256.5
E	1	No	79.8	51.9	31.8	~	107.1
F	1	Yes	100.7	67	26.4	209.7	200.9
G	1	No	91.8	62.8	35.2	~	168.8
H	1	Yes	87.1	74	34.4	256.9	233.3
I	1	No	124.3	73.4	37.5	~	354.4
L	1	No	143.9	65.9	37.4	~	373.4
M	1	No	145.4	76.6	35.9	~	447.5
R	1	No	75.8	68.3	36.9	~	159.6
T	1	No	122.8	70	32.3	~	301.8
Θ	1	No	96.5	76.8	36.4	~	263.4
A	2	Yes	72	52.7	33.1	110	104.8
B	2	Yes	96.1	70.4	36.1	290.5	261.4
C	2	Yes	58.6	42.3	32.9	94.5	65.2
D	2	Yes	98.3	72	36.8	258.3	155.4
E	2	Yes	84.2	56.3	33.3	169.8	154.9
F	2	Yes	76.9	41.6	30.6	100	85.5
G	2	Yes	64.7	54.8	30.8	99.9	65.7
I	2	Yes	128.4	71.3	30.1	288.6	282.4
L	2	No	148.2	76.9	32.8	~	461.7
M	2	No	119.9	64	38.1	~	315.9
R	2	Yes	74.5	62.2	33.8	184.7	146.3
T	2	No	126.6	70.9	31.4	~	271

Knapper	Evaluation	Levallois Flake Produced	Maximum length (mm) (inc. flake)	Maximum width (mm) (inc. flake)	Maximum depth (mm) (inc. flake)	Core Mass (g) (inc. flake)	Core Mass (g) (ex. flake)
Θ	2	No	82.5	64.9	34.7	~	208.3
A	3	Yes	59.1	72.2	34.2	162.3	142.6
B	3	Yes	75.2	36.1	43.7	326.3	320.9
C	3	Yes	59.5	56.2	20.1	213.7	79.9
D	3	Yes	71.4	56.8	22	163.5	110
E	3	Yes	73	56.8	19.6	135.9	89.1
F	3	Yes	79.2	56.7	27	175.9	109.3
G	3	Yes	67.4	42.5	28.9	77.6	69.7

Levallois Flake

Knapper	Evaluation	Maximum length (mm)	Maximum width (mm)	Maximum thickness (mm)	Termination	Platform thickness (mm)	Mass (g)	Percentage Surface Area Covered
A	1	36.1	46	10.9	H	2.6	17	42.4
C	1	27.1	31.8	10.5	S	8.2	8.2	32.9
F	1	35.6	40	8.5	S	7.8	8.8	19.3
H	1	49	56.8	13.1	F	14.8	23.6	44.4
A	2	32	25	6.5	H	6.1	5.1	22.1
B	2	62.9	38.9	16.7	F	14.7	29.2	32.5
C	2	59.6	42.7	10.8	OS	10.7	29.4	103.9
D	2	96.7	66.4	22.9	OS	6.6	102.9	111
E	2	60.4	36.1	7.2	F	7.9	14.8	43.5
F	2	31.9	41	10.5	S	9.4	14.5	44.6
G	2	52.4	50.7	14.4	F	13.9	34.2	78.6
I	2	31.4	30.5	6	H	9.9	6.2	11.9
R	2	57.1	49.9	15.8	F	12.9	38.4	63.6

Knapper	Evaluation	Maximum length (mm)	Maximum width (mm)	Maximum thickness (mm)	Termination	Platform thickness (mm)	Mass (g)	Percentage Surface Area Covered
A	3	37.4	46.9	10.8	H	8.8	19.7	43.6
B	3	43.5	31.4	4.9	F	M	5.4	19.9
C	3	90.2	64.4	27	O/S	14.2	133.8	151.6
D	3	79.5	53.4	13.8	O/S	12.9	53.5	98.7
E	3	45	29.4	8.1	H	6.1	8.5	29.7
F	3	52	40.1	8.3	H	5.1	16.2	48.9
G	3	41.1	29.1	7.5	H	M	7.9	37.6

Levallois Debitage

Knapper	Evaluation	Total					Dorsal Flakes				Ventral flakes				Undetermined flakes
				Termination			Platform				Platform				
		Mass (g)	Number	Feather	Hinge	Step	Flat	Faceted	Undetermined	Total	Flat	Faceted	Undetermined	Total	Total
A	1	508.7	41	36	4	1	32	0	1	33	0	8	0	8	0
B	1	487.6	58	53	4	1	17	11	6	34	4	13	3	20	4
C	1	594.9	122	114	4	4	86	2	2	90	0	32	0	32	0
D	1	385.5	73	69	3	1	40	0	2	42	0	13	0	13	18
E	1	538.1	43	40	1	2	28	0	1	29	0	14	0	14	0
F	1	429.1	49	47	2	0	21	1	3	25	0	15	0	15	9
G	1	480.2	27	22	4	1	14	0	1	15	0	12	0	12	0
H	1	407.2	39	37	1	1	34	0	0	34	0	5	1	6	0
I	1	287.6	90	67	13	10	23	9	6	38	23	10	0	33	19
L	1	274	76	55	8	13	21	10	2	33	7	18	3	28	15
M	1	255.9	70	59	2	9	2	6	0	8	46	10	0	56	6
R	1	507.7	174	142	11	21	47	17	4	68	13	19	4	36	70
T	1	388.7	112	89	6	17	25	13	0	38	20	23	0	43	31

Knapper	Evaluation	Total					Dorsal Flakes				Ventral flakes				Undetermined flakes
				Termination			Platform				Platform				
		Mass (g)	Number	Feather	Hinge	Step	Flat	Faceted	Undetermined	Total	Flat	Faceted	Undetermined	Total	Total
Θ	1	388.5	91	73	7	11	26	17	1	44	30	5	1	36	11
A	2	539.8	58	53	4	1	32	0	0	32	2	8	0	10	16
B	2	404.2	73	63	2	8	31	10	2	43	15	8	1	24	6
C	2	575.6	180	167	4	9	127	6	4	137	0	7	0	7	36
D	2	404.7	57	51	0	6	39	0	3	42	3	6	0	9	6
E	2	495.4	47	42	1	4	25	0	0	25	0	13	0	13	8
F	2	631.1	76	63	8	5	42	2	0	44	0	5	0	5	27
G	2	544.3	78	68	1	9	39	0	3	42	2	14	0	16	20
I	2	387.6	63	62	1	0	28	10	1	38	2	23	0	25	4
L	2	203.7	45	38	3	4	10	3	2	15	7	15	1	23	7
M	2	362.3	76	66	2	8	9	12	0	21	17	24	3	44	11
R	2	454.9	123	110	6	7	10	32	2	44	36	17	0	53	26
T	2	362.3	76	66	2	8	9	12	0	21	17	24	3	44	11
Θ	2	505.5	70	68	2	0	29	7	1	37	1	20	0	21	12
A	3	515.9	60	55	2	3	40	2	0	42	0	10	1	11	7
B	3	360.8	67	65	1	1	55	0	1	56	0	7	0	7	4
C	3	492.7	108	102	3	3	66	9	4	79	0	24	0	24	5
D	3	515.3	63	62	0	1	40	0	1	41	0	19	0	19	3
E	3	533.9	64	62	0	2	27	0	2	29	0	27	1	28	7
F	3	505.7	66	64	2	0	38	0	1	39	0	9	0	9	18
G	3	590.4	71	69	1	1	37	6	2	45	2	17	0	19	7

Appendix 6 – Taught Sessions

Core

Core Session 1:

20/01/11

9-12:

- Reading Stone Tools – 1st session of the module.
- Introduction to Mechanics of flintknapping.
- Introduction to terms.

Demo:

- Levallois Core.
- Blade production by pressure (stomach crutch).

Present:

Instructors	Subjects	Others
Bruce Bradley	A	Samir Patel
Antony Whitlock	B	Reading Stone Tools Class
Nada Khreisheh	C	
	D	
	E	
	F	

2-5:

- Introduction to Oldowan technology – making predictable flakes.

Practice:

- Divided into pairs – one teaching, one practising, then switch.
- Then individual practice of flake making.
- Input from instructors.

Present:

Instructors	Subjects	Others
Bruce Bradley	A	Samir Patel
Antony Whitlock	B	Stuart Page
Nada Khreisheh	C	
	D	
	E	
	F	

Comments:

Generally lots of hits without follow through, hinge fractures and missing where they wanted to hit.

A – Hitting too hard, producing chunks rather than flakes.

B – Problems with choosing correct platform angles.

C – No follow through, power grip rather than precision grip, problems choosing angles.

D – Good at identifying correct angles.

E – Good at identifying correct angles, hitting into concavities.

F – Initially hitting at too steep a platform angle, improved quickly producing microblades.

Core Session 1a

9/03/11

2-4:

- 1st catch up session for G and H to bring them up to core group level.
- Intro to flaking.
- 1st session for Q (wider experienced).

Demo:

- Big core reduction to flake and core blanks.
- Flaking from smaller cores.

Practice:

- Flaking

Present:

Instructors	Subjects	Others
Bruce Bradley	G	Material Culture Class
Nada Khreisheh	H	
Antony Whitlock	Q	
	Ξ	

Comments:

H – Bouncing blows – need more follow-through.

G – Too much force, big hammerstone, big core.

Hammerstone scraping surface.

Core Session 2:

21/01/11

10-1:

- Introduction to unifacial retouch and platform reduction.
- Introduced concepts of marginal and non-marginal flaking.
- Introduction to soft hammer flaking.

Demo:

- Scraper retouch with a stone and an antler.
- Retouching flakes to make drills.
- Prediction of flakes by drawing on core with marker pen.
- Bladelet core by direct percussion including platform reduction.

Practice:

- Everyone practising flaking and retouching.

Present:

Instructors	Subjects	Others
Bruce Bradley	A	Samir Patel
Antony Whitlock	B	
Nada Khreisheh	C	
	D	
	E	
	F	

Comments:

Everyone is dealing well with flaking. Most moving to trying retouch but generally not hitting hard enough to take flakes off.

A – Problems with aim.

B – Problems with angles.

C – Not following through when hitting, problems aiming.

D – Got the hang of flaking.

E – Got the hang of flaking.

F – Got the hang of flaking.

2-5:

Demo:

- Creation of flakes from large nodule.
- Blade making with wood hammer.

Viewed:

- Danish dagger.

Practice:

- Flake making and retouch.

Present:

Instructors	Subjects	Others
Bruce Bradley	A	Samir Patel
Antony Whitlock	B	Stuart Page
Nada Khreisheh	C	
	D	
	E	
	F	

Comments:

D – Making microliths.

Core Session 3:

22/1/11

2-5:

- Introduction to Levallois.

Demo:

- Levallois core formation and flake removal.

Practice:

- Continued flaking, retouch and bladelet production.
- Some tried Levallois.

Present:

Instructors	Subjects	Others
Bruce Bradley	A	Samir Patel
Antony Whitlock	B	
Nada Khreisheh	C	
	D	
	E	
	F	

Comments:

- C, F and D tried Levallois technology.

Core Session 4:

26/1/11

2-5:

- Continued practice and 1st evaluations (flaking).

Practice:

- Flaking, microblades and Levallois cores.

Present:

Instructors	Subjects
Bruce Bradley	A
Antony Whitlock	B
Nada Khreisheh	C
	D
	E
	F

Comments:

- AW gave instruction while BB and NK carried out evaluations.

Core Session 5

27/01/11

9-5:

- Fieldtrip to Seaton.
- Collection of flint for Reading Stone Tools class.
- Explanation of raw material desirable qualities.

Demo:

- Taking big flakes off large nodules – Bruce.

Practice:

- Some of the core group did a bit of flaking on the beach.

Present:

Instructors	Subjects	Others
Bruce Bradley	A	Reading stone tools class.
Antony Whitlock	B	
Nada Khreisheh	C	
	D	
	E	

Core Session 6:

3/2/11

9-12:

- Reading Stone Tools first knapping class.

Demo:

- Flaking – BB.

Practice:

- Class split into 2 groups.
- All practicing flaking.

Present:

Instructors	Subjects	Others
Bruce Bradley	A	Reading Stone Tools class
Antony Whitlock	B	
Nada Khreisheh	C	
	D	
	E	

Comments:

- A + D – Flaking practice.
- E – Levallois, handaxe and retouch practice.
- C – Handaxe and Levallois practice.
- B – Flake reduction and Levallois.

Core Session 7

9/2/11

2-5:

- Session focussing on Levallois core production and bladelets.
- Explanation of Stuart Page's project.
- Γ got introduction to the project and instruction on flaking.

Demo:

- Bladelet core production.
- Levallois cores in greater detail.

Practising:

- All core group practised bladelets.
- Γ practised flaking.

Present:

Instructors	Subjects	Others
Bruce Bradley	A	Allan Smith
Antony Whitlock	B	
Nada Khreisheh	C	
	D	
	E	
	F	
	Γ	

Comments:

- Γ – had flaking evaluation – 1st session for him.

Core Session 8

10/02/11

9-12:

- Reading Stone Tools class.
- Opportunity for further flaking, retouching and using tools for class report.

Practice:

- B – practiced retouch
- D – practiced retouch and Levallois.

Present:

Instructors	Subjects	Others
Bruce Bradley	B	Reading Stone Tools class
Nada Khreisheh	D	

Core Session 9

5/4/11

5-7:

- 1st core group handaxe session.
- Introduction to handaxes.
- Explanation of the bifacial plane.

Demo:

- Generic handaxe by BB.

Practice:

- Handaxe making, focus on creating bifacial edge.
- C and E left at 6.

Present:

Instructors	Subjects	Others
Bruce Bradley	A	Nancy Littlefield
Antony Whitlock	B	Samir Patel
Nada Khreisheh	C	
	D	
	E	
	F	
	G	

Comments:

- G – hitting too hard but getting pretty good results.
- B – Problems thinning.
- E – Problems thinning.
- A – Problems aiming and thinning.
- C – Working unifacially first.
- F – Alright – problems with angles.
- D – Problems with angles.

Core Session 9a

13/4/11

9-11:

- Catch up handaxe session for H.

Demo:

- BB creating a biface plane.

Practice:

- Given one on one instruction while making 1st handaxe.

Present:

Instructors	Subjects
Bruce Bradley	H

Comments:

- Very good 1st attempt.

Core Session 10

16/04/11:

2-3:

- Catch up Levallois session for G and H.
- Also attended by rest of core group (excluding A).
- Demo only not practice with instruction.

Demo:

- Levallois tortoise core technology by BB.
- 3x failed Levallois flake removals.

Present:

Instructors	Subjects
Bruce Bradley	B
Nada Khreisheh	C
Antony Whitlock	D
	E
	F
	G
	H
	Θ

Core Session 11

18/4/11

1.30-4.30:

- Knapping session with Mike Dothager – rocker punch technique.
- Explanation by BB of his background.
- Shown materials and examples of artefacts from a number of archaeological sites.

Demo:

- MD demonstrated rocker punch technique on floor holding the rock with feet.
- Demonstrated using a number of different punches replicated after examples from a number of archaeological sites.

Practice:

- Everyone practiced using hammerstones first then some practiced with antler punches.

Present:

Instructors	Subjects	Others
Mike Dothager	A	Antony Whitlock
	B	Nada Khreisheh
	C	
	D	
	E	
	F	
	G	
	Θ	

Core Session 12

14/09/11

2.30-3.00:

- Levallois session.

Demo:

- Bruce Bradley demonstrated Levallois preferential flake removal.
- Showed how to remove the core from a large flake.
- Showed how to shape the core, creating a dome.
- Showed final flake platform preparation.
- Showed final flake removal

Present:

Instructors	Subjects	Others
Bruce Bradley	A	Antony Whitlock
	C	Nada Khreisheh
	D	
	E	
	F	
	G	
	H	

Core Session 13

15/09/11

9.00-10.00:

- Handaxe session.

Demo:

- Bruce Bradley demonstrated handaxe technology.
- Used hammerstone only.

Present:

Instructors	Subjects	Others
Bruce Bradley	A	Antony Whitlock
	C	Nada Khreisheh
	D	
	E	
	F	
	G	
	H	

Core Session 14

17/09/11

2.00-5.00:

- Demo of Danish technologies by Bo Madsen.

Demo:

- Bo Madsen demonstrated how to make a square axe rough-out using hard hammer percussion.
- He then showed indirect percussion using an antler punch for finer shaping of a square axe.
- He also demonstrated dagger preform work using soft hammer percussion.
- Showed how to set up ridge on blade core using indirect punch percussion.
- Showed indirect blade production using antler punch.

Present:

Instructors	Subjects	Others
Bo Madsen	A	Antony Whitlock
	C	Nada Khreisheh
	D	Bruce Bradley
	E	
	F	
	G	

Core Session 15

21/09/11

2.00-3.00:

- Pressure flaking demo.

Demo:

- Bruce Bradley demonstrated pressure flaking of small points using a copper pressure flaker.
- Showed how to set up a platform and remove the flake.
- Talked about flake spacing.
- Demonstrated how to run long flakes down ridges.

Present:

Instructors	Subjects	Others
Bruce Bradley	A	Antony Whitlock
	C	Nada Khreisheh
	D	
	E	
	F	
	G	

Core Session 16

20/03/12

2.00-4.00:

- Platform preparation session.
- Explanation of platforms by BB, drawn on the board.
- Marginal vs non-marginal platforms
- Blades and handaxes.
- Reduction and faceting.

Demo:

- Bruce Bradley demonstrated platform preparation for handaxes on a porcelain core.
- He drew some of the platforms onto the core using a marker.
- Talked about thinning ends before the middle.
- Some flakes passed around the class.
- Some platform preps passed around too.
- Blade technology and platform preparation demonstrated on porcelain by BB, Upper Palaeolithic style.

Present:

Instructors	Subjects	Others
Bruce Bradley	A	Colin Diggins
Antony Whitlock	B	
Nada Khreisheh	C	
	D	
	E	
	F	
	M	
	T	
	Θ	

Comments:

- M stayed until 3.
- No practice.

Core Session 17

3/04/12

4.00-4.45:

- Upper Palaeolithic blade making session.
- Explanation of technology by BB

Demo:

- BB demonstrated preparation of core with hammerstone.
- Also demonstrated setting up a crested blade to start core, preparing the platform with faceting, removing the crested blade and removing further blades after more preparation, losing core length each time.
- Made a bidirectional core for altering the surface.
- Flaked from the back to prepare the surface.

Present:

Instructors	Subjects	Others
Bruce Bradley	B	Colin Diggins
Nada Khreisheh	C	
Antony Whitlock	D	
	E	
	F	
	G	

Core Session 18

4/04/12

3.15-4.15:

- Laurel leaf session.
- Explanation of technology by BB

Demo:

- BB demonstration of Solutrean laurel leaf technology from semi-knapped core – using mix of antler and stone.
- Early – middle stage flaking.

Present:

Instructors	Subjects	Others
Bruce Bradley	B	Colin Diggins
Nada Khreisheh	D	
Antony Whitlock	E	
	G	

Core Session 19

2/10/12

2.00-5.00:

- General group knapping session for core and wider group.
- Whole group got a final chance to knap with input from experts and from other group members.

Present:

Instructors	Subjects
Bruce Bradley	C
Nada Khreisheh	D
	E
	G
	I
	K
	M

Wider Group

Wider Beginners Session 1

2/2/11

2-5:

- First session for wider group with no previous experience.
- Introduction to flake fracture mechanics.

Demo:

- Knocking flakes off a large nodule.
- Predictable flaking demo.

Practice:

- All took cores and practiced flaking with input from N.K, B.B and A.W.

Present:

Instructors	Subjects	Others
Bruce Bradley	I	Marisa Lazarri
Antony Whitlock	J	
Nada Khreisheh	K	
	L	
	M	
	N	
	O	
	P	

Comments:

- Lots of miss hits and hitting into flat edges.
- N – Very good
- P – Bouncing blows otherwise good.
- O – Hammerstone scraping platform.
- I – Problems with angles.
- Marisa – Bouncing blows.
- L – Getting some good flakes.

Wider Beginners Session 2

15/03/11

10-11.30:

- 2nd session for wider group.
- Introduction to Stuart's project and blade production.

Demo:

- Big flakes from nodules.
- Blade making.

Practice:

- Shaping blade cores.
- Making blades.

Present:

Instructors	Subjects
Bruce Bradley	D
Antony Whitlock	K
Nada Khreisheh	L
	P
	Q

Comments:

P – Very good

K – Lots of hinges

L – Pretty good

Q – 1st session.

Wider Beginners 2a

17/03/11

10-11:

- Catch up session for beginners who missed 2nd session.
- Chance to flake with input.
- Shown blade cores
- Explanation of blades.
- BB gave instruction on platform reduction.

Practice:

- Blade making and flaking.

Present:

Instructors	Subjects
Bruce Bradley	I
Nada Khreisheh	M

Wider Beginners Session 2b

18/03/11

12-1:

- Catch up session for J (couldn't make 2nd beginners session).
- Chance to flake with input.
- Shown blade cores.
- Explanation of blade making.
- Shown platform reduction.

Practice:

- Flaking and blade making.

Present:

Instructors	Subjects
Nada Khreisheh	J

Comments:

Problems with aim.

Wider Beginners Session 3a

31/10/11

10-12:

- Catch up handaxe session for M.
- Explanation of handaxes by AW.
- One piece of rock chosen which both AW and M worked on.
- Bifacial plane drawn on the piece and explained by AW.
- Explanation of marginal and non-marginal flaking.

Practice:

- Handaxe making, working same piece. AW took some flakes from it too.

Present:

Supervisor	Subject
AW	M

Comments:

- Good motor skills.
- Had been shown platform preparation by F.

Wider Beginners Session 4

19/11/11

2-4:

- 1st Levallois Session for beginners group.
- BB broke up large rock into flakes for use.
- Explanation of Levallois technology.
- Levallois demo.
- Asks L to predict where to hit and what would come off.

Practice:

- L had to leave early so no practice.

Present:

Supervisor	**Subject**
BB	L
AW	
NK	

Wider Beginners Session 4a

23/2/12

2-4:

- Catch up Levallois Session for beginners group.
- Demo by BB (flakes produced by AW).
- Explanation of levallois technology.
- Flaking dorsal surface, faceting, hitting ridges to create doming flakes.
- Preparation of platform for final flake, passed round class.

Practice:

- Everyone practiced.

Present:

Supervisor	Subject	Other
BB	I	Colin Diggins
AW	M	Marisa Lazzari
NK		Rafael Corletoni

Comments:

- I – Very good once flaking more confidently.
- M – Ok, good confident blows.

<u>Wider Beginners Session 5</u>

4/7/12

12.30-1.30:

- Levallois and handaxe practice session for L.
- Handaxe and levallois techniques explained.
- Each flake directed for handaxe.
- Levallois explained then L allowed to practice without instruction.

Practice:

- Practiced for most of the hour on handaxe and levallois.

Present:

Supervisor	**Subject**
NK	L

Comments:

- L broke 2 handaxes in half.

Wider Experienced Session 1

31/1/11

10-1:

- First session for wider group with experience.
- Introduction to project.
- 1st flaking evaluation for some.

Practice:

- Group practiced flaking while evaluations took place.

Present:

Instructors	Subjects
Bruce Bradley	R
Antony Whitlock	S
Nada Khreisheh	T
	U
	V
	X
	Z
	Θ

Comments:

- S, T, V, X, Z and Θ evaluated.
- X and Z given teaching to improve flaking performance.

Wider Experienced Session 1a

11/02/11

10-12:

- Catch up first session for Δ.
- Introduction to project.
- First flaking evaluation.
- Given some instruction on flaking.

Practice:

- Practiced flaking for 30mins before evaluation took place.
- Then practice after evaluation with instruction from NK.

Present:

Instructors	Subjects
Nada Khreisheh	Δ

Wider Experienced Session 1b

18/02/11

12-1:

- Catch up first session for W and Λ.
- First flaking evaluations.

Practice:

- Half hour flaking practice before evaluation.
- Each continued flaking while other was evaluated.

Present:

Instructors	Subjects
Nada Khreisheh	W
	Λ

2-5:

- Introduction to Levallois.

Demo:

- Levallois core production by NK.

Practice:

- Both practiced Levallois for the whole session.

Present:

Instructors	Subjects
Nada Khreisheh	W
Antony Whitlock	Λ

Comments:

- Λ picked it up quickly apart from final Levallois flake platform preparation.
- W kept breaking cores in half – hammerstone too big?

Wider Experienced Session 2

16/03/11

2-5:

- Introductory Levallois session for wider experienced group.
- Detailed explanation of Levallois tortoise core technology.

Demo:

- Making big flakes from nodules.
- Levallois tortoise core.

Practice:

- Everyone practised Levallois.

Present:

Instructors	Subjects	Others
Bruce Bradley	R	Stuart Page
Antony Whitlock	S	
Nada Khreisheh	T	
	V	
	Γ	
	Θ	
	Ξ	

Comments:

R did not stay for practice.

Wider Experienced Session 2a

31/03/11

9-12:

- Catch up Levallois session.
- Explanation of Levallois technology by N.K

Demo:

- Core shaping, platform preparation, flake removal by N.K.

Practice:

- Practised Levallois tortoise core technology.

Present:

Instructors	Subjects
Nada Khreisheh	U
Antony Whitlock	

Comments:

- Took a while to get the hang of doming flakes but once this was picked up was very good.

Wider Experienced Session 3a

18/11/11

2-4:

- Catch up handaxe session for V.
- AW selected a rock with some challenges.
- Concept of biface plane explained and drawn on the rock.
- Both worked on rock with AW doing some platform preparation.
- Shown soft hammer.
- Explanation of marginal and non-marginal flaking.

Practice:

- Handaxe making.

Present:

Supervisor	Subject
AW	V

Comments:

Did well but scared of hitting leg so held in hand.

Wider Experienced Session 4

9/11/11

2-4:

- Levallois session.
- Explanation of Levallois technology by BB.
- Described as off-set biface.
- Levallois demonstration.
- Flake drawn on piece with marker.
- Flakes and cores passed round the class.

Practice:

- Levallois preferential core making.

Present:

Supervisor	Subject
BB	T
NK	
AW	

Wider Session 3

19/10/11

2-4:

- 1st handaxe session for wider group (beginners and experienced combined).
- Explanation of handaxes by BB.
- Concept of biface plane explained and drawn on the white board and shown on a flake.
- Handaxe flaking demonstration.
- Explanation of marginal and non-marginal flaking.

Practice:

- Handaxe making, H left before practice.

Present:

Supervisor	**Subject**
BB	H
NK	I
AW	K
	L
	R
	T
	Θ

10. Bibliography

Ambrose, S.H., 2001. Paleolithic technology and human evolution. *Science*, 291(5509), 1748–1753.

Andrefsky, W., 1998. *Lithics: Macroscopic Approaches to Analysis*, Cambridge: Cambridge University Press.

Andrews, B., 2003. Measuring prehistoric craftsman skill: contemplating its application to Mesoamerican core-blade research. In K. G. Hirth, (ed.): *Mesoamerican Lithic Technology: Experimentation and Interpretation*. Salt Lake City: University of Utah Press, 208–19.

Apel, J., 2008. Knowledge, know-how and raw material - the production of late Neolithic flint daggers in Scandinavia. *Journal of Archaeological Method and Theory*, 15(1), 91–111.

Arbib, M.A., 2005. From monkey-like action recognition to human language: an evolutionary framework for neurolinguistics. *Behavioral and Brain Sciences*, 28(2), 105–124.

Aubry, T., Bradley, B., Almeida, M., Walter, B., Neves, M.J., Pelegrin, J., Lenoir, M. & Tiffagom, M., 2008. Solutrean laurel leaf production at Maitreaux: an experimental approach guided by techno-economic analysis. *World Archaeology*, 40, 48–66.

Bagwell, E.A., 2002. Ceramic form and skill: attempting to identify child producers at Pecos Pueblo, New Mexico. In K. A. Kamp, (ed.): *Children in the Prehistoric Puebloan Southwest*. Salt Lake City: University of Utah Press, 90–107.

Bamforth, D.B., 1991. Flintknapping skill, communal hunting, and Paleoindian projectile point typology. *The Plains Anthropologist*, 36(137), 309–322.

Bamforth, D.B. & Finlay, N., 2008. Introduction: archaeological approaches to lithic production skill and craft learning. *Journal of Archaeological Method and Theory*, 15(1), 1–27.

Bamforth, D.B. & Hicks, K., 2008. Production skill and Paleoindian workgroup organization in the Medicine Creek Drainage, Southwestern Nebraska. *Journal of Archaeological Method and Theory*, 15(1), 132–153.

Baxter, J.E., 2005. *The Archaeology of Childhood: Children, Gender, and Material Culture*, Lanham: Rowman Altamira.

Binford, L.R., 1986. An Alyawara day: making men’s knives and beyond. *American Antiquity*, 51(3), 547–562.

Bleed, P., 2008. Skill matters. *Journal of Archaeological Method and Theory*, 15(1), 154–166.

Bodu, P., 1996. Les chasseurs Magdeleniens de Pincevent: quelques aspects de leurs comportements. *Lithic Technology*, 21(1), 48–66.

Bodu, P., Karlin, C. & Ploux, S., 1990. Who’s who? The Magdalenian flintknappers of Pincevent, France. In E. Cziesla et al., (eds.). *The Big Puzzle: International Symposium on Refitting Stone Artefacts*. Bonn: Holos, 143–63.

Bordes, F., 1971. Physical evolution and technological evolution in man: a parallelism. *World Archaeology*, 3(1), 1–5.

Bower, B., 2007. Children of prehistory: stone age kids left their marks on cave art and stone Tools. *Science News*, 171(17), 264–266.

Bradley, B., 1977. *Experimental Lithic Technology with Special Reference to the Middle Palaeolithic*. Ph.D. thesis, Cambridge: University of Cambridge.

Bril, B., Roux, V. & Dietrich, G., 2000. Habileté impliquées dans la taille des perles en calcédoine: caractéristiques motrices et cognitives d’une action située complexe. In V. Roux, (ed.): *Cornaline de l’Inde: Des Pratiques Techniques de Cambray aux Techno-systèmes de l’Indus*. France: Foundation Maison des Sciences de L’homme, 207–332.

Butler, C., 2005. *Prehistoric Flintwork*, Stroud: Tempus.

Byrne, R.W. & Russon, A.E., 1998. Learning by imitation: a hierarchical approach. *Behavioral and Brain Sciences*, 21(5), 667–684.

Callahan, E., 1979. The basics of biface knapping in the Eastern fluted point tradition: a manual for flintknappers and lithic analysts. *Archaeology of Eastern North America*, 7(1), 1–180.

Carty, W.M. & Senapati, U., 1998. Porcelain—raw materials, processing, phase evolution, and mechanical behavior. *Journal of the American Ceramic Society*, 81(1), 3–20.

Cavalli-Sforza, L.L., Feldman, M.W., Chen, K.H., & Dornbusch, S.M., 1982. Theory and Observation in Cultural Transmission. *Science*, 218(4567), 19–27.

Chazan, M., 1997. Redefining Levallois. *Journal of Human Evolution*, 33(6), 719–735.

Clark, J.E., 2003. Craftsmanship and craft specialization. In K. G. Hirth, (ed.). *Mesoamerican Lithic Technology: Experimentation and Interpretation*. Salt Lake City: University of Utah Press, 221–33.

Clark, J.E., 1997. Prismatic blademaking, craftsmanship, and production. *Ancient Mesoamerica*, 8(1), 137–159.

Copeland, L., 1983. Levallois/non-Levallois determination in the Early Levant Mousterian: problems and questions for 1983. *Paléorient*, 9(2), 15–27.

Cotterell, B., 2010. *Fracture and Life*, London: Imperial College Press.

Coward, F. & Gamble, C., 2008. Big brains, small worlds: material culture and the evolution of the mind. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 363(1499), 1969–1979.

Crown, P.L., 2001. Learning to make pottery in the Prehispanic American Southwest. *Journal of Anthropological Research*, 57(4), 451–469.

Crown, P.L., 2007. Life histories of pots and potters: situating the individual in archaeology. *American Antiquity*, 72(4), 677–690.

Crown, P.L., 1999. Socialization in American Southwest pottery decoration. In J. M. Skibo & G. M. Feinman, (eds.). *Pottery and People: A Dynamic Interaction*. Salt Lake City: The University of Utah Press, 25–43.

Csibra, G. & Gergely, G., 2011. Natural pedagogy as evolutionary adaptation. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 366(1567), 1149–1157.

Cziesla, E., Eickhoff, S., Arts, N. & Winter, D., (eds.), 1990. *The Big Puzzle: International Symposium on Refitting Stone Artefacts*, Bonn: Holos.

Davidson, I., 2011. Stone tools and the evolution of hominin and human cognition. In A. Nowell & I. Davidson, (eds.). *Stone Tools and the Evolution of Human Cognition*. Boulder: University Press of Colorado, 185–205.

Davidson, I. & McGrew, W.C., 2005. Stone tools and the uniqueness of human culture. *Journal of the Royal Anthropological Institute*, 11(4), 793–817.

Davidson, I. & Nowell, A., 2011. Introduction and overview. In A. Nowell & I. Davidson, (eds.). *Stone Tools and the Evolution of Human Cognition*. Colorado: University Press of Colorado, 1–11.

Dobres, M. A., 1995. Gender and prehistoric technology: on the social agency of technical strategies. *World Archaeology*, 27(1), 25–49.

Edmonds, M., 1990. Description, understanding and the chaîne opératoire. *Archaeological Review from Cambridge*, 9(1), 55–70.

Emery, K., 2010. *A re-examination of variability in handaxe form in the British Palaeolithic.* PhD thesis. London: UCL.

Eren, M., I., 2008. *Experimental lithic technology with special reference to Levallois skill*. Unpublished MA Thesis. University of Exeter.

Eren, M., I., Bradley, B.A. & Sampson, C.G., 2011. Middle Palaeolithic skill level and the individual knapper: an experiment. *American Antiquity*, 76(2), 229–51.

Eren, M.I., Lycett, S. J., Roos, C. I. & Sampson, C. G., 2011. Toolstone constraints on knapping skill: Levallois reduction with two different raw materials. *Journal of Archaeological Science*, 38(10), 2731–2739.

Eren, M.I. & Lycett, S.J., 2012. Why Levallois? A morphometric comparison of experimental "preferential" Levallois flakes versus debitage flakes. *PLoS ONE*, 7(1).

Ferguson, J.R., 2008. The when, where, and how of novices in craft production. *Journal of Archaeological Method and Theory*, 15(1), 51–67.

Finlay, N., 1997. Kid knapping: the missing children in lithic analysis. In J. Moore & E. Scott, (eds.). *Invisible People and Processes: Writing Gender and Childhood into European Archaeology*. London: Leicester University Press, 203–12.

Finlay, N., 2008. Blank concerns: issues of skill and consistency in the replication of Scottish Later Mesolithic blades. *Journal of Archaeological Method and Theory*, 15(1), 68–90.

Finlay, N., 2013. Gender and lithic studies in prehistoric archaeology. In D. Bolger, (ed.). *A Companion to Gender Prehistory*. Chichester: John Wiley & Sons, 142–160.

Fischer, A., 1989. A late Palaeolithic "school" of flint-knapping at Trollesgave, Denmark: results from refitting. *Acta Archaeologica*, 60, 33–49.

Fischer, A., 1990. On being a pupil of a flintknapper of 11,000 years ago: a preliminary analysis based on conjoined flint artefacts from the Trollesgave site. In E. Cziesla, S. Eickhoff, N. Arts & D. Winter (eds.). *The Big Puzzle: International Symposium on Refitting Stone Artefacts*. Bonn: Holos, 447–64.

Flenniken, J.J., 1984. The past, present, and future of flintknapping: an anthropological perspective. *Annual Review of Anthropology*, 13, 187–203.

Gamble, C., 1996. Hominin behaviour in the Middle Pleistocene: an English perspective. In C. Gamble & A. J. Lawson, (eds.) *The English Palaeolithic Reviewed*. Trust for Wessex Archaeology Ltd, 63–71.

Gamble, C., 1998. Palaeolithic society and the release from proximity: a network approach to intimate relations. *World Archaeology*, 29(3), 426–449.

Gamble, C. & Porr, M. (eds.), 2005. *The hominid individual in context: archeological investigations of Lower and Middle Palaeolithic landscapes, locales and artefacts*, Oxford: Routledge.

Geribàs, N., Mosquera, M. & Vergès, J.M., 2010. What novice knappers have to learn to become expert stone toolmakers. *Journal of Archaeological Science*, 37(11), 2857–2870.

Gero, J.M., 1991. Genderlithics: women's roles in stone tool production. In J. M. Gero & M. W. Conkey, (eds.) *Engendering Archaeology: Women and Prehistory*. Oxford: Blackwell, 163–93.

Grimm, L., 2000. Apprentice flintknapping: relating material culture and social practice in the Upper Palaeolithic. In J. S. Derevenski, (ed.). *Children and Material Culture*. London: Routledge, 53–71.

Hardaker, T. & Dunn, S., 2005. The Flip Test - a new statistical measure for quantifying symmetry in stone tools. *Antiquity*, 79(306). Available at: http://antiquity.ac.uk/projgall/hardaker306/ [Accessed July 2, 2013].

Hayden, B. & Cannon, A., 1984. Interaction inferences in archaeology and learning frameworks of the Maya. *Journal of Anthropological Archaeology*, 3(4), 325–367.

Hewlett, B.S. & Cavalli-Sforza, L.L., 1986. Cultural transmission among Aka pygmies. *American Anthropologist*, 88(4), 922–934.

Hewlett, B.S., Fouts, H.N., Boyette, A.H., & Hewlett, B.L., 2011. Social learning among Congo Basin hunter–gatherers. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 366(1567), 1168–1178.

Hodder, I., 1990. Technology in the humanities : a commentary. *Archaeological Review from Cambridge*, 9(1), 154–157.

Högberg, A., 2008. Playing with flint: tracing a child's imitation of adult work in a lithic assemblage. *Journal of Archaeological Method and Theory*, 15(1), 112–131.

Holloway, R.L., 1969. Culture: a human domain. *Current Anthropology*, 10(4), 395–412.

Hopkinson, T. & White, M.J., 2005. The Acheulean and the handaxe. In C. Gamble & M. Porr, (eds). *The hominin individual in context: archaeological investigations of Lower and Middle Palaeolithic landscapes, locales and artefacts*. Oxford: Routledge, 13–28.

Hosfield, R., 2011. The British Lower Palaeolithic of the early Middle Pleistocene. *Quaternary Science Reviews*, 30(11–12), 1486–1510.

Hosfield, R. & Chambers, J.C., 2009. Genuine diversity? The Broom biface assemblage. *Proceedings of the Prehistoric Society*, 75, 65–100.

Ingold, T., 2000. *The perception of the environment: essays in livelihood, dwelling and skill*, London: Routledge

Ingold, T. 2001. From the transmission of representation to the education of attention. In H. Whitehouse (ed*). The debated mind: evolutionary psychology versus ethnography*. New York: Berg, 113-153.

Johnson, L.L., 1978. A history of flint-knapping experimentation, 1838-1976. *Current Anthropology*, 19(2), 337–372.

Karlin, C. & Julien, M., 1994. Prehistoric technology: a cognitive science. In C. Renfrew & E. B. Zubrow, (eds.). *The Ancient Mind: Elements of Cognitive Archaeology*. Cambridge: Press Syndicate of the University of Cambridge, 152–64.

Kennedy, G.E., 2003. Palaeolithic grandmothers? Life history theory and early Homo. *Journal of the Royal Anthropological Institute*, 9(3), 549–572.

Key, C.A., 2000. The evolution of human life history. *World Archaeology*, 31(3), 329–350.

Khreisheh, N., Davies, D. & Bradley, B., 2013. Extending experimental control: the use of porcelain in flaked stone experimentation. *Advances in Archaeological Practice: A Journal of the Society for American Archaeology*, 1(1), 37–46.

Kuhn, S.L. & Stiner, M.C., 1998. Middle Palaeolithic “Creativity”: Reflections on an oxymoron. In S. Mithen, (ed.) *Creativity in Human Evolution and Prehistory*. London: Routledge, 143–64.

Lave, J. & Wenger, E., 1996. *Situated learning: legitimate peripheral participation*, Cambridge: Cambridge University Press.

Lemonnier, P., 1989. The study of material culture today: toward an anthropology of technical systems. *Journal of Anthropological Archaeology*, 5, 147-86.

Lemmonier, P. (ed), 1993. *Technological choices: transformation in material cultures since the Neolithic.* London: Routledge.

Lohse, J.C., 2010. Evidence for learning and skill transmission in Clovis blade production and core maintenance. In B. A. Bradley, M. B. Collins, & A. Hemmings, (eds.). *Clovis Technology*. Michigan: Intl Monographs in Prehistory, 157–76.

Lohse, J., 2011. Step by step. *Lithic Technology*, 36(2), 97–108.

Machin, A.J., Hosfield, R.T. & Mithen, S.J., 2007. Why are some handaxes symmetrical? Testing the influence of handaxe morphology on butchery effectiveness. *Journal of Archaeological Science*, 34(6), 883–893.

McGrew, W.C., 1992. *Chimpanzee Material Culture: Implications for Human Evolution*, Cambridge: Cambridge University Press.

McGrew, W.C., 1987. Tools to get food: the subsistants of Tasmanian Aborigines and Tanzanian Chimpanzees Compared. *Journal of Anthropological Research*, 43(3), 247–258.

Minar, C.J. & Crown, P.L., 2001. Learning and craft production: an introduction. *Journal of Anthropological Research*, 57(4), 369–380.

Mithen, S.J., 1996. *The prehistory of the mind: the cognitive origins of art, religion and science*, Thames and Hudson.

Mithen, S.J., 1998. Introduction to Part II. In S. Mithen, (ed.). *Creativity in Human Evolution and Prehistory*. London: Routledge, 93–109.

Moore, M.W., 2010. “Grammars of action” and stone flaking design space. In A. Nowell & I. Davidson, (eds.). *Stone Tools and the Evolution of Human Cognition*. Boulder: University Press of Colorado, 13–43.

Newcomer, M.H., 1971. Some quantitative experiments in handaxe manufacture. *World Archaeology*, 3(1), 85–94.

Noble, W. & Davidson, I., 1996. *Human Evolution, Language and Mind: a Psychological and Archaeological Inquiry*, Cambridge: Cambridge University Press.

Nonaka, T., Bril, B. & Rein, R., 2010. How do stone knappers predict and control the outcome of flaking? Implications for understanding early stone tool technology. *Journal of Human Evolution*, 59(2), 155–167.

Odell, G.H., 2003. *Lithic Analysis*, New York: Springer.

Olausson, D.J., 1998. Different strokes for different folks, possible reasons for variation in quality of knapping. *Lithic Technology*, 23(2), 90–115.

Olausson, D.J., 2008. Does practice make perfect? Craft expertise as a factor in aggrandizer strategies. *Journal of Archaeological Method and Theory*, 15(1), 28–50.

Pelegrin, J., 1990. Prehistoric lithic technology : some aspects of research. *Archaeological Review from Cambridge*, 9(1), 116–25.

Pelegrin, J., 2005. Remarks about archaeological techniques and methods of knapping: elements of a cognitive approach to stone knapping. In V. Roux & B. Bril, (eds.). *Stone Knapping: The Necessary Conditions for a Uniquely Hominin Behaviour*. Cambridge: McDonald Institute for Archaeological Research, University of Cambridge, 23–33.

Petraglia, M.D., 2003. The Lower Paleolithic of the Arabian Peninsula: occupations, adaptations, and dispersals. *Journal of World Prehistory*, 17(2), 141–179.

Pettitt, P.B., 2000. Neanderthal lifecycles: developmental and social phases in the lives of the last Archaics. *World Archaeology*, 31(3), pp.351–366.

Pettitt, P.B. & White, M., 2012. *The British Palaeolithic: human societies at the edge of the Pleistocene world*, Oxford: Routledge.

Pigeot, N., 1990. Technical and social actors. Flintknapping specialists and apprentices at Magdalenian Etiolles. *Archaeological Review from Cambridge*, 9(1), 126–41.

Pope, M. & Roberts, M., 2005. Observations on the relationship between Palaeolithic individuals and artefact scatters at the Middle Pleistocene site of Boxgrove. In C. Gamble & M. Porr, (eds). *The hominin individual in context: archaeological investigations of Lower and Middle Palaeolithic landscapes, locales and artefacts*. Oxford: Routledge, 81–97.

Potts, R., 1991. Why the Oldowan? Plio-Pleistocene toolmaking and the transport of resources. *Journal of Anthropological Research*, 47(2), 153–176.

Preece, R.C., Gowlett, J.A.J., Parfitt, S.A., Bridgland, D.R. & Lewis, S.G., 2006. Humans in the Hoxnian: habitat, context and fire use at Beeches Pit, West Stow, Suffolk, UK. *Journal of Quaternary Science*, 21(5), 485–496.

Ramirez Rozzi, F.V. & Bermudez de Castro, J.M., 2004. Surprisingly rapid growth in Neanderthals. *Nature*, 428(6986), 936–939.

Roche, H., 2005. From simple flaking to shaping: stone-knapping evolution among early hominins. In V. Roux & B. Bril, (eds.). *Stone Knapping: The Necessary Conditions for a Uniquely Hominin Behaviour*. Oxford: Oxbow, 35–48.

Roffman, I., Savage-Rumbaugh, S., Rubert-Pugh, E., Ronen, A. & Nevo, E., 2012. Stone tool production and utilization by bonobo-chimpanzees (Pan paniscus). *Proceedings of the National Academy of Sciences*, 109(36), 14500–14503.

Root, M.J., 1997. Production for exchange at the Knife River flint quarries, North Dakota. *Lithic Technology*, 22(1), 33–50.

Roth, G. & Dicke, U., 2005. Evolution of the brain and intelligence. *Trends in Cognitive Sciences*, 9(5), 250–257.

Roux, V., 1990. The psychological analysis of technical activities: a contribution to the study of craft specialisation. *Archaeological Review from Cambridge*, 9(1), 142–153.

Roux, V. & David, E., 2005. Planning abilities as a dynamic perceptual-motor skill: an actualistic study of different levels of expertise involved in stone knapping. In V. Roux & B. Bril, (eds.). *Stone Knapping: the Necessary Conditions for a Uniquely Hominin Behaviour*. Cambridge: McDonald Institute for Archaeological Research, University of Cambridge, 91–108.

Savage, G., 1963. *Porcelain through the Ages*, Harmondsworth: Penguin Books Ltd.

Schlanger, N., 1996. Understanding Levallois: lithic technology and cognitive Archaeology. *Cambridge Archaeological Journal*, 6(2), 231–254.

Scott, B., 2010. The investigation of Baker's Hole, Northfleet, Kent, 1909–1914; the impact of collection history upon the interpretation of archaeological data. *Proceedings of the Geologists' Association*, 121(1), 77–82.

Semaw, S., 2000. The world’s oldest stone artefacts from Gona, Ethiopia: their implications for understanding stone technology and patterns of human evolution between 2·6-1·5 million years ago. *Journal of Archaeological Science*, 27(12), 1197–1214.

Shaw, A.D. & White, M.J., 2003. Another look at the Cuxton handaxe assemblage. *Proceedings of the Prehistoric Society.*, 69, 305–314.

Shea, J.J., 2006. Child’s play: reflections on the invisibility of children in the Paleolithic record. *Evolutionary Anthropology: Issues, News, and Reviews*, 15(6), 212–216.

Sheets, P.D., 1978. From craftsman to cog: quantitative views of Mesoamerican lithic technology. In R. Sidrys, (ed.). *Papers on the Economy and Architecture of the Ancient Maya*. Los Angeles: Institute of Archaeology, University of California, 40–71.

Shelley, P.H., 1990. Variation in lithic assemblages: an experiment. *Journal of Field Archaeology*, 17(2), 187–193.

Sinclair, A., 2000. Constellations of knowledge: human agency and material affordance in lithic technology. In M. Dobres & J. E. Robb, (eds.) *Agency in Archaeology*. London: Routledge, 196–212.

Stapert, D. & Krist, J.S., 1990. The Hamburgian site of Oldeholtwolde (NL): some results of the refitting analysis. In E. Cziesla, S. Eickhoff, N. Arts & D. Winter (eds.). *The Big Puzzle: International Symposium on Refitting Stone Artefacts*. Bonn: Holos, 371–404.

Stout, D., 2002. Skill and cognition in stone tool production: an ethnographic case study from Irian Jaya. *Current Anthropology*, 43(5), 693–722.

Stout, D. 2005. The social and cultural context of stone-knapping skill acquisition. In V. Roux & B. Bril, (eds.). *Stone Knapping: The Necessary Conditions for a Uniquely Hominin Behaviour*. Cambridge: McDonald Institute for Archaeological Research, University of Cambridge, 331–340.

Stout, D. & Chaminade, T., 2007. The evolutionary neuroscience of tool making. *Neuropsychologia*, 45(5), 1091–1100.

Stout, D., Toth, N., Schick, K. & Chaminade, T., 2008. Neural correlates of Early Stone Age toolmaking: technology, language and cognition in human evolution. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 363(1499), 1939 –1949.

Stout, D., Semaw, S., Rogers, M. J. & Cauche, D., 2010. Technological variation in the earliest Oldowan from Gona, Afar, Ethiopia. *Journal of Human Evolution*, 58(6), 474–491.

Stout, D., Apel, J., Commander, J. & Roberts, M., in press. Late Acheulean technology and cognition at Boxgrove. *Journal of Archaeological Science*, 41, 576-90.

Stringer, C. & Andrews, P., 2011. *The Complete World of Human Evolution*, London: Thames and Hudson.

de la Torre, I., 2011. Insights on the technical competence of the early Oldowan. In A. Nowell & I. Davidson, (eds.). *Stone Tools and the Evolution of Human Cognition*. Colorado: University Press of Colorado, 45–65.

de la Torre, I. & Mora, R., 2013. The transition to the Acheulean in East Africa: an assessment of paradigms and evidence from Olduvai Gorge (Tanzania). *Journal of Archaeological Method and Theory*, 1–43.

Torrence, R., 1986. *Production and Exchange of Stone Tools*, Cambridge: Cambridge University Press.

Toth, N. et al., 1993. Pan the tool-maker: investigations into the stone tool-making and tool-using capabilities of a bonobo (Pan paniscus). *Journal of Archaeological Science*, 20(1), 81–91.

Vygotsky, L.S., 1976. *Mind in Society: the Development of Higher Psychological Processes*, London: Harvard University Press.

Whittaker, J.C., 1994. *Flintknapping: Making and Understanding Stone Tools*, Austin: University of Texas Press.

Whittaker, J.C., 2004. *American Flintknappers: Stone Age Art in the Age of Computers*, Austin: University of Texas Press.

Winton, V., 2005. An investigation of knapping-skill development in the manufacture of Palaeolithic handaxes. In V. Roux & B. Bril, (eds.) *Stone Knapping: The Necessary Conditions for a Uniquely Hominin Behaviour*. Cambridge: McDonald Institute for Archaeological Research, University of Cambridge, 109–116.

Wynn, T., 1995. Handaxe enigmas. *World Archaeology*, 27(1), 10–24.

Wynn, T. & Coolidge, F.L., 2004. The expert Neandertal mind. *Journal of Human Evolution*, 46(4), 467–487.

Wynn, T. & Coolidge, F.L., 2011. How Levallois reduction is similar to, and not similar, to playing chess. In A. Nowell & I. Davidson, (eds.) *Stone Tools and the Evolution of Human Cognition*. Boulder: University Press of Colorado, 83–103.

Web

Flintknapping Hall of Fame 2013:

http://flintknappinghalloffame.blogspot.co.uk/2013/01/errett-callahan-hall-of-fame.html [Accessed October 2, 2013].

Lithic Casting Laboratory 2013:

http://www.lithiccastinglab.com/gallery-pages/mikedothagerrockerpunchpage1.htm [Accessed October 3, 2013]

Psychometric Success 2013:

http://www.psychometric-success.com/ [Accessed October 2, 2013].