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Situated and distributed cognition in artifact negotiation and trade-specific skills: A cognitive ethnography of Kashmiri carpet weaving practice

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Abstract

This article describes various ways actors in Kashmiri carpet weaving practice deploy a range of artifacts, from symbolic, to material, to hybrid, in order to achieve diverse cognitive accomplishments in their particular task domains: information representation, inter and intra-domain communication, distribution of cognitive labor across people and time, coordination of team activities, and carrying of cultural heritage. In this repertoire, some artifacts position themselves as naïve tools in the actors' environment to the point of being ignored; however, their usage-in-context unfolds their cognitive involvement in the tasks. These usages-in-context are shown through artifact analysis of their *routine, improvised*, and *opportunistic* uses, where cognitive artifacts like *talim*—the central artifact of this practice—are shown to play not only multifunctional roles beyond representation, but are also complemented by *trade-specific skills* bearing strong cognitive implications in a task.

Keywords

artifact analysis, carpet designing, cognitive ethnography, Kashmiri carpet weaving, *talim*

The relationship between tools and cognition has traditionally been discussed in philosophy, anthropology, archaeology, neuroscience, psychology, and cognitive science spawning unsettled debates on various themes from artifact theorization and phenomenology of their use (philosophy), co-evolution of tools and mind (archaeology and anthropology),

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their neural representation (neuroscience), etc. Psychology and cognitive science accounts have primarily dwelt on mediational roles of tools and artifacts in cognition (Vygotsky, 1978), development of tool use (Kahrs & Lockman, 2014) and tool innovation (Beck, Apperly, Chappell, Guthrie, & Cutting, 2011) among children, artifacts' versus tools' representation (Dellantonio, Mulatti, & Job, 2013), categorization (Malt & Sloman, 2006), functional fixedness (German & Barrett, 2005), representational and cognitive functions of artifacts (Hutchins, 1995; Norman, 1991), taxonomy of cognitive artifacts (Heersmink, 2013), human vs. animal tool use (Vaesen, 2012), etc.

In this terrain, cultural-historical activity theory, inspired by Vygotsky (1978) and Leontiev (1972/1979), emphasized actor–artifact relations in human activity wherein artifacts act as indispensable mediators between subject and object. In activity analysis, Vygotskian *tool-mediation* is supplemented by Leontiev's "*technical division of labor*" (p. 60) which is enriched further by Engestrom's (1987, p. 63) collective activity system which includes tools, subject, object, rules, community, and division of labor. Overall, activity theory recognizes broader classes of psychological, material, and cultural tools as inseparable components of an activity. A related analysis is found in time-and-motion studies (Gilbreth, 1911),[1] but whereas they focus on physical aspects of a task (movements, durations, etc.), activity theory takes a specific human activity embedded in its social, historical, material, and cultural context as a unit of analysis (Engestrom, 1987).

Inspired by this, theories such as *situated* (Lave, 1988) and *distributed cognition* (Hutchins, 1995) try to reveal specific cognitive accomplishments embedded in these activities. *Situated cognition* shows how individuals engage with their tools and artifacts to bring about specific cognitive achievements in their routine task-contexts, whereas *distributed cognition* shows how artifacts feature in cognitive tasks undertaken by a network of actors with varied roles and expertise. For instance, situated cognition shows how participants engage with their environment to accomplish cognitive operations in a particular activity, e.g., mathematical operations while grocery shopping (Lave, Murtaugh, & de la Rocha, 1984), whereas distributed cognition shows how information propagates through actor–artifact networks in a task, e.g., information flow among crew members in ship navigation (Hutchins, 1995). Accordingly, the *situated–distributed* framework reveals the unfolding of cognitive phenomena embedded in typical activities of the participants, where artifact analysis is an analytic lens provided by the framework.

The artifact analysis focuses on cognitive engagement of people with their complex socio-technical environments in an ongoing activity by highlighting cognitive or epistemic roles played by *artifacts* in that activity. As such, it traces the routes of *information propagation* in a task (Hutchins, 1995), ways participants *coordinate* their activities in collaborative tasks (Suchman, 1997), how effective *communication* amongst them is engendered, etc. So far, it has revealed how: (a) physical artifacts, e.g., display-boards act as *memory* devices in air defense exercises (Boguslaw & Porter, 1962), the wheel acts as *memory* resource and *queuing* device for managing orders by cooks in a restaurant (Porter, 1987), a whiteboard serves as public *reminder* of daily activities in news production (Bellotti & Rogers, 1997), mariners use a compass to *predict* tides (Hutchins, 1995); (b) paper objects, e.g., medical records, besides being a *representation* of a patient's medical history, *encode temporal relations* in it, *create historicity*, and produce a "medical body" (Berg & Bowker, 1997), flight paper strips, with their rich visual cues and annotating affordances, enable constant *monitoring and updating of information* by ground staff at airports (Mackay, 1999), maps, charts, forms, and manuals, lined in their particular spatial arrangements, speed up *information retrieval* and facilitate *shared situated awareness* among pilots on the flight deck (Nomura, Hutchins, & Holder, 2006), clipboards enable *information transfer* under time pressure conditions in nurses' work, provide instant *access* to selective information, and act as a *plan* for patient care *coordination* (Gurses, Xiao, & Hu, 2009), a diary acts as a *reminder* of information and enables building *situation assessment* by personnel in rescue operations (Garbis & Waern, 1999); and (c) computing technologies *coordinate* activities of distributed ground staff at airports, making the operations room a center of coordination (Suchman, 1997), alarm screens *inform* about faulty circuits and enable workers to collaboratively *plan* new routes in a telecommunication center (Hindmarsh & Heath, 2000), etc.

A key concern in artifact analysis studies has been showing cognitive functions of different *artifact-kinds*: representational–non-representational, cognitive–non-cognitive, etc. Cognitive artifacts are held to perform largely representational functions (Norman, 1991, p. 25). Among these, representational artifacts like maps, checklists, displays, etc. have received the most attention (Hutchins, 1995; Norman, 1991) in contrast to cognitive functions performed by non-representational artifacts (Heersmink, 2013), natural objects (Hutchins, 1995), or by manipulating the task environment (Kirsh, 1995). The cognitive functions of the artifacts are held to be supervening on their "manipulable physical structures" as by manipulating those structures, "one automatically manipulates the information they contain" (Heersmink, 2013, p. 479). In this context, the cognitive import of particular ways of engaging with the artifacts, i.e., the trade-specific skills, is not discussed at length.

This article makes two points. First, there could be cognitive artifacts which, besides representation, perform cognitive functions like communication, learning, encoding of temporal actions and carriers of cultural heritage, where some of these functions do not supervene on their "manipulable physical structure" as these functions do not activate *until* cultural norms are taken into account. Second, there are culturally learned skill-behaviors which complement the use of an artifact and consequent cognitive performance in a task. To drive home these points, I discuss the *routine, improvised*, and *opportunistic* uses of seven artifacts used in Kashmiri carpet weaving and show how actors not only use artifacts to perform a plethora of functions (cognitive, non-cognitive), but also complement them with culturally learned skills, especially during contingencies.

To achieve this, the observation of participants' performances *in situ* is required. Cognitive Ethnography provides such a methodology. It is a field-based approach to study cognitive processes as they unfold in the situated actions of participants (Dubbels, 2011; Hutchins, 1995). It uncovers various ways cognition emerges from actors participating in their specific settings, in their particular roles and relationships, social institutions, hierarchies, languages, actor–artifact networks, etc. As such, it involves prolonged observation of participants in their natural settings, an analysis of tools and artifacts to gauge their cognitive contribution, an appreciation of their roles and relationships to assess the routes of information transmission among them, their sense-making practices, and so on. Artifact analysis has been carried out in navigation (Hutchins, 1995), healthcare units (Nemeth & Cook, 2013), and flight operations (Nomura et al., 2006), among others. There are hardly any cognitive studies on Kashmiri carpet weaving practice, except for Khan (1993), who has analyzed work organization in weaving.[2] The present study investigates situated and distributed cognitive processes in all constituent domains of this practice, namely designing, coding, and weaving.

Methodology

This paper has arisen from my larger study on situated and distributed cognitive processes in Kashmiri carpet weaving with special reference to how actors negotiate *talim*, the central artifact of this practice, in their different task domains. Towards that, a 14-month fieldwork was conducted in Srinagar, Kashmir during 2015–2016 (and was resumed in June, 2017). Methods used included *participant observation*, in which I learned to design, code, and weave from expert respondents; *video-recording* of constituent activities; *document analysis* of talims, graphs, etc.; and *semi* and *un-structured interactions* with the respondents, who include manual (M) and CAD designers (CD), talim writers (TW), talim trainers (TT), weavers (W), manufactures (M), and other stakeholders (OS). The interactions took place in Hindi, in which both respondents and researcher are fluent. Interactions were audio or video recorded wherever permitted, and fieldnotes were taken during and after interactions. In addition, video-recorded *think-aloud* sessions were conducted with coders to assess their coding strategies.

The Kashmiri carpet weaving practice

Kashmiri carpets are renowned for their design complexity, exquisite color schemes, and remarkable finish. Made of silk or wool, these are hand-knotted, pile carpets. While carpet weaving has been extant in India since 5th century BC (Goswami, 2009, p. 144), *pile* carpet weaving is believed to have been introduced here by Kashmiri ruler Zain-ul-Abidin, who brought artisans from Central Asia (Mathur, 2004, p. 18) in the 16th century.

The practice comprises three task domains, viz. designing, coding, and weaving. In the design phase, the designers (*naqash*) create designs either manually on graph paper, or digitally with CAD. Manual designing has been prevalent traditionally since it was first documented by Moorcroft and Trebeck (1841) and Leitner (1882) in shawl weaving and by Lawrence (1893) in carpet weaving, which shows the identical nature of design and production processes prevalent in both domains. In manual design, the designer, after drawing the designs, assigns the color scheme by writing color codes in the motifs on the graph. The coded graphs are then passed to the talim-writers (*talim-guru* or *talim-nawis*) who write those codes systematically, in symbolic script on long strips of paper, called *talim* (pronounced *taa'leem*). At times, a talim-copyist (*nakkal* or *nakal-nawis*) is employed to make its copies. This makes designing a distributed process among designers and coders: while the designer creates designs, the coder encodes them and makes the designs conveyable to weavers to whom these are passed. The weavers (*kaalbaaf*) decode the symbolic talim, interpret its instructions, and weave the same accordingly. In digital design, all these tasks, from design creation to coding, are carried out by the designers themselves who design and generate talims digitally, removing talim-writers and talim-copyists from the practice.

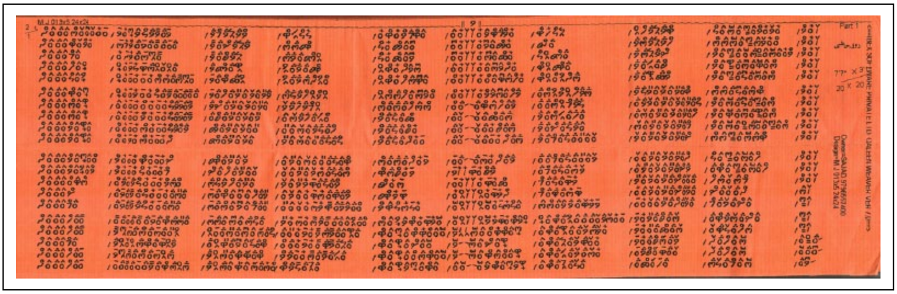

Figure 1. Talim roll. Courtesy, Sajad Nazir, Srinagar.

Artifact analysis

The artifact analysis uncovers the complex ways in which individuals perform cognitive operations in a task, the nature of constraints placed by their environments, and the resultant negotiated character of their artifacts. An analysis of such *in-situ* performances in Kashmiri carpet weaving reveals a variety of cognitive phenomena embedded in actors' routine engagement with their socio-technical surroundings. In this paper, I undertake an *artifact-centered* analysis, instead of a *domain-centered* analysis (the type of analysis usually found in literature which examines certain artifacts used in a particular task-domain, say, plotting charts in a navigation task; Hutchins, 1995). In contrast to domain-specific artifacts, there could be artifacts, as in this practice, which *travel* from one task domain to another and don different garbs for the actors during this journey. To reveal this negotiated character, an *artifact-centered* analysis which examines cognitive contributions of a particular artifact in its *routine, improvised*, and *opportunistic* uses irrespective of the task-domain, the nature of being complemented by trade-specific skills and how an activity unfolds, via these artifacts, over time is more suitable. I will first examine the talim, the central artifact of Kashmiri carpet weaving practice.

The Talim

The talim is a coded script, written on long strips of usually orange, rust, or brown colored paper. It is comprised of practice-specific symbols, in which the designs drawn by the designer are encoded systematically in rows and columns. One row in a talim roll is taken as one *instruction* pertaining to weaving of one row on the loom. As it may not be possible to represent the code for a large carpet on only one roll, the auxiliary rolls, called *parts*, are attached to the main roll, called the *page*, both of which are indicated in the margins of the rolls. For instance, 21/3 written in the margins of a roll means it is the 3rd part of page no. 21 in the talim set and is processed as such by the weavers: first the main page, followed by its parts sequentially (Figure 1).

The talim-roll in Figure 1 is numbered 2/1, and encodes *kuldar* (vertical-half) design of a carpet measuring 3.1 × 7.7 feet having knottage of 20 × 20, i.e., 400 knots per square inch (psi). This strip is 18 cm broad (vertical) and 61 cm long (horizontal). The weavers fold the roll from the middle such that only two blocks of the code (usually 10 lines) are visible at a time. The folded roll is then inserted in the warp threads of the loom. The talim serves a variety of cognitive functions in the practice, viz. (a) information repository, (b) computational support, (c) encoder of temporal actions, (d) communicative device, (e) distributor of cognitive labor, and (f) carrier of cultural heritage.

Information repository

The guiding logic of the talim is: *how many* knots of a particular *color* should a weaver weave so that the design emerges during weaving. Consequently, one unit of the talim comprises: *color code* positioned above or below the *number code*. As such, it acts as a information repository of breath-taking amount. To generate the talim, the coder transforms the visual design, drawn on graph paper, to its symbolic representation via codes written in the design. This compacts the design information related to motifs, their orientation, color schemes, etc., spread over a number of graphs into symbols organized in rows and columns on a paper roll which is then called *talim*. With talims, the weavers are saved from having to process millions of tiny cells in the graph. They process these talims as "text" by adopting different reading modalities. The systematic organization of information presented in them makes further cognitive operations like visual search, addition, and so on, possible in the code.

Computational support

As information repository, the talim provides immense computational support to the weavers. Without talim, weavers would be required to extract information from the graph itself, which is what happens in Ladakh (Saraf, 1990, p. 96). In Kashmiri carpet designing, a standard "inch-square" graph-sheet measures 22 × 17.5 inches where one inch-square comprises 400 cells, i.e., there is a total 154,000 cells in the sheet. If the design is spread over more than one graph, this total is further multiplied. From coded graphs, the weavers need to proceed as follows to extract the required information: (a) locate the cell in the graph wherefrom the design information needs to be picked, e.g., 20.188 (20th row, 188th column); (b) count all cells falling under that cell-color indicated by its code (e.g., green indicated as a "+" symbol); (c) continue counting till the last cell falling under green (say, up to 20.202); (d) get total number of cells with green (i.e., 14 green). The result of the cognitive operations is the action: obtain green colored yarn and weave 14 knots with it on the loom.

What trade-offs would be involved with this information extraction? Baber notes that "tools provide a set of constraints on task performance, both in terms of *definable outcome* [emphasis added] and also in terms of *structure of performance* [emphasis added]" (2003, p. 107). The choice of graph as representational medium puts processing constraints on the weavers. Step (a) requires the weaver to conduct a visual *search* in the graph, which contains millions of tiny cells. This places high cognitive costs on their working memory. Step (b) requires him to *count* those tiny cells, while *keeping location* intact in his memory. In a densely cluttered medium like a graph, the weaver is likely to lose either the count or the location of counting. The *locational recall* becomes more taxing when the weaver shifts attention from graph to loom for weaving and then back to the graph. Thus, error potential is extremely high. With complex designs and longer-sized carpets requiring a larger number of graphs, the time and effort to conduct these operations increases exponentially.

Hence, one immediately perceptible trade-off in using graphs for weaving is the *design complexity*. The more complex the design is, the more difficult it is to locate its information in the graph. Because of this, the designs in Ladakh and Amritsar traditions are far less complex compared to Kashmir. These traditions weave simple designs; for example, Amritsar weaves only "boxed" designs having repetitive motifs inside boxes which weavers often memorize. In contrast, when talim is employed it "transforms the task," to use Hutchins' phrase (1990, p. 205), and alters the way the weavers encounter the problem of information extraction. Instead of the cognitive operations outlined in steps (a) through (d) given earlier, the weaver's task with talim is: (a) locate the instruction in the row and the column (e.g., 4th row, 2nd column); (b) read and decode the instruction (e.g., 14+ as 14 green); and (c) perform action: obtain green colored yarn and weave 14 knots with it.

The weavers' cognitive operations are altered as well as reduced: *locate* the instruction and *read* it. The operations of *locating, counting*, and *totaling* are replaced with *locating* and *reading* as weavers are given the total number of cells, i.e., 14g at the outset in the talim, which preempts *counting*. Recall that one unit in the talim comprises the *number of knots* plus their *color*. All that the weaver now needs to do is *read off* this information after locating it in the code. Now, the *locating* operation is facilitated by the columnar structure of the talim. As Figure 1 shows, every column is divided into four blocks of five rows each, and is segregated from the other columns by a "/" (*alch*) in the end. During weaving, the weavers fold the roll from the middle which further reduces the searchable space, as only two blocks of 10 lines now exist in their visual field at any point of time. Thus, the structural organization of the code in row-columns and the physical action of folding the roll significantly shrinks the problem space for weavers. Courtesy of this page layout and the folding action, it becomes easier to *locate* the 4th row, 2nd column in the talim than to locate 20th row, 188th column in the graph which can neither be organized, nor acted upon.

Further, reading and decoding of the code happens simultaneously, which contains an interpretative component. In repetitive patterns, this interpretative component comes to force when the weaver reaches the middle portion on the loom from where he adopts a different reading modality on the same instruction to weave the repetition. The interpretation, however, does not change the *reading* character of processing: he still *reads* the instruction, albeit in a different modality of right-to-left. Hence, while processing graphs, major cognitive effort is spent on the *locating* operation; in talim, it is spent on the *reading* operation, irrespective of the design pattern.

Thus, the talim alters the way the weaver approaches the problem space, restructures the task, and facilitates diverse cognitive operations. For instance, it facilitates computing the total number of knots in a roll by allowing actors to multiply the columnar-row total (total number of knots in a column of a row) with number of columns, or in a carpet by multiplying roll knots-total (total number of knots in a roll) with number of pages in the set, etc. In addition, it allows for making a variety of inferences. First, it allows for inference about design element, e.g., the roll in Figure 1 mentions "daul hashiya" in the margins which indicates that this roll encodes the design of lower borders of the carpet.

Second, it allows for inference about design area, e.g., the roll mentions 20 × 20 knottage in the margin, i.e., 400 knots psi. As the columnar-row total in the roll is also 20, every column, in this roll, encodes design pertaining to one inch-square on the loom. Because the total number of columns is nine, except the last column indicating repetition, this roll represents nine inch-squares of design on the loom. Third, it allows for inference about design-type: The "~" and "|" signs at the end of the rows indicate a repetitive pattern and prompt the weavers to adopt different reading modality from that point onwards. Finally, it allows for inference about weaving: as there are 20 rows in this roll, it contains weaving instructions for 20 rows on the loom.

Encoder of temporal actions

The logic of talim addresses a weaving problem faced by the weavers, viz. which colored knots should be woven and in how many numbers to weave the design. To address this problem, the talim specifies the *number of knots* and *color* in the *same* manner, and thereby guides their weaving. For instance, if the weaver needs to weave 6 knots of green followed by 5 knots of blue, the information is represented as such in the talim as: 6g 5b. Thus, the talim encodes the temporal ordering of weaving. It *precomputes* (Norman, 1991), in advance, how many knots of which color need to be woven.

Communicative device

The talim acts as a communicative device in inter-domain (from coder to weaver) and intra-domain scenarios (among weavers themselves). In the former, instead of design representations like graphs or digital output, the talim communicates design information to weavers. It guides their weaving, but not as a plan which they follow letter by letter. It guides their weaving *only* in terms of *when particular colored knots should be woven and in how many numbers*, as besides this seemingly explicit instruction, the weavers also impose interpretative frameworks in the form of reading modalities on these instructions which are not part of the code itself—a fact noted by Khan (1993) as well. The imposition of these interpretative frameworks ensures extraction of different types of information from the code, which is required to weave different repetitive patterns.

Second, in the intra-domain scenario, multi-weaver settings are noteworthy in the sense that more than one weaver sits on the loom to weave the design. In such settings, some mechanism is required whereby information contained in a talim instruction is conveyed to the other weavers. The talim in such cases acts as a *text* which can be read aloud by one weaver while followed by other weavers, and allows them to work as a team.[3]

It is to be noted that the referents of talim symbols can always be altered, e.g., the designer or manufacturer may decide to use the "+" sign, which is normally used for green, for blue instead in the talim, such that wherever the weaver encounters "+" in the talim he uses blue thread during weaving. In such situations especially, the weavers follow the talim only as a guide and are not bound by it, as their weave actions, like human actions generally (Suchman, 2007), turn out to be more than merely following plans. Despite this, the talim is such an accurate device of design communication that 100%

accuracy from design coding to the final product off the loom is guaranteed. The inadvertent errors pertaining to miscoding of designs by the coders or inaccurate decoding by the weavers are external to the logic of the talim itself which guarantees precision in coding and decoding of designs even after decades.

Distribution of cognitive labor

The talim distributes the cognitive labor of design creation and communication among the designer-coder and among weavers in multi-weaver settings. In former scenario, the designer creates the design, and the coder encodes it and makes it communicable, thereby distributing the cognitive labor between them.[4] In the latter scenario, i.e. among weavers, the talim acts as a distributor of information extraction among the team of weavers in multi-weaver settings which emerge during weaving of longer-size carpets, e.g., 9 × 12 feet, where each weaver weaves a specific portion of a few feet on the loom. As mentioned earlier also, the code for such sizes is spread into a number of *parts* of the talim *page*. For instance, the roll no. 21 in Figure 1 has two parts that encode design pertaining to different portions on the loom, say 21/1 to x portion woven by weaver-1, 21/2 to y portion woven by weaver-2. They read aloud these rolls and are followed by weavers 3 and 4 respectively on adjacent portions. The cognitive labor involved in information extraction from code is thereby distributed among both weaver-1 and weaver-2, via these parts. No weaver has the sole responsibility of extracting *all* the information from *all* the rolls. Since each weaver is responsible for his particular portion on the loom, his responsibility is limited to extracting information from *that* roll catering to *that* portion only. The talim establishes this locus of responsibility through its different rolls, just as flight strips do in air traffic control (Mackay, 1999). It establishes roles and hierarchies in the *karkhana* (factory) as medical records establish roles in a medical practice (Berg & Bowker, 1997, pp. 526–527). This is because the reader-weavers are invariably held in higher esteem and given more privileges than listener-weavers in the *karkhana* and in the practice generally. Further, since the talim encodes weaving actions prior to the actual weaving, it is a form of "precomputation" (Norman, 1991, p. 21) which distributes the cognitive operation of encoding temporal actions across different time-scales, besides different actors. These time-scales may range from weeks, months, years, to even a century. When it is done across centuries, it acts as a repository of cultural heritage.

Carrier of cultural heritage

The talim acts as the interface of culture and cognition as culture-specific designs are encoded in practice-specific symbols. The practice uses its own numeration symbols, nomenclature, and reading terminologies unknown even to native Kashmiris. As the market has been traditionally competitive, the actors/*karkhanas* fiercely guard their designs and talims, which are passed on as family/*karkhana* heritage from one generation to another. Due to the high rate of accuracy in the coded information, the talim yields the same design even after a hundred years. This enables creation of replicas of antique carpets. With this, the talim acts as a carrier of cultural heritage, a creator of historicity, and a mechanism for the revival of cultural relics.

In light of the above functions, the talim can be seen as a cognitive artifact par excellence. It performs all functions required of a *cognitive artifact* (Norman, 1991): it distributes action across time (precomputation), across people (distributed cognition), and alters the task structure. Yet, it has functions beyond representation. As a hybrid of symbolic and material aspects, it *coordinates* the weaving activity of the weavers' team in multi-weaver settings and has a particular way of engaging with it. In this repertory, certain skills are deployed only in certain contingency situations, which we will see later in the paper. Heersmink (2013, p. 479) considers cognitive functions to be supervening on their informational structure which further supervenes on the manipulable physical structure of the artifacts. However, there could be some functions which activate outside this materiality. When cultural values are attached to talim, it acts as a carrier of cultural heritage which is different from merely distributing information over different time-scales. For something to be termed as a heritage, it needs appropriate cultural approval. The talims receive this approval, but other artifacts of the practice, for example, shade cards, do not, even if they are equally hybrid like the talim, play similar functions, and are preserved for long periods of time.

Shade card (*rang-ticket*)

The shade card (*rang-ticket*) is a physical structure and is constructed on a strip of paper. On this strip, the thread samples are fixed through two holes and their respective color-codes are written, above or below the base numeral, i.e., one.

The digital setting produces a digital shade card, i.e., a colored print-out of shades with their respective color codes. The rang-ticket plays a plethora of cognitive functions in the practice:

Communicative device

The rang-ticket acts as a communicative device in three scenarios: designer-to-manufacturer, manufacturer-to-dyer, and manufacturer-to-weaver. A carpet design may involve 12–35 colors, including different shades of the same color, which adds further complexity. As such, one color may require a larger quantity of yarn for weaving than the others. Hence, a manufacturer's problem is: *which shade* of yarn and in *what quantity* should be dyed? The rang-ticket facilitates this decision-making by communicating information about shades via *its actual sample* of threads to the manufacturer, while the quantity is conveyed usually verbally.

The manufacturer passes this rang-ticket to the dyer who must have precise information about shades, as careless replacement of one shade with another, e.g., scarlet red with crimson red, can wreak havoc in the design. The *actual sample* of the *thread* removes ambiguity about shades in this communication.

Finally, the rang-ticket and the dyed yarns are passed to the weavers. Here, it communicates (a) the *number* of colors and their shades used in the carpet and (b) the *codes* of those shades, as weavers will be working with talim which contains only coded representations of those colors. Though the colors have conventional codes, in certain contexts of design protection, the designers may assign a different code to a color, interchange color-codes, or change code-positioning for different shades of the same color. For instance, in Figure S1 (see Supplemental Material Online), yellow (*zard*, indicated by "w") is differentiated by assigning an inverted "w" in its other shade. This necessitates that the weaver has prior information regarding code-color association in order to decode them correctly during weaving.

Thus, the communicative purpose of the rang-ticket is contextual. It communicates different types of information to different actors: to the manufacturer, it informs about shades and number of color-yarns to be dyed (their quantity is explained verbally); to dyers, it conveys information regarding the shades to dye the yarn; and to weavers, it conveys information about constituent elements of yet another artifact, i.e., the talim, to establish code-color association. As these actors could be temporally as well geographically separated, the significance of the rang-ticket's ability to correctly convey this information increases.

Stable representation

The rang-ticket acts as an active and stable representation in a weaver's environment. The carpets usually have a long gestation period, from 6 months to 2 years or more, depending on the size and number of weavers employed.[5] The larger the size and the lesser the number of weavers employed, the more time it takes to weave a carpet. In such cases, if a particular yarn gets exhausted, it becomes a herculean task to dye the *same shade*. The rang-ticket then acts as a stable representation of shades being used in weaving and can be consulted any time as a reference frame. As a tangible artifact, it exists in public space and can be shared with other stakeholders, such as designers and dyers.

Pedagogical role

The rang-ticket acts as a bridge between past abstract processing (the coding) and the future materiality, i.e., the actual weaving with the yarn; and between the abstract representation of symbolic talim and its material referent, i.e., the color threads. Because of this, it acts as a learning device when it is used to teach code-color associations to novices.

The rang-ticket is, thus, a socially constructed artifact imparting different information to different actors and is accordingly negotiated by the actors. Like talim, it is a hybrid cognitive artifact: it is symbolic and material, and thereby facilitates communication in specific contexts, yet it is seldom treated as a cultural artifact.

We now come to the most tool-saturated environment of the practice, the weavers' environment, and examine cognitive roles played by key artifacts within it.

Weaver's environment

In a small *karkhana* (factory) at Srinagar where I worked as a learner-cum-observer, four weavers worked on a loom, while four other weavers worked on an adjacent loom. Besides recording their real-time weaving daily, I would learn and weave on the same loom. The methodology was: the weavers would weave on their loom while I would set my camera on one side, sit beside them, observe their weaving and take notes on what they were doing which included specifics of talim reading, their weaving actions corresponding to the reading, etc., and ask questions, if any, when the talim was *not* being read on the loom, i.e., when they would fill knots they had left during talim-reading. Thus, they would keep weaving throughout this period while I would observe, take notes, and ask questions. In their off-duty hours, I would practice weaving on the same loom under the instruction of the *vasta* (Head) and two other weavers. At times, I also used two cameras to capture weaving from both ends of the loom. Informal interactions during breaks would also be audio/video recorded, wherever possible, along with note-taking.

The weavers' environment primarily exists around their upright wooden loom where they sit on a wooden board (*pa'ttar*) placed on the floor. The loom consists of two wooden rollers (*vaan-koot*), at bottom and at top, between which warp threads (whose number depends on the carpet-size) are fixed. On these warp threads, the weavers weave knots (*fiyoor*) with short threads called weft threads. The loom is invariably placed near a window such that the weaver's back is to that window. This spatial arrangement facilitates adequate ventilation in the room and allows light to fall on the warp from behind the weavers' back. The loom has a long rope (*tujras*) bound, end to end, on its upper roller, on which small yarn-balls (*rang-fuch*), weighing around 10 grams each, lay suspended. The weavers pull down threads from these balls, clip short strands, and weave knots below. When a ball is exhausted, it is replenished from a yarn box kept beside the loom or from some other repository outside the loom environment. The talim roll is inserted in the warp threads of the loom (see Figure S2 in Supplemental Material Online).

The weavers read instructions from these rolls, decode, and weave the same. Their weaving activity proceeds as follows: (a) read instruction from talim, (b) get thread of a particular shade conveyed by talim, (c) weave knots with that thread on the weaving area on the loom, and (d) read instruction again.

In this sequence of steps, the tools and artifacts required by weavers are: *talim, yarn*, and *clipped threads* for weaving the knot. All these are placed in the weavers' environment in such a manner that none of these interferes with their principal activity of weaving. We look at the first step and its corresponding artifact, talim. The talim acts as a principle cognitive resource for weavers which they consult for: (a) information extraction (reading instruction for weaving) and (b) evaluation (comparing instruction with what has been woven).

Information extraction. Since weavers' weaving is guided by talim, it needs to be in their constant visual access. To facilitate this, they insert talim rolls in warp-threads of the loom *at their eye level* (Figure S2 in Supplemental Material Online) which facilitates uninterrupted and easy reading of the code. Further, as they must weave simultaneously with information extraction, they need to switch their attention from code to the *weaving-area*, i.e., that portion on the warp-threads where weaving of the current row is underway (Figure S2). The roll-placement at gaze-level facilitates gaze-travel from code to the weaving area below and divides their attentional resources equally between code reading and weaving. A deviation in roll positioning, above or below the gaze level, can interrupt either the spontaneous flow of reading or the weaving below. The shifting gaze of the weaver from talim to weaving is thus not a random perceptual act, but is situated within the overall activity of weaving, and makes coordination between code and its material realization in the form of weaving possible. Seeing is a situated activity

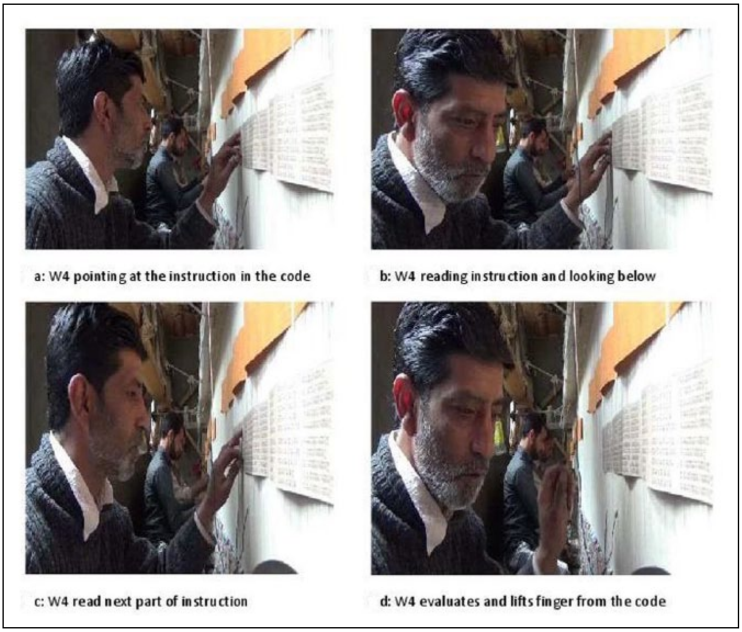

Figure 2. Evaluation being done by W4

(Goodwin & Goodwin, 1996) informed by the task relevancy in the local environment suffused with tools and equipment. In these warp threads, the main *page* of the talim is inserted first, followed by sequential insertion of its auxiliary *parts*. This arrangement establishes a linear order of processing on rolls and puts them in shared access of other weavers. On my primary observational loom in the *karkhana*, while the main *page* and a small portion of *part*-1 fixed in the corner is read aloud by weaver-1 (W1) which is listened and followed by weaver-4, its part-2 and 3 fixed in the middle is read aloud by weaver-2 (W2) sitting beside W1 and is followed by weaver-3 in the middle. The roll placement on the loom accords with the weavers' seating arrangement and distributes the cognitive task of information extraction among both reader-weavers, i.e., W1 and W2 equally.

Evaluation. Besides reading, the weavers were found to consult the talim for evaluation purposes. For instance, consider the following fragment:

Fragment 1. Here, weaver-4 (W4), who followed W1's reading of part-1 and had a photocopy of the main *page* with him, had just finished weaving a line from the roll. However, upon finishing the row, he doubted if he wove correctly (see Figure 2a–d). At 6.27, in the recorded observation file, W4 pointed, with his index finger, to that particular instruction in the talim (see Figure 2a).

6.27: A cursory glance at the talim roll, in Figure 1, shows the homogenous nature of code with all symbols looking alike. Consequently, W4 needs some mechanism to locate a particular instruction during his search. He uses his embodied resources for this *locating* and *identification*. With his index finger, he locates the instruction in the code. The finger-pointing pulls the object of interest out of the homogenous background to his attention and makes it available for further processing.

6.30: Once that instruction is located, W4 reads the information embedded in it and looks below, at the weaving area, to compare it with what he has just woven (Figure 2b).

Notice that his pointing finger remains at the instruction during comparison. The visual homogeneity of the code is a potential source of distraction and his finger ensures that he does not lose his identified location during the cognitive activity of *comparing*, which has necessitated shifting his gaze off the code to the weaving-area below. Hand-positioning near stimuli affects visual processing as objects in "perihand space" receive attentional priority as compared to objects placed elsewhere (Reed, Betz, Garza, & Roberts, 2010) and thereby allows more items to be retained in one's visual short term memory (Tseng & Bridegman, 2011). By keeping his finger at the identified location, W4 uses it as a *memory cue* to facilitate locational recall later.

6.32: After evaluation, W4 shifts his gaze above, slightly traces his finger farther, and reads the next part of the instruction (Figure 2c).

6.34: After reading information off that part, he shifts his gaze down again to evaluate his weaving (Figure 2d).

After this second evaluation, he removes his fingers from the code and starts weaving below that which he had suspended during evaluation.

In the span of a few seconds (6.27–6.33), thus, W4 performs a variety of cognitive tasks: *perceiving* the code, *locating* and *identifying* the instruction, *reading* and *decoding* information from it, *comparing* the decoded information with the woven knots below, *evaluating* the correctness of the comparison, and locating and identifying the second part of instruction and all other operations in the same sequence. All these cognitive achievements have become possible due to immense computational support provided by W4's environment among which, foremost, is providing the talim's continuous access in warp threads which invalidates at the outset building any prior representation of the environment in the weavers' minds. The code is *always there* to be consulted and its *uninterrupted availability* and its particular *positioning* in the loom environment make it a handy artifact that can be accessed anytime for any genre of cognitive processing. The weaver's use of his embodied resources, i.e., index finger as a search device, further contributes to this processing.

Now, the second step of the weaving process requires accessing yarn of a particular color for weaving the knot. Minute observation of this step revealed the cognitive significance of another seemingly naïve artifact in the weavers' environment, i.e., *tujras* or the yarn rope.

Yarn rope (tujras)

During weaving, a recurring problem that weavers face is to choose yarn of the appropriate color upon encountering the instruction. If a design involves, say 25 colors, the weaver's problem is *how* and *where* to keep this baffling variety of yarn-balls so as to keep them handy when needed, but without having them interfere with weaving when not required. For instance, if the talim instruction reads: 2b 5y 3g 5r, the weaver must have blue, yellow, and green balls, but since he has encountered red for the first time and may not encounter it again in the next few rows perhaps, he needs red yarn nonetheless, but not so near that it interferes with his picking of the other yarns.

To address this problem, the weavers use a yarn-ball rope (*tujras*) and bind it, end to end, on the upper roller (*vaan-koot*) of the loom and suspend small yarns-balls, weighing around 10 grams each, of all the colors used in the design as per the rang-ticket (Figure S3 in Supplemental Material Online).

The loose ends of these balls droop down to the weaver's reach below. This ensures that the balls always remain within the weaver's visual field via these loose ends without interfering with their weaving. As they encounter color after color in the talim, they need to rapidly switch from one yarn to the other. Instead of looking above at the balls time and again to identify and pick the appropriate ball, they identify the required thread via its loose end, grab it, clip a short strand from it, and weave the knot below on the weaving area. This spatial arrangement of balls and their loose ends thereby *simplifies* their perception and *sorts out* the shades and their eventual *choice* by the weavers. Keeping these balls otherwise in a basket, etc., would have added complexity to the weaver's environment: they would need to first *locate* and *identify* the required ball among bundles of other balls and then disentangle their threads to pick the appropriate one. Having them tidily dangling on the rope above ensures that the threads of two balls do not intermingle and the weaver's precious time is not wasted in *sorting* them out. The yarn rope, thus, serves as a time-saving heuristic and eases the load off the weaver's working memory as they need not *remember* which yarn-ball is placed where, which would be required *if* these were lying casually in bunches around them. The weaver's memory is thereby offloaded to the environment courtesy of this arrangement.

It may not be out of place here to report an interesting, alternative arrangement carried out by a household weaver, outside this karkhana, whom I had the opportunity to visit during my fieldwork. On that loom, it was observed that the weaver had bound the more frequently used balls, pertaining to the principal colors of the carpet, in the center of the rope and pushed the less frequently used ones, pertaining to least used colors, to either end. This arrangement encoded information about "most-used" and "least-used" colors of the design and established *categories* of "most" and "least" in the middle and periphery of the rope respectively. The cognitive process of *categorization*, thus, can be achieved through manipulation of the environment and is clearly embedded in the situated practice of this actor. The weaver need not reason about these facts abstractly in her mind as she enacts her reasoning via this arrangement of balls. People are known to exploit resources of their environment to enact situated reasoning in their day to day contexts (Lave, 1988).

It is to be noted that the yarn rope is a regular feature of the loom environment in the practice and as such, can be seen as a "*long-term* informational structuring" of the environment (Kirsh, 1995) which is why, as Kirsh (2008) stresses, "history matters" (p. 58) and should be known in the activities of a community of practice.

As per the third step of the weaving process, the weavers must clip the thread off the yarn-ball and weave a knot on the weaving area. In this context, small dangling threads on the weaving area reveal their significance (see Figure S4 in Supplemental Material Online).

When weavers clip threads off the loose ends of yarn-balls above, they generally clip long strands. While they use some portion for immediate weaving, the rest is left dangling on the weaving area itself. When they encounter the same colors again in the talim, they first visit these dangling portions to get the required thread. If thread is available, it is clipped short from there and is woven into the knots. If not, only then does the weaver visit the yarn balls above via their loose ends and clip long threads again. These dangling threads, thus, act as *handy repositories* which save time and effort in repeatedly accessing the yarn balls. Without them, weavers would have had to access the yarn-balls above at every point in the instruction. However, the simple act of *leaving some portion* of threads on the weaving area *saves time* and *effort* associated with accessing the balls above, thereby displaying "cultivated opportunism" (Kirsh, 1995, p. 48), which involves leaving items in the workplace that may come in handy later on.

The rotating rod (pech-lur)

The row that weavers are *currently* weaving is defined as *weaving-area* here. The height of the weaving-area, from the floor below, is usually around three feet. From the point where the lower roller of the loom starts, almost two feet of woven carpet called the *woven portion*, is visible at the weaving-area (Figure S4 in Supplemental Material Online). As mentioned before, the weaving-area coincides with the weaver's hand-positioning in their normal sitting position. If this area becomes higher or lower, the weaver would need to put more cognitive effort into shifting their gaze from the talim to the weaving-area below and more physical effort in straining their hands, above or below the weaving-area, for weaving. The hand-positioning during an activity, thus, has systematic effects on regulating perception and manipulation of the environment. This "reachability" is a measurable entity through which perception is calibrated and consequently can be effected through tool-use (Brockmole, Davoli, Abrams, & Witt, 2013, p. 39). As weaving proceeds, day after day, the woven-portion increases on the loom, resulting in an elevation of the weaving area above the weaver's reach. The elevation problem increases weavers' cognitive and physical efforts during weaving. To solve it, they need a mechanism to keep the weaving area within reach.

For this, they use a tool in their loom environment to check the elevation of the weaving-area periodically, say after every 10–12 days. The upper and lower rollers of the loom have a heavy iron chain fixed between them in the corner. The weavers insert a small rod, called *pech-lur*, into this chain and rotate it repeatedly. This rolls the lower roller, simultaneously rolling the *woven portion* over it, which brings the *weaving area* down. They keep rolling the lower roller till the weaving area is sufficiently within reach. This simple action thus reduces their subsequent cognitive effort which would have ensued with a higher weaving area.

Loom markers

After weaving the row, weavers close it by passing first a thick cotton thread (*yath-paud*) and then a sewing thread (*aum-paud*) between the warp threads from end to end on the loom and forcibly thump these threads down repeatedly with an iron-fork (*panja).* The thumping action ensures that these binding threads do not come out of their position, thus sealing the row completely and making the weaving area ready for the next row.

However, there is a catch. If the thumping is carried out with extreme force, it may press the weaving area too deep, resulting in a reduction of the carpet height, say a few inches less than the required 12 feet on the loom. Now, since weavers are guided by talim during weaving, it means that the complete carpet should be woven by the time the talim-set finishes, i.e., a complete 12 feet. But, as we have seen, extreme thumping may reduce the height the carpet is supposed to reach in the end.

To avoid this, the weavers bring on board specific trade-specific skills which they learn and inherit from their weaving tradition. These skills ensure that they complete the carpet as they reach the last roll in the talim set. This skill-set involves a number of cognitive strategies having significant implications: (a) loom marking, (b) comparing loom markers vis-à-vis the talim set, and (c) employing corrective measures in case discrepancies are found.

Loom marking. The weavers do a periodic assessment of the carpet's height on the warp-threads by marking indicators at various points on these threads. This assessment is usually done by taking the central design-element, i.e., the *chaand*, as reference on the already woven portion, and measuring it against the point, which the complete *chaand* should reach on the warp threads. The reference point is marked with a pen (Point A) and from A onwards, the required height of the carpet is indicated by the second mark (Point B). This Point B *indicates* completion of carpet on the loom and accordingly that the talim-set should be able to guide weaving until reaching this point. The weavers, in this setting, use a pen and measuring tape to carry out this assessment (Figure 3).

The cognitive tasks involved in this loom-marking activity are *measurement, comparison*, and *evaluation* and are carried out via improvised uses of artifacts like measuring tape and markers which are not specific to the practice, but are deployed when required.

Comparing loom markers vis-à-vis the talim-set. The weavers keep comparing these markers vis-a-vis the talim-set to ensure that the required carpet height is achieved by the time the talim-set finishes. The *visible markers* ensure that the comparison between required height and remaining rolls is not misguided, which could occur in the absence of these markers or inadvertently by an actor. Their public visibility ensures that the comparison can be evaluated by other weavers as well.

Use of corrective measures. However, what if a gap is encountered, such as asymmetry between the remaining rolls which should guide weaving until point B, i.e., the completion point of the ordered size? For completion, sufficient rolls should be available in the set to guide weaving till point B, but asymmetry indicates that fewer rolls than necessary remain in the set vis-à-vis the remaining height. It is not because the complete set was not generated, but the physical action of thumping had reduced the carpet height, while rolls pertaining to those rows have already been used. Thus, while the entire set is being woven, *the required height of the carpet is not coming out on the loom as it should have* due to severe thumping of the rows-space by the iron fork during binding. This leads to

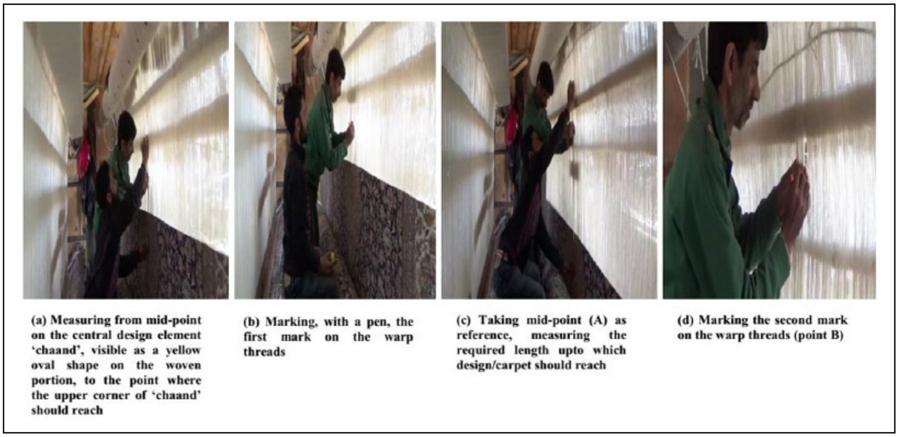

Figure 3. Measurement being done on the loom.

exhaustion of rolls in the set, but checks the progress of height on the loom. For instance, if one talim roll guides weaving activity of one-inch and there are 30 remaining rolls in the set, i.e., for guiding weaving of 30 inches or two-and-a-half feet, but the weavers' evaluation shows the required height of three feet till point B, then a discrepancy of half an inch, due to the thumping action, occurs. The remaining 30 rolls can only guide the weaving of two-and-a-half feet, but in order to complete the required 12 feet, three feet must be woven. This is the gap which the weavers now must fill.

In order to do so, the weavers may employ any or all of these three corrective strategies. First, they can weave rows on their own without being guided by the talim. Since self-guided weaving may beget errors in design, the best strategy is to weave the *same* row as the preceding one on the weaving area, so that same design as in the preceding row is woven. This weaving of parallel rows (*paras-vaar*), on the one hand, physically fills the gap pertaining to a row and on the other, avoids design distortion. To employ this strategy, the weavers, after every 10–12 rows, may weave a parallel row. Second, they can use a thicker sewing thread (*aum-paud*) to physically reduce the gap. Third, they can stamp the iron-fork lightly so that the density of binding threads remains the same and physically fills the inches.

These are trade-specific skills that weavers learn through their tradition. An artifact has particular ways of engaging with it which supplements its particular functions. The above-mentioned skills and behaviors are the most invisible component of their numerous cognitive achievements during weaving. The cognitive activities of *loom-marking, constant evaluation*, and *compensatory skill behaviors* complement their central artifact, i.e., the talim, demonstrating that an artifact alone is not a guarantee of the completion of a task, be it cognitive or non-cognitive, unless it is put into situated uses by the participants. The talim would have been a guarantee if it alone was sufficient to lead the weaving to its logical end, but as we have seen, the weavers' own actions may create dents in their weaving which they then compensate for by their own actions. Thus, culturally learned, trade-specific skills enhance an artifact use. Because of this, the talim is *not a* *plan* of precise actions or a literal "program," which Khan (1993) maintains it to be: "The script is a set of instructions which can quite *literally* [emphasis added] be followed in a manner very similar to a *program* [emphasis added] or a routine that a computer might follow" (p. 48). As such, the weavers are not *machines* carrying out this program, as the situation in which they are embedded changes moment-by-moment due to their own weaving actions. To adjust with the changing situation, they may manipulate or even bypass the talim. The eventual design creation on the loom is thus a complex cognitive achievement which weavers bring about by (a) performing seemingly naive physical actions with significant cognitive consequences, e.g., thumping heavily leading to reduction in the height of the carpet, or using a thicker thread to *reduce* the gap (*gap-reduction*) or (b) deploying a range of artifacts during weaving: from *symbolic* talim, *interpretative* frameworks under which instructions are decoded, *linguistic mediation* in reading aloud, to material tools.

As we have seen, some of these are not even regular artifacts in their environment like the measuring tape, but are incorporated, on the fly, into the activity from outside the setting. Further, these are only "one possible component of situated cognitive systems" (Heersmink, 2013, p. 468), like the above, and are supplemented by particular skills of engaging with them. We come now to opportunistic uses of artifacts in this practice.

Artifact plasticity in different task-domains

Besides computational support, artifact analysis discloses opportunistic uses of tools and artifacts by actors. To use a tool for the purpose other than that for which it is designed can be seen as artifact plasticity. A tool or an artifact is plastic in nature, vulnerable to the context of use, and intentional stance of the user. The designers in the practice were found to construct equipment on the fly to meet contingencies of their context.

Tracing equipment

During one of the design observations, a manual designer, D7, was observed to construct tracing equipment on the spot. Having found tracing paper alone insufficient for his purposes, he put two small tables on the floor with a gap between them. He then placed a glass sheet over the gap and put a flashlight beneath it and switched it on. Having done this, he spread the tracing paper and the graph on the glass sheet, while the light shooting from below the glass illuminated the graph and its drawing. D7 then traced the design over the graph. In another such instance, D1 used the natural light coming from a window as a reflector, spread graph over the window such that the design drawn on it got illumined by the sunlight coming from outside, and then showed the tracing procedure on that graph.

All these are improvised uses of tools such as tables, glass sheets, a flashlight, and a window. None of these is originally meant to work as a reflector, but when used and negotiated as per the context, either as a standalone artifact (window) or in a joint construction (table, glass sheet, and a flashlight), these enable the cognitive task of design creation via tracing. Designers often use a window as a reflector in this practice as a corrective measure when no tracing equipment or electric power is available. The skillful uses of these artifacts show the situated nature of their design activities and negotiated character of these artifacts. Not only do they create equipment on the fly (tracing equipment), but also deploy natural resources (sunlight) for the cognitive task of designing. Such situated improvisations (Goodwin, 1997) were found to be done by coders also in the practice.

Wooden blocks

To understand the coding strategies, video-recorded *think aloud* sessions were conducted with the coders. During one such session, a coder, TW6, was found to use small wooden blocks and rubber while writing codes from the graph. The post-session interaction with TW6 revealed the cognitive import of using these items. A graph has a strong visual clutter with the design spread in millions of tiny cells and codes written inside the motifs. The coders calculate each cell falling under a particular code in the graph, and write them systematically on paper strips. The immensity of information present in these cells is a potential source of error: the coders may easily mistake a row or a column from which they are calculating or mistake one grid for the other when their gaze travels to the strip for writing codes and back to the graph, etc. To avoid this, TW6 *created boundaries* around the grid by placing a wooden block and rubber around it, which segregated the current grid from the adjacent ones and cognitively fixed the grid under processing. After writing codes, when his gaze travels back to the graph, the wooden block ensures that his gaze does not slip outside this boundary. It serves as a mechanism of *locational recall* by ensuring that TW6 correctly identifies the location of the current grid amid this clutter. Likewise, the rubber placed below the grid creates the lower boundary.[6] An artifact can, thus, be made to serve a variety of functions, cognitive or non-cognitive, which depends not only on the context of their deployment, but also on the intention of the user. A summary of artifacts used in the practice is provided in Table 1.

Conclusion

This paper has discussed the ways actors in Kashmiri carpet weaving deploy a range of artifacts, from symbolic to material, to undertake diverse cognitive actions. Besides using hybrid artifacts like the talim and the shade card, they use seemingly naïve artifacts but with strong cognitive implications (yarn rope), construct artifacts on the fly (tracing equipment), and even deploy natural resources (sunlight) to carry out their tasks. The opportunistic uses and "situated improvisations" (Goodwin, 1997, p. 123) carried out by actors give these artifacts a "negotiated" (Wenger, 1998, p. 288ff.) character during which artifacts are made to don multifunctional garbs, e.g., an artifact (wooden blocks) performing the cognitive function of *locational recall* and an artifact (window) performing the non-cognitive function of reflection, though both were not originally intended for these purposes. In this repertory, the overtly representational artifacts such as the talim and shade cards serve different functions to different actors, from being an information repository and computational support, distributor of cognitive labor across people and time, to being the carrier of cultural heritage. This last function becomes possible due to the activation of appropriate cultural norms, showing that all functions of a cognitive

Table 1. Summary of artifacts used in weaving.

Artifact	Nature	Uses	Functions
1. Talim	Hybrid (representational)	Routine	Information repository Computational support Encoder of temporal actions Communicative device Distributor of cognitive labor Carrier of cultural heritage
2. Shade card	Hybrid (representational)	Routine	Communicative device Stable representation Learning device
3. Yarn rope	Material (non-rep.)	Routine	Simplification of perception Sorting Choice Memory offloading
4. Rotating rod	Material (non-rep.)	Routine	Maintaining reachability
5. Loom markers	Symbolic (representational)	Opportunistic/ Improvised	Height indicators
6. Tracing equipment	Material (non-rep.)	Opportunistic / Improvised	Tracing
7. Wooden blocks	Material (non-rep.)	Improvised	Locational recall Boundary marking

artifact do not supervene on their informational-material structure alone. Besides this, the artifact-uses are enriched by the trade-specific skills of the actors which bear strong cognitive implications, but which are learned by the actors through their tradition.

The theoretical lenses of *situated* and *distributed* cognition (Hutchins, 1995, 2006; Lave, 1988; Suchman, 2007) and the methodological tools provided by *cognitive ethnography* (Dubbels, 2011; Hutchins, 1995; Williams, 2006) have been immensely helpful in unearthing these actor–artifact relationships in the practice. In light of these relationships, situated and distributed cognition emerge as two ways of looking at cognition—the complex ways it is embedded in the situated practices of the participants, how it is distributed among participants, their artifacts and sociocultural settings that give varied weights to their roles, hierarchies, and expertise-levels. For instance, though the extraction of design information is distributed over actor–artifact network, i.e., the talim and the team of weavers, but how this information is to be put to use in weaving the design crucially depends on their situated skills, which they have learnt through their tradition—for example, the corrective skills used to detect and remove discrepancies in the talim vis-à-vis weaving. Lave (1988) clarified this relation long ago as '"cognition' observed in everyday practice, which is distributed—stretched over, not divided among—mind, body, activity, and culturally organized settings (including other actors)" (p.1). This is also what Hutchins (2006) has to say about *distributed cognition*: "From a cultural point of view, cognition is distributed through time, between person and a culturally constructed environment, and among persons in socially organized settings" (p. 377). The two approaches are thus not exclusive, but complementary. The analysis of various artifacts in their *routine, improvised*, and *opportunistic* uses, as has been done in this paper, underscores this complementarity by showing, on the one hand, the negotiated character of the artifacts, and on the other, complex actor–artifact relationships engendering this negotiation in the situated practices of the participants.

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Notes

1. I am thankful to the anonymous reviewer for pointing this out to me.
2. Harris (1991, 1997, 2000) is notable for talim usage in Kashmiri shawl weaving.
3. The linguistic mediation in multi-weaver settings is reserved for a separate paper.
4. This distribution prevails only in manual settings, as in digital settings, the designer herself generates the talim.
5. Very small sizes like 2×3 may take only a month. I consider here the average period of average carpet sizes which are usually longer ones.
6. The analysis of these sessions is reserved for a separate paper.

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