Variation in Lithic Assemblages: An Experiment

Phillip H. Shelley
Eastern New Mexico University
Portales, NM

Results of analyses of experimentally generated core and debitage samples from novice and experienced flintworkers are compared. Variability in type and number of errors, successful error corrections, and morphology of stylized tools appear to be related to level of expertise. Patterned variation in attributes exists which may be used to infer or test for aboriginal skill level.

Introduction

Since Binford's cogent statements on the need to focus archaeological research on cultural processes to explain how and why change in prehistoric material culture may have occurred, few such attempts have been made (Binford 1965). One particular process which has received some archaeological attention is enculturation. Using ethnographic information on teaching and learning of Puebloan ceramics manufacturing, archaeologists have employed spatial patterning of similar ceramics to infer various aspects of sociopolitical organization (Hill 1968, 1970). Unfortunately, such attempts have been few and far between. A reason for this may be the lack of ethnographic or ethnoarchaeological documentation of realms of artifactual variation which can be equated with specific cultural processes. In Binfordian terms, we lack the middle range theories to tie processes to patterned variation in the archaeological record (Binford 1977: 2–10). The information presented here may provide a means to study enculturation within lithic technological systems and, by extension, a way to infer some aspects of sociopolitical organization.

No one was ever "born" a flintworker. Like other kinematic-dependent learning experiences, flintworking evidences a recurrent realm of beginners' errors. Beginners not only err more frequently than do more experienced workers, they also make more consistent errors. Experimental observations indicate that this source of variation in a lithic sample is both patterned and identifiable.

Relatively little ethnographic information exists concerning the teaching of flintworking. What does exist focuses primarily on who does the teaching, and where this education takes place (Gusinde 1961: 563; Wallace and Hoebel 1952: 126–127). These accounts are useful in describing how lithic technological enculturation may have been carried out. They do not, however, provide the detail necessary to differentiate the products of enculturation from the results of other technological or use-related processes. This lack of definition has led to some non-anthropological speculation concerning our ability to identify the products of learners (i.e., Waldorf 1975: 30).

Data Collection

The information presented here was generated during blind tests by student beginners and experienced flintworkers over an 11-year period. Samples of cores and flakes from various reduction strategies, including unidirectional blade production, multidirectional flake production, and bifacial core production were collected from 31 students at the beginning and end of 15-week courses in flintworking. In addition, samples were also collected from 11 experienced flintworkers, all of whom were considered adept, but who varied to some degree in "artistic" ability.

Samples were collected from students at random. Selection for inclusion in the sample was based upon a draw of the lot which matched a student's numerical position in an alphabetic sequence. Once selected, a sample of the student's cores and debitage was collected. Because of the close proximity of students to each other when working, however, there may have been a slight mixing of debris samples. The total sample was collected from approximately one-third of the students enrolled in various lithic technology courses.

Collections from experienced flintworkers were primarily samples of convenience. These samples were collected in most instances after an afternoon or evening of socializing and flintworking. Those who participated in the experiments, however, did so unknowingly, at least until the samples were collected, in order to minimize any conscious bias.

Data Manipulations

In analysis, a variety of attributes were observed and measured. Included were the standard metric attributes of weight, length, width, thickness, and a variety of platform and platform remnant measurements. In addition to these metric characteristics, raw material type, undesirable raw material properties, bulbar definition, termination type, dorsal-surface/core-face flake scars, and several other technological attribute states were recorded.

Once collected, the data were submitted to chi-square analyses in order to identify those attributes that varied significantly (at the 90% confidence level) between the two groups of flintworkers. Only those variables that differed significantly are included in this discussion. In the tables and figures presented, all variables have been converted to percentages of the sample that they represent.

Various rock types have been lumped in lithomechanically equivalent groups (i.e., cryptocrystalline and vitreous silicates). These combinations were carried out after analysis in an effort to more clearly show technological attribute patterning. The combining of rock types into general categories was done by observing the fracture characteristics of various material types and aggregating those which responded similarly to force application. In addition to mechanics, the degree of silicification, isotropy, homogeneity, and crystallinity were considered in determining lithomechanically equivalent rock types (see Crabtree 1972: 18).

In both groups the predominant raw materials were cryptocrystalline silicates (cherts, silicified woods, and chalcedonies) and vitreous silicates (obsidians and tachylyte). Minor amounts of microcrystalline igneous and sedimentary rocks (vitrophyres, basalts, and orthoquartzites) were also used by experimenters; however, they have been excluded in this discussion. Even though no statistically significant differences in attribute state frequency were found between lithomechanical categories, this separation is maintained in the tabulated data.

Some information concerning attribute recognition and recording is necessary before discussing the variation observed in the products and by-products produced by beginning and experienced flintworkers. On all cores negative flake scars were counted and for each scar the type of termination was recorded (i.e., feather termination, hinge termination, or step termination). Because in several instances only partial flake scars from early stages of reduction were preserved, an "indeterminate termination" category was also included in the analysis. In addition, those cores which exhibited hinge or step terminations were also coded as exhibiting stacked stepping if more than five separate in-line flake scars (i.e., flakes which were initiated from basically the same point of force application and propagated in the same general direction) terminated in hinge or step terminations. Also recorded in analyses were instances of battering or direct impact to the face or front of cores.

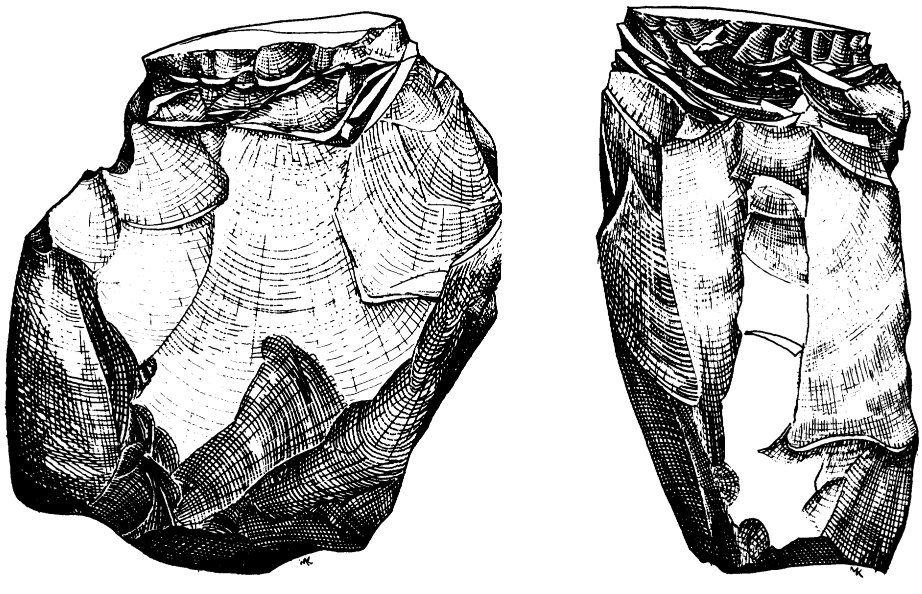
On bifacial cores, the cross-section of the biface at midpoint along the long axis was categorized, and if these cores were broken transversely, the type of transverse fracture was recorded, when discernible. One additional characteristic recorded on bifacial cores was degree of edge sinuosity. This qualitative distinction was made by comparing the existing edge line to a hypothetical straight edge. The degree of sinuosity was classed into three categories (slightly, moderately, or very sinuous) based upon the analyst's approximation of the degree of deviation from the hypothetical.

After collecting flake scar data, the number of hinge and step terminations were combined, as both were seen to be unsuccessful attempts at flake removal. The hinge/step terminations and feather terminations were summed and converted to relative frequencies of total flake scars by category (experienced or beginner).

Errors in Core Reduction

In the sample at hand, cores were considered to be the best subset for comparative purposes, because there was no doubt of the producer. Two hundred eighty-six cores were collected from beginners; however, only 162 cores collected at the end of the courses are used in this analysis. This selection excludes the earliest work of neophytes, and limits the data to those more comparable to the products of learners in a stone tool-making and -using society. These materials are compared to the entire sample of 121 cores collected from experienced workers (TABLES 1, 2).

Beginning flintworkers more frequently discarded cores, regardless of reduction strategy, as a result of committing repeated unsuccessful attempts at flake removal from basically the same location on the core platform or edge. These multiple errors resulted in "stacked" step terminations on the face or front of the objective piece (FIG. 1). In biface production these errors inevitably resulted in an exaggerated triangular cross section (FIG. 2). In addition, in flake or blade production, beginners frequently discarded cores as a result of eliminating all approaches to successful detachment when multiple stacked hinge or step terminations occurred (FIGS. 1, 2). Beginners' cores also



A B

Figure 1. Discarded beginners' blade cores: A, chert; B, obsidian. Note stacked step terminations on proximal ends of cores.

exhibited a much higher frequency of unsuccessful flake removals and force applications to the face or front of cores, including battering of hinge or step terminations as well as misplaced blows.

In comparison, experienced flintworkers seldom discarded cores as a result of errors which are common in the beginners' sample. In almost all cases of biface production these flintworkers quit work either as a result of perceived completion, perverse or end shock fracture of the objective piece, or the discovery of a natural imperfection (i.e., a vug). (A vug is a cavity, often with a mineral lining of different composition than that of the surrounding rock.) Both perverse and end shock fractures are primarily a result of excessive platform loading and concomitant transverse failure (Crabtree 1972: 60, 82). It should be noted that only discarded bifaces are used in these analyses. In all cases of flake and blade production, reduction ceased when the cores and/or resultant flakes were considered too small to be usable by the flintworker, or when a natural imperfection was encountered. The dis-

Table 1. Variation in blade core attribute data. All values in columns are percentages.

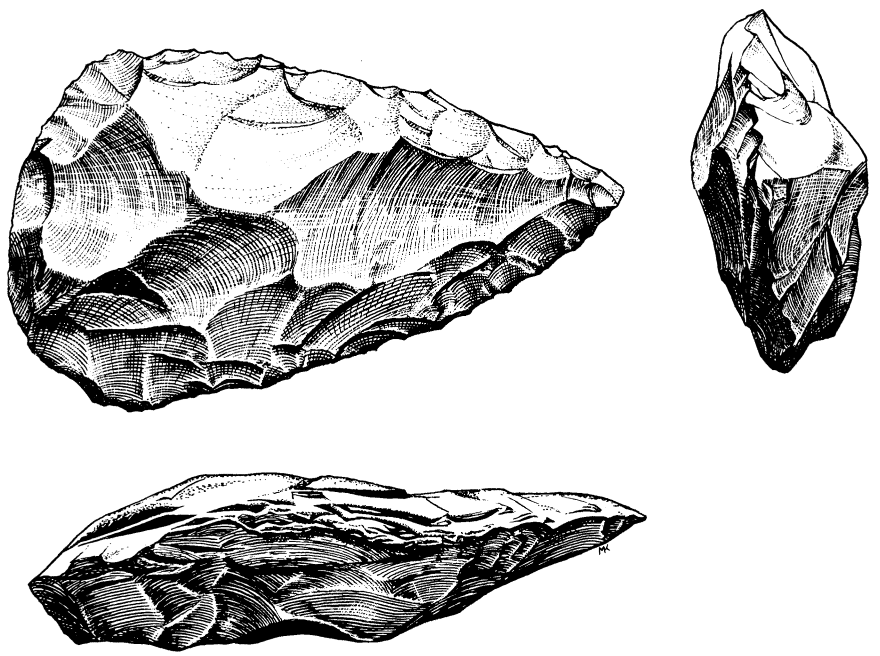
	Beginners		*Experienced*	
	Crypto-crystalline silicates (N=*60*)	*Vitreous silicates* (N=*29*)	*Crypto-crystalline silicates* (N=*43*)	*Vitreous silicates* (N=*17*)
Stacked steps*	27	22	6	7
Hinge/step	52	54	19	22
Feather	48	46	81	78
Face-battering	23	31	1	1

*Percentage of those cores exhibiting hinge/step terminations.

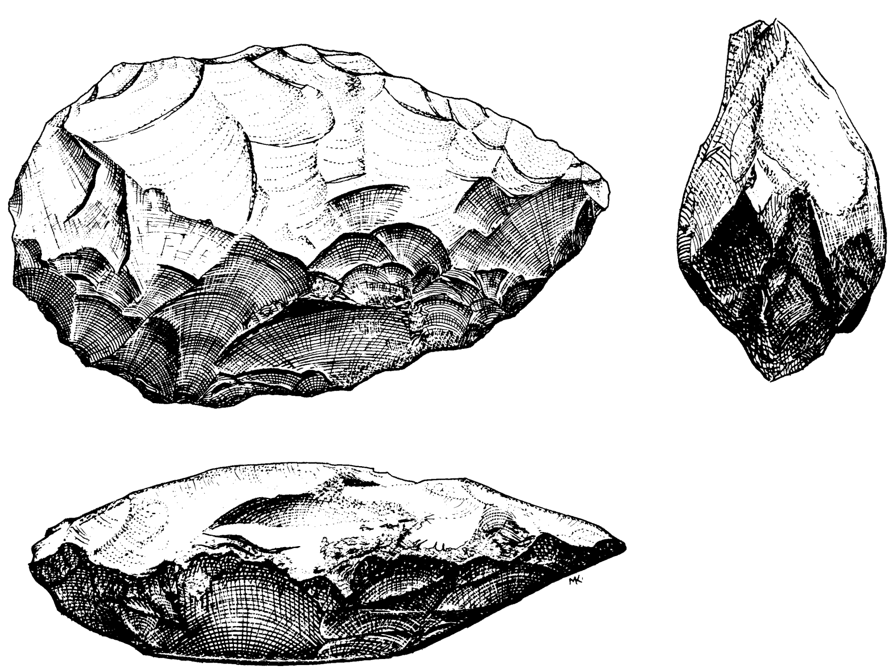
Table 2. Variation in bifacial core attribute data. All values in columns are percentages.

	Beginners		*Experienced*	
	Crypto-crystalline silicates (N=*42*)	*Vitreous silicates* (N=*31*)	*Crypto-crystalline silicates* (N=*31*)	*Vitreous silicates* (N=*30*)
Stacked steps*	61	54	4	2
Hinge/step	43	51	16	19
Feather	57	49	84	81
Face-battering	12	9	3	1
Cross-section:				
Bi-plano	2	3	12	16
Bi-convex	15	12	37	57
Plano-convex	13	11	51	27
Triangular	70	74	0	0
Breakage:				
Perverse	4	6	17	22
End shock	11	11	15	26
Edge sinuosity:				
Slight	5	11	53	61
Moderate	44	41	44	34
Extreme	51	48	3	5

*Percentage of those cores exhibiting hinge/step terminations.



A



B

Figure 2. Discarded beginners' bifacial cores: A, chert; B, chalcedony. Note triangular cross-sections, sinuous edges, and stacked step terminations on faces.

carded cores exhibited relatively little battering and/or stacked stepping.

Intuitively, one might expect discarded beginners' cores to be generally larger/heavier than those of more experienced flintworkers; this analysis showed, however, no statistically significant difference between the two samples. These results are believed to occur primarily as a result of two factors. One is experimental constraint; limited sizes of initial cobbles were presented to all experimenters; therefore in a reductive process, the upper limit of the scale was fixed. A second reason for a lack of significant difference in size may be that experienced flintworkers more frequently discarded cores because of natural imperfections (i.e., pieces with vugs, cleavage planes, phenocrysts, etc.) than did learners. This behavior may reflect increased raw material selectivity among more experienced flintworkers.

Because no records were kept of the rate of success per reductions attempted, no quantitative evidence can be offered on the possible differential rate at which beginners or experienced workers may contribute discarded cores to the record per reduction attempt. It is suspected, however, that beginners may contribute more to the core lithic sample in certain circumstances. This may be the case in quarry or acquisition sites, which would be the most efficient areas to carry out the learning processes, as is suggested by some ethnographic documentation (Bordaz 1971). It should also be kept in mind when speculating on such cultural formation processes that quite frequently an experienced flintworker can successfully recover a core discarded by a frustrated beginner.

Table 3. Variation in debitage attribute data. All values in columns are percentages.

	Beginners		*Experienced*	
	Crypto-crystalline silicates (N=*39,832*)	*Vitreous silicates* (N=*32,180*)	*Crypto-crystalline silicates* (N=*41,317*)	*Vitreous silicates* (N=*31,044*)
LILFS*	58	61	48	44
Whole and distal terminations:				
Hinge/step	50	51	38	44
Feather	50	49	62	56
Pick-up flake terminations:				
Hinge/step	61	72	27	21
Feather	29	28	73	79
Whole and proximal platform remnants:				
Prepared	49	60	81	90
Unprepared	51	40	19	10
Overhang removed	52	52	84	86
Overhang present	48	48	16	14

*Limited information lithic fragments (see text for further discussion).

Flake Terminations and Dorsal Surface Errors

Flakes were sampled by taking a shovel or dustpan transect through debitage piles at the end of a reduction attempt. This sampling procedure resulted in the collection of 129,863 pieces from beginners and 72,361 pieces from experienced flintworkers (TABLE 3). As in the case of cores, only the 71,012 pieces of debitage collected from students at the end of the course are used here for the beginners' sample, and several rock types have been combined into lithomechanically equivalent raw material categories. Flakes from all stages of reduction, regardless of technique, have been combined in Table 3.

In the samples from both groups, what is here referred to as limited information lithic fragments (LILFS) constituted a majority of the items collected (TABLE 3). This category includes longitudinal and medial flake fragments, and those pieces commonly classed as "non-diagnostic shatter" (Bucy 1974), or debris (Crabtree 1972). It may prove to be significant that beginners produced relatively more of these pieces, regardless of technique or raw material, than did more experienced workers. Personal observation suggests that this pattern results from the inability of a beginner to control fracture processes. Less experienced flintworkers frequently cannot judge the amount of force necessary to successfully detach a flake, and consequently they apply too much or too little force. Too little force ultimately results in multiple incipient fractures in the objective piece. This in turn results in the fragmentation of flakes when they are finally detached. When excessive force is applied, flakes are fragmented as a result of torsion fracture or are fractured in tension through contact with a stationary object.

When whole flakes and distal and proximal flake fragments are considered, it is clear that many patterns in attribute variation correspond to degree of expertise. As discussed with core data, both groups of flintworkers make errors during the reduction process. Experienced flintworkers less frequently produce flakes with hinge or step terminations, however. In addition, experienced flintworkers more frequently successfully correct their errors, as measured by "pick-up flakes" with feather terminations (Muto 1974). Less experienced flintworkers not only produce hinge and step terminations at a moderately higher rate, but more importantly, more frequently fail to successfully correct their errors.

Beginners fail relatively more frequently to prepare platforms regardless of reduction strategy employed, while more expert workers not only prepare platforms more systematically, but are also careful to remove overhang in blade and flake production.

Discussion

This study of the processes of learning indicates that patterned variation is identifiable which indicates the degree of skill of a flintworker. Because adeptness is generally a function of experience and frequency of participation, measurement of the level of proficiency can be used to infer the degree of production involvement found in a sample. Beginners are to some degree analogous to part-time workers. They do not have the manual control or range of knowledge of full-time workers. The relationship of beginners to more experienced workers may be comparable to generalized versus specialized workers.

The assumption that less specialized flintworkers err more frequently has been tested archaeologically in a comparison of Mesoamerican blade core debitage and Yokut biface debitage (Sheets 1978). Similarly, Muto (1974) has suggested that the type of error correction technique employed in a reduction strategy may vary individually, and the archaeological study of such might be used to infer centralized or generalized manufacturing.

Archaeologists have become increasingly concerned with identifying levels of specialization evidenced in artifact assemblages. Craft specialization is generally conceived as systematically related to the degree of systemic nucleation and centralization (White 1949; Trigger 1972; Von Betalanffy 1968; Plog and Bates 1980). Consequently, identification of specialization has been used to study the degree of organizational complexity in the population from which samples were drawn (Shelley 1983; Rice 1981; Evans 1973). A majority of the archaeological studies of specialization have attempted to elucidate the degree of production differentiation by reference to ethnographically recorded traits of specialists' products, or by variation in spatial patterning assumed to reflect specialized rather than generalized production organization.

The results presented here suggest that the products and by-products of learning and more skilled flintworkers exhibit realms of variation which reflect level of skill. If one is willing to accept the premise that technological expertise reflects occupational intensity then such measures may be used as a means of testing for the degree of specialization exhibited in a prehistoric sample. Even though it may be difficult to differentiate full-time specialists' products from part-time specialists' products in archaeological situations, the results presented here may be useful in differentiating between specialized and generalized lithic production systems (Adams 1970; Muller 1984, 1986; Seymore 1988). For those interested in the development of complex societies, elucidation of the degree of specialization has become increasingly important as a means of estimating the degree of systemic differentiation and nucleation in a prehistoric culture.

Recognition of the products of learning in a lithic sample can also help decrease the possibility of misinterpreting spurious attribute patterning. For example, a majority of the bifaces discarded by beginners fit morphologically into a pick category. They are bifacially worked, somewhat pointed, have a triangular cross-section, and are battered. If the speculation above, concerning where such processes take place, is correct, then discarded beginners' bifaces or morphological picks are to be expected in those situations where they are most frequently found in the archaeological literature, raw material acquisition sites (Holmes 1919; Womack 1976).

As with many other experimental results, those presented here represent an attempt to isolate one aspect of human behavior which contributes to the formation and patterning of the archaeological record. It is hoped that, through independent verification and further examination, the processes and products discussed here can be recognized archaeologically and used to examine variation in levels of skill.

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Phillip H. Shelley currently serves as Chair of the Department of Social and Behavioral Sciences and is Associate Professor of Anthropology at Eastern New Mexico University. He received his Ph.D. in Anthropology from Washington State University in 1983 and has concentrated his research on the prehistory, geoarchaeology, and lithic technology of the SW United States. His mailing address is Station 3, ENMU, Portales, NM 88130.

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