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ORIGINAL ARTICLE

Cognitive bearing of techno-advances in Kashmiri carpet designing

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Abstract The design process in Kashmiri carpet weaving is a distributed process encompassing a number of actors and artifacts. These include a designer called *naqash* who creates the design on graphs, and a coder called *talim-guru* who encodes that design in a specific notation called *talim* which is deciphered and interpreted by the weavers to weave the design. The technological interventions over the years have influenced these artifacts considerably and triggered major changes in the practice, from heralding profound cognitive accomplishments in manually driven design process causing major alterations in the overall structure of the practice. The recent intervention is by the digital technology: on the one hand, it has brought precision and speedy processing in the design process, and on the other, it has eliminated some of the crucial actors from the practice. This paper, which forms part of a larger study on the situated and distributed cognitive process in Kashmiri carpet-weaving practice, describes the technological makeover of the design artifacts involved in this practice over the years and their resultant cognitive impact on the design process as well as on the practice.

Keywords Talim · Kashmiri carpet weaving · Carpet designing · Graphs · Notational system

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1 Introduction

The theoretical potency of a paradigm lies in its ability to explain the underlying phenomena through the canons laid down by it. The major paradigms of cognitive science have proven themselves robust enough in this context and have demonstrated their mettle by explaining constituent cognitive processes, be it memory, reasoning, perception or design process. The classical cognitivist paradigm located cognition inside the head and conceived it to be manipulation of representations, a sort of a problem solving in the mind of the conceiver. In design cognition, the design process is defined as a rational problem solving whereby designers search for a suitable solution to their well-defined design problems Simon (1969), for instance, in domains like architecture (Eastman 1969), engineering design (Eistentraut 1997) and product development (Badke-Schaub and Frankenberger 2004).

The embodied-embedded approaches, inspired from phenomenologists like Heidegger (1962) and Merleau-Ponty (1962), in the 1980s challenged this information-processing paradigm and argued that cognition is inseparable from the embodied and situated practices of the individuals in their particular task domains, their socio-technical environs, their tools, artifacts, their roles and hierarchies, all of which have been shaped by historico-cultural forces over the ages (Varela et al. 1991; Kirshner and Whitson 1997). The cognition is held to be *situated* in these practices and *distributed* over actors and artifacts, for instance, the mathematical operations undertaken in real-world settings like grocery shopping (Lave 1988), navigation activity achieved through seamless coordination of people and their artifacts (Hutchins and Palen 1995), information processing through spatial arrangement of tools (Kirsh 1995), meaning construction through gesture and speech in an airline cockpit (Hutchins and Palen 1997), assessment of color categories in a laboratory setting (Goodwin 1997), etc. The design researches too underwent a sea-change and conceived design activity as a designer's reflective conversation with the materials of her situation (Schon 1983), for instance, an architect's conversation with her situation (Schon 1992), or a blacksmith's reflection on materials conditions of his work as well as normative criteria laid down by his esthetic preferences, as he designs and produces a skimmer handle (Keller and Keller 1993), or participants engagement with design materials in a co-designing scenario (Eriksen 2009). For a deeper comparison between information processing and situated cognition paradigms in design cognition, see Dorst and Dijkhuis J (1995)

While the role of design artifacts has attracted widespread research visibility (Roth 1996; Bertelsen 2000; Goldschmidt and Porter 2004), the role of technological interventions *over longer timescales* leading to design artifact's improvisation and the resultant cognitive impact on the design process in a particular practice has been less addressed. Bucciarelli (1988: 168) argues that, 'Artifacts are constituents of design, but like the dictates of a written constitution, they symbolize agreements, are capstones of social exchange and negotiation. Often, in process, they require a fresh reading and a new interpretation' and this relation between 'design knowledge and the artifact,' as per the author, can be provided by ethnographic enquiries.

This paper discusses the developmental trajectory of the principle design artifacts in Kashmiri carpet-weaving practice through the lens of technological interventions over the years and examines the cognitive bearing of these evolving artifacts on the design process as well as on the overall practice. The term 'design artifact' refers to the two artifacts, namely the graph and the talim used in this practice that play primarily representational role in its design process. While the graph depicts a visual design to be woven, the talim encodes that design in practice-specific symbols which are eventually decoded and woven by the weavers. In performing these activities of depiction and encoding, these artifacts act as the repositories of information, communicative devices and a collective heritage. The talim is widely held to be trade secret of the community and has always been fiercely guarded by the owners. In addition to these roles, it will be shown how these artifacts, especially the talim, also act as 'cognitive artifacts' (Norman 1991; Heersmink 2013). This is because besides representing information, these artifacts also allow sophisticated computations via themselves which leads to generation of novel information.

The paper forms part of a larger study on the situated and distributed cognitive processes in Kashmiri carpet-weaving practice, and as such positions itself in *situated and distributed cognition* paradigm. The study investigates first, the *situatedness* of the design process, i.e., the socio-technical and politico-cultural milieu which has shaped the practice, its actors and artifacts, heralding various cognitive accomplishments in its task domains, and consequently, influencing the actors, their roles, relationships, and statuses within the practice; second, it investigates the particular ways in which the cognitive processes involved in the three constituent task domains of this practice, namely designing, coding and weaving are *distributed* across actors and artifacts, language, environment, hierarchies and work organization.

To investigate these issues, the methodology of *cognitive ethnography* has been adopted which allows studying cognition as unfolding in the natural settings of the actors and examines how cognition is shaped by their situated practices, their tools, structures of work organization, linguistic frameworks and so on (Williams 2006; Dubbels 2011). The design cognition research is no exception to currently trending methodology in cognitive science. While ethnographic accounts on the sociality of design process in engineering design (Bucciarelli 1988), systems design (Hughes et al. 1994) are available since long, cognitive ethnography has been successfully applied in studying specific design activities, like *design reuse* (Ball and Ormerod 2000).

2 The Kashmiri carpets

The Kashmiri carpets are renowned over the world for their exquisite designs, elegant color schemes and remarkable finesse in their quality. These carpets are of mostly silk or wool and are hand-knotted, *pile* carpets—a technique which is said to be first introduced in India in sixteenth century by Zain-ul-Abidin, the ruler of Kashmir who brought artisans from Central Asia (Mathur 2004: 18), possibly Samarkand (Gravis 1954: 133; Saraf 1987: 89), even though the usual carpet weaving was extant in India since 5th BC (Goswami 2009: 144).[1] A particular feature of Kashmiri carpet weaving is the usage of a code system in it which runs like a thread in its constituent task domains, that is, from the design process to the eventual weaving. This notational-cum-cryptographic system is called *talim* (pronounced *taa'leem*) which encrypts the visual design in symbols and is deciphered and interpreted by the weavers to weave the design. Though, the talim-system is said to have originally employed in *kani* shawls and later got adapted to carpet weaving (Sajnani 2001: 161), Harris (2001) takes talim to be a 'Kashmiri innovation' and argues that talim might not have been practiced in Persia and as per one version, it was "invented" in

[1] See also Gans-Reudin (1984: 14, 31) and Goswami (2009: 146). For a concise history of carpet manufacturing, see Goswami (2009) and Roy (2004).

eighteenth century by a certain Phorma Kasaba (Harris 2003).[2] While Roy (2004: 226-27) considers talim to be of Kashmiri origin but having 'distant relation in Central Asia' Thompson (2003), while comparing Indian talim-style carpet weaving with Persian cartoon-style carpet weaving, does not trace any link between the two. In any case, the Kashmiri hand-knotted carpet-weaving practice traces its lineage to Persia which continues to render creative inspiration to the artisans.

At present, besides Kashmir, the talim-system is held to be used in carpet weaving in Punjab where it started due to migration of drought-affected Kashmiri artisans in the late nineteenth century (Leitner 1882: xxv; Dewan 2013: 312). The earliest, but brief, record of talim and the design process comes from Moorcroft (1841: 179–180), described in detail later by Leitner (1882) in the context of shawl weaving, and by Lawrence (1895: 377) in the context of carpet weaving. A comparison of their accounts reveals the identical nature of the design process, in terms of actors and artifacts, in both shawl and carpet-weaving domains. While historico-sociological profile of Kashmiri carpets and their position among Indian (Mathur 2004; Gans-Reudin 1984) and oriental carpets (Ford 1981) is adequately documented, almost nothing is known about the cognitive processes involved in their creation. An exception is Khan (1993) who has done cognitive analysis of weaving activity in this practice. Our work investigates panoply of situated and distributed cognitive processes in all the constituent domains of this practice that is, the design process, the code writing and the weaving and seeks to understand the code's negotiation at each juncture.

The present paper describes the developmental trajectory of the principal design artifacts, i.e., the graph and the talim, used in this practice over the years. The way this trajectory has been shaped by technological innovations has its impact on the design process as well as on the structure of the overall practice. Within this trajectory, some of the cognitive bearings of these techno-advances are discussed.

3 Methodology

The findings reported in this paper have arisen out of my ethnographic fieldwork conducted in Srinagar, Kashmir in 2015 (May–November) and in 2016 (ongoing since April). It is a qualitative study which includes *participant observation* involving the learning of designing, coding and weaving from the expert respondents, *video recording* of constituent activities, *document analysis* and *semi- and unstructured interactions* with the community. The interactions are audio or video recorded, wherever permitted, and are supplemented with substantive fieldnotes maintained during and afterward. The respondents include manual designers (D), CAD designers (CD), talim-writers (TW), talim-trainers (TT), weavers (W), manufacturers (M) and other stakeholders (OS) and are represented sequentially like D1, TW1 alongside fieldnote entries as FN and transcripts as TN in the paper. Though, the manual designers nowadays also do the dual job of talim-writing, they are categorized as manual designers only as their primary job is to create designs. Besides a few respondents working in government setups, a majority of them work in private factories and as freelancers. A fair balance of gender-ratio is found in the practice with females equally working as the designers, talim-writers and the weavers.

4 The design process

I first describe a generalized picture of *manually conducted* design process which is prevalent traditionally since Moorcroft (1841). The design process in Kashmiri carpet-weaving practice is a distributed process involving number of actors and artifacts, which have varied over the time due to changes in the nature of technology used. The arrangement of actors is hierarchical.

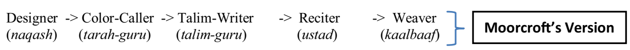
The first actor in the process is the designer *(naqash)* who creates the designs by hand on paper. Earlier, the designs used to be drawn with pencil and a grid would be drawn over the design later. The cells in the grid represented number of knots to be woven on the carpet. After completing the drawing, the *naqash* would put color codes in pencil-drawn motifs. The coded graph would be then handed over to the talim-writer *(talim-guru)* who would calculate or *pick* those color codes, and write them, along with number of knots that particular color needed to be woven, in symbols on a paper roll. The talim-writer required to do intensive calculation to work out the eventual representation. This coded script is called *talim* whose one unit constitutes *number of knots* plus *color* information. Thus, for instance, 4G 3B in a talim-roll may mean 4 knots of green and 3 knots of blue to be woven. At times, the color scheme for the black-and-white design drawn on the graph paper was decided by a different actor, a color caller called *tarah-guru*. Once complete talim has been generated from the graph, a copying person, called talim-copyist *(nakkaal),*[3] would be

[2] Harris (1991, 1997, 2000, 2001, 2003, 2007) is a good source for discussion of talim-usage in Kashmiri shawl-weaving from weaver's perspective. Though, both shawl and carpet-weaving use identical talims, their usage styles differ. I restrict to carpet-weaving practice in my work.

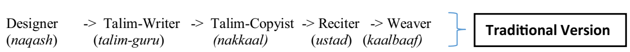
[3] There is no consensus on the term for 'talim-copyist' in local jargon as community knows them as copyist or copier only. A few elderly respondents recall these actors being referred as *nakkaal* or *nakal-karanvol* in olden times.

employed, who would make copies of the talim. This would be required if the same design needed to be woven on more than one looms. Since without coded script, the design cannot be directly woven from the graphs, this encoding is taken here to be part of the design process.

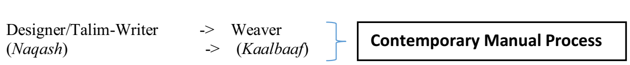
The talim would eventually be passed to the weaver who would either read the code herself, or listened to it being recited by an *ustad* or a trainer, in case she could not read. Thus, the workflow among different actors as described by Moorcroft (1841, vol. 2: 179–180), is from



This arrangement of actors is altered by the time of Leitner (1882) and Lawrence (1895) when talim-copyists are inducted into the process, but color caller is dropped, such that the designer herself takes over the role of the color caller, and the workflow now goes via copyists to the reciter and the weaver:



This traditional work version is still extant today with the exception that no talim-copyists are used, though *there are* professional talim-copyists at a few places. Today, this work version includes highly expert manual designers who create the designs on graph papers and generate the talim as well, either again manually or from computers by scanning the manually drawn graphs in the system. These manual designers usually also do the work of talim-writers; thus, rather it must be so as per one of my respondents, but vice versa may neither be required nor be the case. The contemporary role of *ustad* has changed from being an instructor relaying instructions to roomful of looms, to a fellow weaver on the same loom, who reads aloud the talim in a specific terminology in particular design types. Thus, the workflow in contemporary manual process proceeds as:



The design process culminates at the talim-writing stage and constitute of two cognitive activities: the designing and the coding. The latter has been included in the design process because by undertaking symbolic conversion, the coding makes the graph-based design interpretable and weavable by the weavers. With the sort of design complexity found in Kashmiri carpets, it is virtually impossible for weavers to extract the required information straight from the graph as found in other carpet traditions of India, for instance, in Ladakh (Saraf 1990: 97), where design is woven directly from the graph, but where, the design complexity is apparently far less than their Kashmiri counterparts which makes their information extraction from graph possible. The designing is, thus, a highly *situated* activity: it is amenable to local influences and goals of the designer. The more complex the design is in terms of its constituent motifs, their arrangements, the nature of repetitions, as is found in Kashmiri carpets, the more crucial it is to devise a precise mechanism of information transmission to the weavers. This mechanism in our case is the talim.

Further, as the description of the practice given before reveals, the design process is *distributed* over a number of actors, namely the designer, the talim-writer, the talim-copyists and their particular artifacts, viz. the graphs and the talim. The design complexity itself is a reason for this distribution.

The design activity is, thus, not a search-based problem solving carried out by the designer solely in her head, as cognitivist paradigm in design cognition research had it. The design activity is shaped by the goals, the requirements and the local environment of the designer. The design is rather an, ‘emergent’ phenomenon as, ‘in design, the solution and the problem develop together’ (Cross 1998: 29). In our case, we have seen it in the form of talim, which has been devised as a solution to the problem of transmitting complex designs with precision. This fact could be brought to light only by adopting a situated perspective to cognition and design. Such a perspective, in Kirsh’s (2009: 265) words, sheds light on ‘those aspects of problem solving that reveal how much the machinery of inference, computation and representation is embedded in the social, cultural and material aspects of situations.’

The second work model found in the practice nowadays is the digital version, discussed in detail later.

I, now, describe the developmental trajectory of the principle design artifacts used in this practice taking Leitner’s description, being the oldest as well as detailed, as reference point for the traditional design process. The design artifacts, namely the graph and the talim, have continuously evolved since then. Having attained technological sophistication over the years, these have not only impacted the design process by introducing various cognitive accomplishments in it, but have also altered the structure of the practice as well.

5 Design artifact-1: graph

In manual designing, the design is first drawn on a graph with pencil and color codes are written in the motifs with pen later on. The design is spread over a number of graphs which are calculated in accordance with the measurement of the carpet plus the type of design to be woven. For instance, if a 4 × 6 ($b \times l$) feet carpet is to be woven with a *kashyan* design, in which mirror image of one quarter repeats in the other quarters, and the design pertaining to only one quarter is drawn on the graph. This reduces the graphical representation to 2 × 3 feet. With further calculation of knots per square inch (*psi*), the exact number of graphs required to represent this sort of design is calculated. Since a standard inch-square graph sheet is of 17.5 × 22 inches, more than one graph will be required to create our example design. These graphs can be spread next to each other on the floor to have a holistic view of the design.

In 1882, Leitner reports drawing of the designs on 'paper' in shawl-design process. From that 'plan' (design/*naksha*), the head of the workshop 'estimates' the number of knots required for the warp threads which are laid accordingly on the loom (p. xxvi).[4] The 'plan' exactly matches the warp structure in terms of length and breadth and is also fixed, beneath the warp structure,[5] so that the weaver may see it while weaving. Through this drawing fixed beneath the warp, the 'head' estimates the number of knots required in particular color and recites the same, which the other weavers follow and weave accordingly on their looms. A 'clerk' jots down the instructions being relayed by the 'head' in the 'shawl-alphabet' called *talim*. The 'plan' of the shawl from the talim can be re-produced again anytime later. The workflow as per this description is:

Designer -> Head/Reciter -> Talim-Writer -> Weaver[6]
(*Tarah-saz*) (*Ustad*) (*talim-nawis*)

The designers seem working out here a *physical grid* as the plan paper, laid and visible beneath the vertical warp threads, exactly match their length and breadth. This juxtaposition might have allowed the counting actor to estimate *how many warp threads fall in a particular motif and color* drawn on the paper. This is my conjecture that by working out a physical grid like this *only* that they were able to determine the knot count, which is why, talim-nawis notes the same, *after* the knots have been estimated and relayed aloud by the Head. This also explains her arrival after the reciter in the workflow. There is no other way that the exact knots count could be determined. Keeping in mind the dexterity with which the same design could be woven again from the talim years later, some precise representation would have been required. The Leitner's design description and the workflow emerging from it discloses the nature of the graphical representation worked out *before* paper-based representations arrived on the scene.

At the onset of the developmental trajectory of this design artifact; thus, the graphical representation used to be *physically devised* by the actors right on the loom. It is speculated to have increased the cognitive workload of the concerned actors as they needed to draw the designs, work out the grid and make the drawing computation ready as well. This requirement would have certainly ceased with the emergence of *paper-based grids*. My elderly respondents, while describing the design process during the earliest times of their career, reminisced about drawing the designs first on a plain paper and then manually drawing the grid over it. This hand-drawn grid represented 5 × 5 knot structure in a cell, but these twenty-five knots were *not* explicitly represented in the cell. Because of this, the number of knots would be still calculated on 'shumar' or guess work. This was cognitively arduous as the coder needed to guess number of cells falling within a motif which, at times, caused calculation errors.

It is during 1950s that the designers started using printed grid or graph paper called *alchay-graph.* This alchay-graph, too however, did not separately represent 5 × 5 = 25 knots/cell in the cell block, which again required the coders to calculate the number of knots on *shumar*. At this stage, we can discern the printing technology started making its impact on the design process by offering a preprinted grid to the designer, but cognitive load is still enormous.

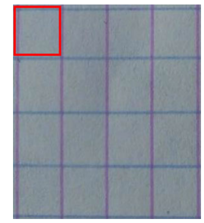
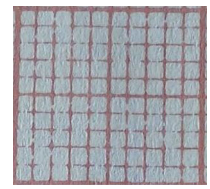
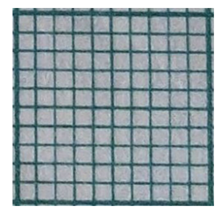
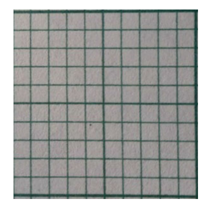
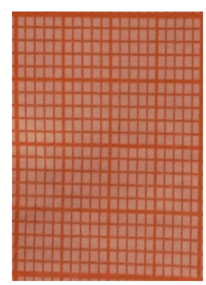
By 1970s, the advent of centimeter-graph in the market heralded cognitive ease in the process, as the cell block now gave clear representation of number of knots/cells in it. A cm-graph represents 100 knots/cells in one cm-square block, where every single cell is clearly discernible inside the cell block. The recent innovation in this trajectory is the 'inch-square graph' which most precisely represents the number of knots *per square inch* (*psi*). In this graph, the grid structure is composed of internal grid blocks of 25 × 25 cells giving a total of 400 knots psi. This is the most perfect graphical representation of carpet's knot structure devised so far, since one column in talim, with a columnar-row total of 20 knots, exactly matches this 400 knots structure, which further corresponds to the base 20 × 20 knottage in the practice. One-inch square column

[4] Warp threads are vertically fixed on the loom and weft-threads are those with which knots are tied on these threads. As such, weft-threads run horizontally, left to right and vice versa, on the loom. One knot is a cross-tie of vertical and horizontal threads, and consequently, can be represented in a grid-like structure.

[5] In shawl-weaving, the loom is positioned horizontally as if going from the lap of the weaver to beyond, because of which the graph can be placed beneath the warp threads, while in carpet-weaving, the loom is vertically positioned and warp threads are fixed like drapes.

[6] A clear difference between Leitner's description of design process vis-à-vis traditional version can be discerned: while tarah-guru is skipped, the role and arrangement of other actors is altered. The coding is done by the 'head of the manufactory' instead of a talim-writer, who recites the instructions by 'estimating' them from the plan *directly* laid beneath the warp threads, which talim-nawis listens and writes down.

Table 1 Developmental trajectory of graphs over the years

Year (Apprx.)	Graph	Features	Use	Snapshot
1950s	Alchay-graph	Imprecise, no internal grid in the cell, 1 unit cell shown as red box = 5 × 5 = 25 knots/cells which are not visible within the cell block; calculation of knots inside the cell block based on guess work. Printed version started in 1950s. Before that, it was drawn by hand after designer has completed the drawing	Not in use	
1970s	Sava-cm (One and a quarter cm)	One and a quarter cm, internal grid visible: 1 cm-square block = 4 sub-blocks of 5 × 5 grid = i.e., 25 × 4 = 100 knots per cm-square block. A little bigger than the usual cm so as to make the knots clearly visible	Rarely used	
1970s	Centimeter-graph or cm-graph	Internal grid in cell block visible: 1 cm-square = 4 blocks of 5 × 5 grid. That is, 25 × 4 = 100 knots per cm-square	Used at times	
1980s	Inch graph	Internal grid visible. 1 inch-square block = 4 sub-blocks of 5 × 5 grid = 25 × 4 = 100 knots per inch-square	Not in use	
1990s	Inch-square graph	Precise, internal grid structure in a cell visible: 16 blocks per square inch with 5 × 5 = 25 knots per sub-block. That is, 400 knots per square inch. Exact representation of the carpet with 20 × 20 = 400 knots per inch-square	Most widely used	

on this graph = one column in talim = 400 knots, represented as 20 knots/cells per row.

The table below summarizes the arrival of different graphs on the carpet-designing scene over the years. The table reflects the general consensus extracted from the recollections of my respondents, except minor differences. The names of the graphs are the way these are referred to by the community. The progression is neither linear nor mutually exclusive as different graphical representations, at times, co-existed with others and their usage more or large depended on the choice of the designer (Table 1).

The standard inch-square graph sheet is of 17.5 × 22 inches and is used only in carpet designing. Besides these commonly used representations, there is also mention of specific 16 × 16, 18 × 18 and 10 × 10 graphs by my respondents which are not used anymore. Currently, only inch-square and cm-graphs are used in manual designing, and very rarely, the *sava*-cm graph.

The above table reveals how printing brought increasing technological sophistication in the development of graphs and as a result, brought greater cognitive efficiency in the design process, viz.: First, the printing intervention let the designer get rid of drawing manual grid after creating the design. The designer is left to work on the creative aspect of designing only. Second, while *alchay*-graph, whether hand-drawn or printed after 1950s involved guess work in calculating the knots, the later graphs showed the internal grid structure in the cell blocks. This enabled visual distinctness of cells inside the block, and consequently, made the calculation of knot cells easier and brought precision in the coding. The construction of talim from such a graphical representation now precluded error-prone estimation and could be meticulous.

Insofar as the second artifact, i.e., the talim, is concerned, its printed appearance had to await the emergence of digital technology in the practice. Since talim is a symbolic artifact, its developmental trajectory is traced with respect to its structural features as well as its materiality, both of which have evolved over the years.

6 Design artifact-2: talim

The talim is a notational-cum-cryptographic system which has been devised specifically to encode the visual design in symbols. These symbols are of two types: symbols representing the number of knots to be woven in an inch, referred here as *number symbols*, and symbols indicating colors in which those knots should be woven, called *color symbols,* which are positioned above or below the number symbols.

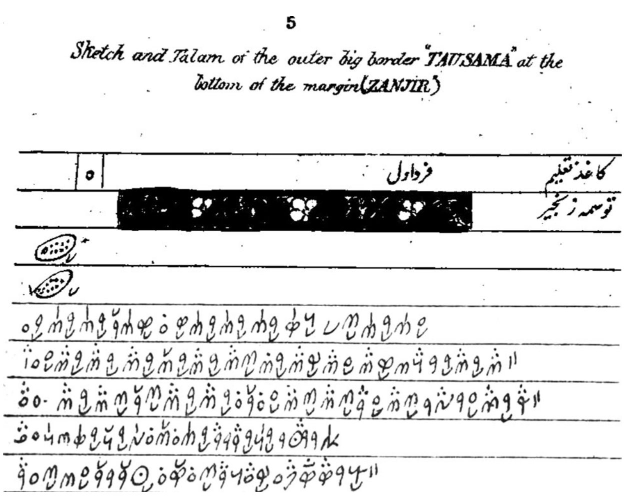


Fig. 1 Shawl-talim by Leitner (1882)

The oldest record that we have of talim, as noted earlier, is Leitner (1882) who presented two varieties of talims in his report: The *first* is a 4-page shawl-talim representing borders of a shawl (p. 5). The *second* is a 4-row specimen of a carpet-talim given in the Appendix (p. 18). The construction of both the talims is identical as can be seen from these snapshots (Figs. 1, 2):

An analysis of the above reveals functional and anatomical equivalence between carpet and shawl talims, together referred to as Leitner's talim in this paper, except a few colors which are referred differently in the carpet-talim, which Leitner duly notes in the Appendix (p. 18).

The talim, currently being used, is in vogue since the earliest times of my respondents' career (i.e., around 1950s) and since there are not any other intermediary versions available in the literature from 1882 to 1950, Harris (1997) has compared different shawl-talims. the same can contrasted directly with the Leitner's talim. First the structural elements: the symbols used for number and color representations in contemporary talim are tabulated below (Tables 2, 3):

The circle for representing numerals beyond ten and its multiples is slightly elongated and tilted sideways. For pedagogical purposes, however, simple circle can also be used. A typical contemporary talim-roll looks like follows (Fig. 3):

This talim page represents Kashyan design of a carpet measuring, 36 × 60 inches, i.e., 3 × 5 feet ($b \times l$) with 24 × 24 knottage, i.e., 576 knots psi. This particular paper roll occurs at Page No. 15, Part 1 of the talim-set of this design. The structural features of a typical talim, as above, are as follows:

- The talim-script is generally written/printed on orange, rust or brown colored long paper rolls. The code is divided into rows and columns and is folded in the middle, i.e., after two blocks of the columns. This folding facilitates the insertion of the fragile paper roll in the warp threads of the loom. Further, each column is divided into 4 blocks of

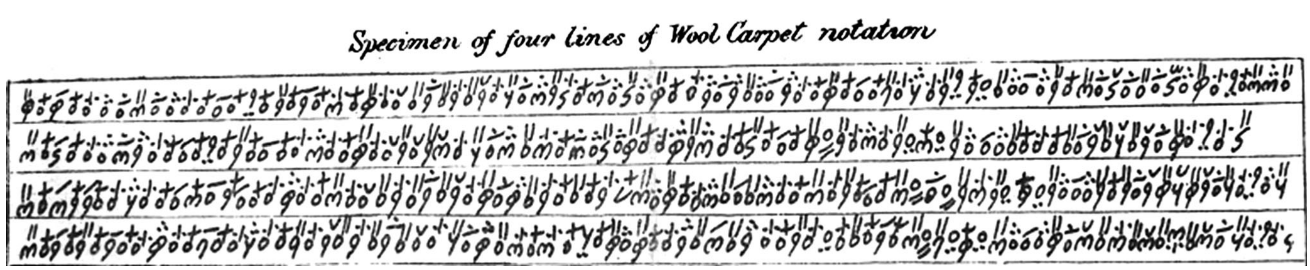


Fig. 2 Carpet-talim by Leitner (1882)

Table 2 Number symbols

Numeral	Symbol
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Table 3 Symbols of representative colors

Color (English)	Color (in Talim Lexicon)	Symbol	Position [above/below the number symbol]
Black	Cheen		Above
White	Danti		Above
Yellow	Zard		Above
Light Yellow	Makai		Above
Blue	Parozi		Below
Sky Blue	Malie		Above
Green	Sabz		Above
Bottle Green	Zangary		Below
Light Pink	Badami		Above
Dark Pink	Gulabi		Above
Red	Anari		Above
Golden Brown	Dalcheen		Above
Dark Brown	Doday		Above
Gray	Rackh		Above

5 rows each, which makes 20 rows per column. One column, thus, comprising of four blocks, represents one-inch square on the 'inch-square graph sheet.

- The total number of knots represented in each row of a column, called *columnar-row total*, is generally 20. It is irrespective of the knottage of the carpet. Thus, a carpet knottage of 24 × 24 or 16 × 16 psi can also be represented in a columnar-row total of 20 knots. In this sense, 20 × 20, either on graph or as a columnar-row total in the code, is just a representation which can denote any measurement. To achieve this, the designer needs to calculate the number of graphs required to draw the design with that particular measurement, knottage and its corresponding representation in the type of graph, before creating the design. With this calculation, rather, the work of the designer starts. The coder, likewise, can generate a talim of any columnar-row total from the graph, for instance, generating a talim of 16 knots per columnar-row from an inch-square graph, in which one block is a representation of 20 × 20 knots per columnar-row. Since, 20 × 20 is the most widely used knottage in carpet design, the talim with 20 knots per columnar-row is the most widely used talim, both are called *base knottage* and *base columnar-row* in the paper.
- A plenty of useful computations can be made on the talim-roll itself. For instance, calculating the total number of knots in a column (*column-total*), e.g., 20 knots in a columnar-row × 20 rows per column gives a total of 400 knots per column; calculating total number of knots in one entire row in the roll (*row-count)*: columnar-row total x number of columns; or calculating total number of knots in the entire roll (*roll-count*) which can be worked out by multiplying the total knots per column with the total number of columns in the roll. In our roll, Part-1 has 10 columns. With 400 knots per column, this roll is a representation of 400 × 10 columns = 4000 knots. The talim acts as a cognitive artifact, par excellence, in this sense (Hutchins and Palen 1995; Norman 1991)
- The color symbols in the talim are written either above or below the number symbol, which is usually convention based. In this extract of the first column of the talim-roll, the color symbols can be seen positioned above the number symbols (Fig. 4).
- Every column in the talim ends with a slash, '/,' called '*alch,*' which indicates the completion of the columnar-row. In Roman and English alphabet symbols, the above extract means (Fig. 5).
  Where b = black, lb = light brown, w = white, y = yellow and sb = sky blue. Note that, the total of every row in the column is twenty. The color progression, from one row to the other below, can be noticed. This particular extract is of border design in the carpet.

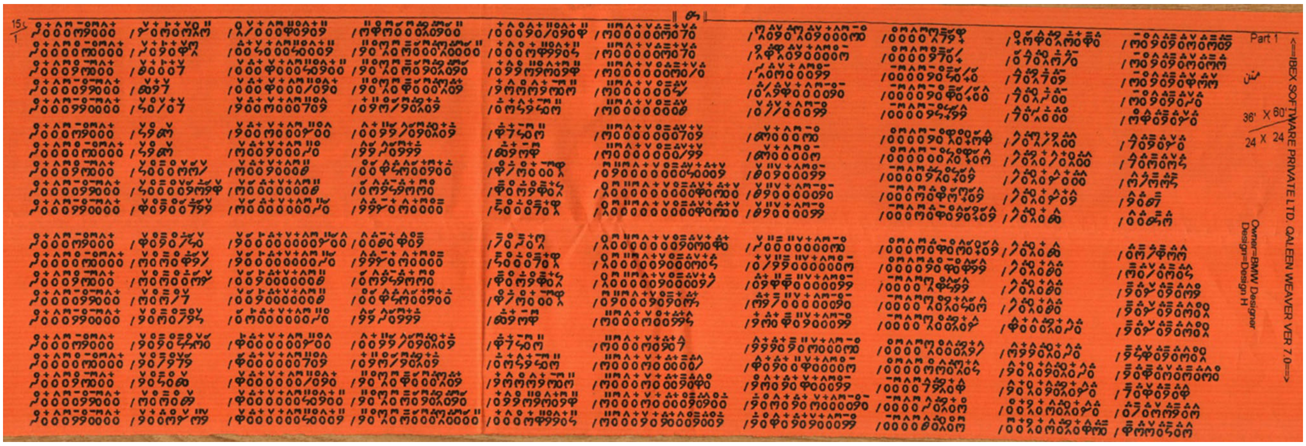


Fig. 3 A contemporary talim-roll. Courtesy: BMW Designers, Srinagar

- The specifications of the carpet, i.e., its measurement, knottage, design type etc., are given in the right margin of the roll. The page and part number of the roll, if that roll is divided into more than one parts, is indicated in the left margin. These details may also include the designer's or the talim-writer's name and the details of the software plus its version if talim has been generated digitally.

Let us now compare the contemporary talim with the oldest version. Both, the contemporary and the Leitner's talim, possess identical compositional structure, i.e., the color symbols positioned above or below the number symbols. Despite this prominent, but sole similarity, the Leitner's talim differs from the contemporary talim in respect of:

- *The differences in number symbols* During Leitner's time, the symbols used for 6, 8 and 9 were , and , respectively (p. 2), whereas, nowadays the symbols used for these numerals are: 6 = , 8 = and 9 = . Further, for representing multiples of 10, the number of dots would be likewise multiplied within the circle earlier, e.g., to represent 10, one dot inside the circle would be used; for 20, two dots; for 30, three dots etc. In the shawl-talim excerpt given before, we can see the very first line of the code starting with 8 dots and a small circle for the symbol of 1, inside a bigger circle with color code positioned below. This comes to a representation of 81 knots.

The contemporary talim does away with representing numerals usually beyond 20 or 24 because of their columnar structure. Consequently, one can represent only 20 knots for example, in a columnar-row. In the case of representing knots of same color beyond 20, the figure is distributed among subsequent columns, not exceeding twenty in each columnar-row again, e.g., the 81 knots of black will be represented as:

The number codes have, thus, clearly evolved over the years since Leitner's time,[7] not to mention here color code of below those 81-knots, representing *zangari* or bottle green color, for which a '+' sign is used nowadays.

One thing that deserves mention here is Leitner's description of the codes in "outside notation" form given in Appendix (p. 15) at the end of his report. In this chart, the number 8 is represented by which somewhat resembles current numeral system. However, the number 11 is again represented as for which the contemporary versions will use . Strangely, in his specimen of carpet-talim, Leitner uses to represent 11 which, too, diverges from the contemporary version, as well as his own

[7] The IICT Report (2009: 30) shows a talim numeral-table up to 100 which uses a novel style of representing numbers beyond 20. Instead of using number of dots to represent multiples of 10, the number-code of that numeral is used inside the tilted-circle instead of dots. For instance, Leitner would use, three dots and the unit-numeral to represent 32 (or as per "outside notation" (p.15) form), this report uses code of three for three dots and unit-numeral outside the tilted-circle like this for 32. Evidently, this is cognitively more efficient system, yet, this is **not used** in actual talim-writing which requires distribution of knots in 20–24 knots per columnar-row only. One exception: the same report shows for 9 which resembles Leitner's version. In digital setting, nowadays, is used; hence I used this symbol in my numeral-table. In manual setting, a talim-writer may also use for 9 depending on her choice.

Fig. 4 Extract of the first column

9b 1lb 1w 1y 3sb 2b 1y 1w 1lb /
9b 1lb 1w 1y 1b 3sb 1b 1y 1w 1br /
9b 1lb 1w 1y 2b 3sb 1y 1w 1g /
9b 1lb 1w 1y 1sb 2b 2sb 1y 1w 1lb /
9b 1lb 1w 1y 2sb 2b 1sb 1y 1w 1lb /

9b 1lb 1w 1y 3sb 2b 1y 1w 1lb /
9b 1lb 1w 1y 1b 3sb 1b 1y 1w 1lb /
9b 1lb 1w 1y 2b 3sb 1y 1w 1lb /
9b 1lb 1w 1y 1sb 2b 2sb 1y 1w 1lb /
9b 1lb 1w 1y 2sb 2b 1sb 1y 1w 1lb /

9b 1lb 1w 1y 3sb 2b 1y 1w 1lb /
9b 1lb 1w 1y 1b 3sb 1b 1y 1w 1lb /
9b 1lb 1w 1y 2b 3sb 1y 1w 1lb /
9b 1lb 1w 1y 1sb 2b 2sb 1y 1w 1lb /
9b 1lb 1w 1y 2sb 2b 1sb 1y 1w 1lb /

9b 1lb 1w 1y 3sb 2b 1y 1w 1lb /
9b 1lb 1w 1y 1b 3sb 1b 1y 1w 1lb /
9b 1lb 1w 1y 2b 3sb 1y 1w 1lb /
9b 1lb 1w 1y 1sb 2b 2sb 1y 1w 1lb /
9b 1lb 1w 1y 2sb 2b 1sb 1y 1w 1lb /

Fig. 5 Roman equivalent of the extract

versions given in various charts for shawl numerals (p. 2), outside notation (p. 15) and this one given below the carpet-talim (p. 18). There is clear inconsistency in Leitner's own description. It is to be noted, however, that these symbols in "outside notation" chart have *neither been used in the shawl-talim nor in the specimen of carpet-talim* by Leitner. Hence, their specific rationale could not be determined.

The contemporary version is consistent in this context: identical symbols, for numbers as well as colors, are used in both shawl and carpet domains. An exception has been introduced by the digital setting, in which the designer may also choose to use roman number symbols in shawl-talim to differentiate it from the carpet-talim. Besides this, the talim in both domains has similar codes and structures.

- *The differences in color symbols* A huge difference is observable in color symbols during Leitner's time and what are used nowadays. These are enumerated below (Table 4):

Besides above, some other colors mentioned by Leitner in his color table (p. 4) like Burzardi or Shakari (with symbol above), Fili or Mushki (above), Sausani or Badgori (above), Kalai (above), Kapuri (below), Kakrezi (above), Udi (above) and Tholi (below) is difficult to ascertain as their nature is left un-depicted in his shade card. Their names as well as symbols do not find any representation in contemporary practice. Further, the color symbols for red (*anari* in contemporary terminology or *gulanari* for Leitner), gray (*rackh* nowadays or *khaki* for Leitner) and dark pink (*gulabi* nowadays or *abbasi* viz. *nafarmani* for Leitner) remain the same.

The evolution of colors' labels and their symbols can be clearly discerned in above comparison. Most of my respondents expressed their unfamiliarity with Leitner's symbols, when shown to them, but also emphasized that a new symbol can be created anytime. This shows the flexible and conventional nature of symbols and respondents' awareness about this conventionality.

- *The difference in structure* The contemporary talim is composed in a columnar structure. The code is divided into different columns whose number depends upon the measurement of the carpet, its design type and the final drawing on the graph in the manual setting. In repeatable patterns, the end of the row is suffixed with a ∫ or ⌄ which indicates the middle point or *advaar* on the loom from where the weaver needs weaving the repetition by reverse-reading the row. In contrast, Leitner's version neither distributes the code into columns nor includes markers like above, but rather goes like a narrative. Further, there is no indicator like *alch* at the end of each columnar-row which may enable visual distinction in the code.
- *The difference in row knots representation* As mentioned before, knot count in each columnar-row remains the same throughout, which is usually twenty, but which is not the case with Leitner's version. A calculation of knot count in Leitner's carpet-talim reveals stark variability in all its four rows, with 175 knots in the first row to 157, 167 and 164 knots,

respectively, in the subsequent rows. Technically, the number of knots in a row means the number of warp threads fixed on the loom. Now, if in one row, 175 knots are woven on equal number of 175 warp threads, and for the second row if there is representation of only 157, then what the weaver is supposed to weave in the remaining 18 threads? The Leitner's shawl-talim, too, is fraught with this inconsistency.

Because of technical deficiencies like above, a majority of my respondents raised concern over the workability of Leitner's talim. For instance, one of my respondents W3 points that, 'every line has different number of knots in it' while another respondent TW2 argues that, 'it does not have an *alch* in it.' Such factors make W3 to claim that, '*ye talim galat hai* [this talim is wrong!] [*FN: Var-1*] and TW2 to declare that, 'Someone has just casually written it… yes, if you convert it to alch, then it can be worked upon!' [*FN: TW2/TW3-1*].

As has been noted earlier, this columnar structure, as per my respondents, is in vogue since earliest times of their career, that is, as long back as 1950s. This time period corresponds with the emergence of printed alchay-graphs on carpet-designing scene which are the oldest ones in the graphs' trajectory. None of my respondents admitted to the existence of any talim apart from what is prevalent nowadays. Between Leitner's time, i.e., in 1882 to 1950, *when* exactly this row-and-column based talim emerged, hence, could not be established. The existing literature is also mute on this point. However, why representational structures of talim had transformed at all can be inferred. A weaver, W2 points out in his roll, 'see every line has 20 knots in it… with this, we get to know how many knots have got woven and how many have been left…' [*FN: Var-1*].

This is the greatest cognitive merit of this structure. It helps in building *situation awareness* (Kirsh 2005) by giving weaver an idea about his current position in the weaving. Situation awareness is the '*sense of presence*' that an actor has in her ongoing activity. It is a metacognitive construct, made possible by various cues present in the external environment, for instance, visual cues in online newspapers aid reader in knowing where she is at the moment (p. 17). The cues like *alch* present in the talim develop this situation awareness among the weavers: courtesy this cue, they are able to learn where exactly they are in the homogenously looking code during weaving. It is especially helpful when they restart weaving after intervals, say after a tea break. The weavers look for the alch they were weaving earlier, and resume weaving from that point onwards. They neither possess nor consult any mental model of the environment as per information-processing paradigm; rather this metacognitive awareness about situation emerges from their interaction with various cues present in their environment. Moreover, when weavers work as a team on the loom in multi-weaver settings, the situation awareness emerges from the artefacts they use as well as their communicative practices (Artman and Garbis 1998). Consequently, my weaver respondents, without exception, opted this structure over Leitner's talim.

It would be, thus, by now clear that the compositional structure of contemporary talim has been consistent over past some seventy years, though its constituent symbols have undergone tremendous transformations since Leitner's time. Beside symbols' evolution, the major development in talim has been in its generative process, i.e., the talim-writing. In this aspect, the digital technology has had such a huge bearing that it not only altered the nature of coding in the design process, but also the overall structure of the carpet-weaving practice. The following section discusses this impact.

7 The advent of digital technology

The digital technology appeared on the carpet-weaving scene at the onset of this century. The two programs, currently in market, are 'Naqash' developed in 1998 and 'Qaleen Weaver' developed in 2004.[8] Both are CAD-based systems which facilitate not only creation of designs in accordance with specific carpet measurement and design type, but also generate the talim in the same row-and-column structure in which talim is written manually. Whatever the program, there is *no difference between a digital and a handwritten talim*: both are anatomically and functionally identical. The digital generation of talim, however, makes many further actions possible: for instance, creating as many copies of talim, printing only a specific portion from the design, feeding antique manually written talims back to the system and extracting the design out of it, re-creating missing portions in the older talims etc. With these features, the coding process shot beyond mere code writing on strips which used to be in the manual setting, thereby altering the nature of coding in the design process.

Besides spontaneous talim-generation, the digital technology opened endless avenues to the designer which have been hitherto unthinkable in manual setting. It is here that the digital technology made a huge impact on the overall structure of the practice. A crucial actor, as we saw in the manual setting, was the *talim-writer*. Once the talim is written, its copies could be made by a separate actor called

[8] For Naqash, see http://www.kashmirlife.net/programming-taleem-480/. For Qaleen Weaver, see: http://graphicweave.com/wp-content/uploads/QaleenWeaverBrochure.pdf.

Table 4 Difference in color symbols

Color	Color (in Talim Lexicon)	Symbol and its positioning in Leitner's Talim	Symbol and its positioning in contemporary version	Remarks
Pink	Gulabi	[above]	[above or below]	For some shades of pink, the symbol is placed above the numeral, while for others, it is placed below. When two different shades of pink are used in the same design, then as a code for one, this sign is used above, and for the other shade, it is used below the numeral
Dark or Bottle Green	Zangari	[below]	[below]	In Leitner's color table [p. 4], two symbols are observed for this color whereas only one is used nowadays
Light Yellow	Basanti [Leitner] Makai [Contemp.]	[below]	[above]	This is Chrome Yellow which Leitner called 'Color of the Sunflower' in his shade card [p. 12]. It is called *makai* nowadays
Yellow	Zardi [Leitner] Zard [Cont.]	[below]	[above]	
Sky Blue	Malai	[below]	[above]	Though, this color was not included in the Leitner's shade card, if we go by its name i.e., Malai, then it turns out to be sky blue color, in which case, its contemporary symbol differs from Leitner's and is placed above the numeral. The plus sign in contemporary version is used for Bottle Green color
White	Chhisi viz: white Danti [Contemp.]	No sign	[above]	Leitner does not assigns any sign for white, which in contemporary version is referred to by an inverted v
Blue	Kasni	[below]	[below]	
Purple	Lajwardi	[above]	[above]	It is 'Dark amethyst' color as per Leitner's shade card (p. 12)
Sky Blue	Asmani	[above]	[above/below]	Asmani, as per Leitner's color table, is sky blue color (p. 4). It is nowadays called Malai and is represented by a bar. Curiously, while Leitner showed the symbol as %, in his example, he used a + sign
Blue	Firozi	[below]	[below]	Firozi is 'Turquoise color' (p. 4), but its nature in his shade card shows it to be sky blue (p. 12). If it is so, it should be another name of Asmani itself which Leitner does not clarifies, but if it is dark blue, then it resembles contemporary nomenclature of Parozi (or Dark Blue) and is represented by an inverted v below. I go by its name and group it under Parozi here
Pink	Badami	[below]	[above]	This is 'Almond Color'
Colors on which very less information in contemporary version is available:				
	Qirmazi or Unaabi	[above]		This is 'Crimson Red' as per Leitner's shade card (p. 12) and is represented with three triangular dots above the number, in the category of Red, in contemporary talim
	Shishi viz. nea-rang	[below]		Leitner is not clear if it is 'Magenta ?' (p. 4) and its nature too is left blank in his shade card (p. 14). If it is, then it is clubbed under the category of Red itself in contemporary talim
	Fustaqi	[below]		This is a 'Pistachio color' as per Leitner's color table (p. 4) and will come under shade of Green or Sabz and is represented by the symbol

the *talim-copyist*, not to mention the *tarah-guru* whose role was taken over by the designers themselves. In contrast to this, the CAD-based systems unlocked a volley of possibilities to the designer: it afforded the opportunity to work in the colored medium right from the start, thereby abandoning the tarah-guru; it allowed generation of talim with a simple print command and in as many copies. This led to the elimination of the talim-writers and the talim-copyists too from the practice. Now, the designer dons the cap of all these actors herself, and makes the design process conform to her authority. The workflow, after the advent of digital technology, has been reshaped as:

Designer -> Weaver
(*Naqash*) -> (*Kaalbaaf*)
} **Digital design process**

Almost 90 % of carpet designing in Kashmir today is held to be done digitally.

7.1 The cognitive benefits of digital technology

The cognitive benefits offered by digital technology have been enormous, for instance:

1. The digital intervention removed the drudgery of writing the code manually which is cognitively extremely stressful as the talim-writer needs to count every single knot cell in the graph. Imagine counting each cell in even a small-sized 2 × 3 feet graphical representation with 20 knots columnar-row structure. That makes 24 × 20 = 480 cells per row multiplied by 36 × 20 = 720 cells per column which is equal to 3,45,600 cells in the graph! In larger sizes like 9 × 12 or 12 × 18 feet involving complex design patterns, the talim-writer's cognitive capacities are pushed to the wall. One single miscalculation and the design is distorted!
2. The designer gets to have a visual feel of the design simultaneously as she creates which is unlike looking at a two-dimensional, black and white, drawing on the graph. On such graphs, the color scheme has to be visualized, rather than experienced in the real-time.
3. Since, a designer may take weeks on end to create the design, to the esthetic satisfaction of themselves and their clients, the design-in-making can be shared with different stakeholders. The screen display is turned into a *shared representation* between the designer and the client on which the clients give their real-time feedback. This is equivalent to drawings being used as shared representations among different architects (Murphy 2004). The decision-making on design creation is thereby distributed among the designer and other stakeholders diminishing designer's hegemony.

7.2 The downside of digital technology

There are a few raising brows on the cognitive accomplishments brought by digital technology, however. Like any other medium, the digital systems also bring their constraints into the process which are well documented in design cognition research (Brown 2009; Oshike 2015). Such constraints are found in this practice as well, for instance:

1. The designing through computers is experienced as placing additional demands on the designer. My manual designer respondents, well versed with digital technology too, underscore high cognitive effort attached with carrying out command or mouse based operations. Where the bulk of cognitive effort ought to be spend on creating aspect during designing, the designers find themselves struggling with commands first. In contrast, the pencil-based manipulations on graphs are easier to perform, which they consequently prefer. The designer can freely sketch, manipulate the paper representation, test their design ideas and so on. Rather, Goldschmidt (2004: 215) considers these features of 'on the spot experimentation and representation cycles' to be the reason because of which the 'introduction of affordable paper' had 'revolutionized' the design process and argues that, 'computer applications that fail to "understand" that directness and immediacy of representation' would have 'little chance to support natural design behavior'. The designers' preference of pencil-and-paper over digital media for designing in software design, architecture and product designing has already been noted by Eckert et al. (2004). The designers' concerns in handicrafts practice like this adds further weight to their findings and clearly sides with former in manual-vs-CAD designing debate.
2. Related to above is the cognitive cost attached with getting acquainted with the digital technology. D2 underscores the cognitive discomforts, like difficulty in memorizing because of his old age, 'I have done computers [designing]. But one thing is there. This is question about my age… I can't remember much. Otherwise, I would have shown those [CAD] people…' *[TN: D2-2v]*. The memorizing of command operations is a big discomfort for elderly users.
3. The computing display is considered an inadequate medium of representation even by the experienced CAD designers. CD4 argues that, 'smaller sized designs are sufficiently seen on the screen…even 6 × 9, 9 × 12 feet designs… but when we create even larger sized designs like 12 × 18, it [the full design] is not fully seen on the screen….' [*FN: CD4-1*]. The computer screen is considered insufficient in offering holistic view of bigger size carpets, a fact noted for architectural drawings by Heath and Luff (2000: 163). In contrast, the manually drawn designs surprisingly get an edge. CD5 notes in this regard, 'you spread graphs in the room… all graphs next to the other…and you will get to see the design… with experience you can visualize the complete design in those graphs' [*FN: CD5-1*]. This spreading of graphs turns the floor into a representational medium and makes the holistic perception of larger designs possible.
4. The various command outcomes are highly suspected by the designers, for example, the conversion effects

emanating from command given for converting designs from one specification to the other. D1 and CD4 accentuate the distortion experienced while converting existing design into larger or smaller measurements. In smaller measurements, the program merely packs down all design elements into smaller space leading to congestion, whereas, when larger measurements are ordered, the design elements are simply zoomed out in the large space, creating extra spaces too between the motifs, which requires filling now by the designer. Likewise, to decrease the congestion in the smaller space, some design motifs need to be deleted manually [*FN: D1- 2; CD4-1*].

This effect is noteworthy. The program can carry out the conversion, but how will it, on its own, know and decide: which design features to remove, where to add more motifs to fill the extra space so created, what sort of motifs would be in harmony with the existing pattern etc.? D5's makes precise observations, 'computer will do only what we will tell it to do.. it will take out only that what we already feed into it… you give a design to a computer—how will it tell where does mistake lie in it? You type something in your computer, it tells you about your grammar mistakes, but how will it show mistakes in a design, or tell—here the flower is 'cut' wrongly, here the leaf's orientation is not correct etc.? How will it tell which color goes with which, whether this color matches with this or not?' [*FN: D5- 3*] This problem is analogous to the frame problem in AI where the system doesn't know which relevant or salient features to select or which redundant elements to scrap. The 'frame problem' is concerned with how to design a system that can select relevant features for reasoning, while ignoring the irrelevant ones at the same time, Dennett's robotic designers' realized: 'we must teach it [the robot] the difference between relevant implications and irrelevant implications… and teach it to ignore the irrelevant implications' (Dennett 1987).

This awareness about *relevancy* is the core of frame problem, found in our case as well where the system does not know which motifs to add and where, and which motifs to delete during conversion. These are neither the faults of a particular software, nor the flaws of the user. A blind conversion, without the creative intervention of the designer, can ruin the design completely, but such an intervention requires technical know how of carpet designing and a sound grounding in the cultural backdrop from which a designer draws inspiration. Kashmiri carpet designing involves cultural motifs peculiar to it, for instance, boteh, tear drop or design types like Tree of Life etc., which are not found in other carpet traditions, or similarly, the geometrical patterns found in their ancestors, i.e., Persian carpets, but not so much in Kashmiri ones. The designer must possess this cultural backdrop in order to even initiate the creative intervention. Further, the carpet designing is not simple drawing, because besides following culturally constrained design conventions, it also involves technical constraints, like working out borders in relation to the central field, the particular design type requirements. This is an artifact design on par with architectural or other engineering design products, besides being a work of art par excellence. It is neither free-flowing nor unstructured as painting, even though, the designer must have a creative vision like that of a painter. It has its own peculiarities, and without understanding those, a trained CAD-operator but untrained designer, can lead the design to an esthetic disaster. Owing to factors like this, D1, D2 and D3 consider computer-based designing as no better than 'copy-paste', and as per D1, a '*soch'* or vision is required, even to counteract the effects of blatant commands, like above.

Despite above drawbacks, however, the benefits of digital technology in carpet designing cannot be undermined. In terms of talim-generation, the digital technology is widely held to be a huge success so much so that a few of my manual-designer respondents also, who do not use computers for designing, use computers for generating talim, however. They hand-draw the design on graph, feed it to the system via scanning, and generate the talim from the scanned design.

8 The latest innovation

It may not be out of place here to report a very latest innovation in talim-representation which is, again, though at present, in the context of shawl domain, but which could be materialized only due to a sophisticated mix of digital and print technology. As we know, per unit of talim constitutes of number of knots plus color. What if the color information is shown directly in the talim instead of referring through its symbol? A novel type of talim precisely does that and composes instructions in colored fonts, for instance, in 4R or 4 Red, the numeral 4 is printed in red text color, in 6SB, the numeral 6 is printed in sky blue text color, in 7G, the numeral 7 is printed green text color and so on: 4 6 7 2 1 / 2 2 2 8 4 / 3 5 2 1 3 6 /

These colored-printed, roman symbol-based instructions, as in above example, similarly refer to 4R 6SB 7G etc. as in normal talim. The only exception is that the color information is not referred textually here, but is conveyed visually. In this case, besides its materiality, the technology has altered the structural features of talim also. Since, this sort of talim is quite new and is being used at a few places only in shawl weaving, its cognitive bearing can at best be speculated at this juncture:

1. Such a composition apparently reduces 'visual complexity' (Kirsh 2005) of the code. This allows easier comprehension, decoding and interpretation by the weaver.
2. When the color information is conveyed visually, the cognitive effort involved in decoding and interpreting the color symbols while weaving is speculated to be reduced.
3. The learner's stress may also get alleviated as she need not now learn and remember potentially infinite color codes and their positioning in the talim. She can just 'catch' that information in the representation itself.

What has kept its non-incorporation so far in carpet weaving, as per D1, is, 'It will be too costly. The manufacturer's cost will increase considerably. Why would he bear this much cost, if work can be done with black and white talim?' *[FN: D1-5].* A carpet, being bigger than a shawl, requires larger talim sets comprising hundreds of rolls. The economic aspect can be seen dictating its terms to the design process from the front here. Consequently, the manufacturer sits as an undisputed sovereign at the peak of actor's hierarchy in the practice making even the design process toe her line.

This non-incorporation, however, ought not to prohibit us from reflecting on the significant link argued throughout the paper, that is, the link between the artifact development, the prevalent technology and their consequent cognitive impacts. Somebody could think about colored talim only because there *is* a color printing and digital technology to make it possible. Any innovation rides upon the provisions of the technology. We can hope that with decreasing costs of the same we are able to see colored carpet talims in future. If 300 years ago, talim could have adapted from shawls to carpet weaving (Saraf 1987: 89, Sajnani 2001: 161) which revolutionized it subsequently, the further techno-advances may enable the history to repeat itself by making possible the adaptation of colored talims now in carpet weaving from the shawl domain.

9 Conclusion

This paper described the developmental trajectory of two design artifacts, namely graph and the talim, used in Kashmiri carpet weaving through the lens of technological interventions, which had their bearing not only on these artifacts, but also on the design process and the structure of the practice. Whereas the printing impacted the graph and resultantly, improvised the cognitive activity of code generation, the digital technology had its cognitive bearing on the overall design process, in terms of heralding speed and precision in the process, enlarging the gamut of coding, and opening endless avenues of creativity in design creation. The latest innovation in this trajectory is the colored talim which is a direct offshoot of the alliance between color printing and the digital technology. While the former did not as much alter the overall structure of the activity, the latter caused major changes in it: it effectively removed two crucial actors, namely the talim-guru and the talim-copyist from the practice, and reduced the design process to the supremacy of the designer.

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References

Artman H, Garbis C (1998) Situation awareness as distributed cognition. In: Proceedings of the European conference on cognitive ergonomics—9, Limerick

Ball LJ, Ormerod TC (2000) Putting ethnography to work: the case for a cognitive ethnography of design. Int J Hum Comput Stud 53:147–168

Badke-Schaub P, Frankenberger E (2004) Design representations in critical situations of product development. In: Goldschmidt G and Porter WL (eds) Design representation. Springer-Verlag, London, 105–126

Bertelsen OW (2000) Design artefacts: towards a design oriented epistemology. Scand J Inf Syst 12:15–27

Brown P (2009) CAD: do computers aid the design process after all? Intersect 2(1):1–15

Bucciarelli LL (1988) An ethnographic perspective to engineering design. Des Stud 9(3):159–168

Cross N (1998) Natural intelligence in design. Des Stud 20:25–39

Dennett D (1987) Cognitive wheels: the frame problem of AI. In: Pylyshyn Z (ed) The robot's dilemma: the frame problem in artificial intelligence. Ablex Publishing, New York, pp 41–64

Dewan P (2013) Amazing Kashmir: almost everything about travel, trekking, religion, culture, wildlife. Manas Publications, New Delhi

Dorst K, Dijkhuis J (1995) Comparing paradigms for describing design activity. Des Stud 16(2):261–274

Dubbels B (2011) Cognitive ethnography: a methodology for measure and analysis of learning for game studies. Int J Gaming Comput Mediat Simul 3(1):68–78

Eastman CM (1969) Cognitive processes and ill-defined problems: a case study from design. In: Proceedings of the 1st international joint conference on artificial intelligence (IJCAI'69), pp 669–690

Eckert CM, Blackwell AF, Stacey MK, Earl CF (2004) Sketching across design domains. In: Gero JS, Tversky B, Knight T (eds) Visual and spatial reasoning in design-iii. University of Sydney, Camperdown, pp 79–101
Eistentraut R (1997) Styles of problem solving and their influence on the design process. Des Stud 20(5):431–437
Eriksen MA (2009) Engaging design materials, formats and framings in specific, situated co-designing: a micro-material perspective. In: Proceedings of the Nordic design research conference, Oslo, Norway
Ford PRJ (1981) Oriental carpet design: a guide to traditional motifs, patterns and symbols. Thames and Hudson, UK
Gans-Reudin E (1984) Indian carpets: with 280 illustrations, 120 in colour. Thames and Hudson, Britain
Goldschmidt G, Porter WL (eds) (2004) Design representation. Springer, New York
Goodwin C (1997) The blackness of black: color categories as situated practice. In: Resnick LB, Saljo R, Pontecorvo C, Burge B (eds) Discourse, tools, and reasoning: essays in situated cognition. Springer, Berlin, pp 111–140
Goswami KK (2009) Developments in handmade carpets: an introduction. In: Goswami KK (ed) Advances in carpet manufacture. Woodhead Publishing, Oxford, pp 138–181
Gravis P (1954) This is Kashmir: Kashmir revisited (history and culture). Jay kay Books, Srinagar **(Reprinted in 2007)**
Harris P (1991) The Kashmir shawl: lessons in history and studies in technology. Ars Textrina 16:105–127
Harris P (1997) Reading between the lines-catalogue of shawl talim. http://tapadesi.com/published-articles/
Harris P (2000) Decoding the talim. Hali 110:82–83
Harris P (2001) Kashmiri shawl survival. Textile Forum, 13. https://tapadesi.files.wordpress.com/2011/10/kashmir-shawl-survival.doc
Harris P (2003) Digital images in Kashmir shawl weaving. Complex Weav J 71:45. https://tapadesi.files.wordpress.com/2011/10/digital-images-in-kashmir-shawl-weaving.doc
Harris P (2007) An eighteenth century digital technology. Cahiers Métiers D'art Craft J 1(1). https://tapadesi.files.wordpress.com/2011/10/an-18th-century-digital-technology.doc
Heath C, Luff P (2000) Technology in action. Cambridge University Press, Cambridge
Heersmink R (2013) A taxonomy of cognitive artefacts: function, information and categories. Rev Philos Psychol 4(3):465–481
Heidegger M (1962) Being and time. Macquarrie J, Robinson E (trans). Blackwell Publishers, Oxford
Hughes J, King V, Rodden T, Andersen H (1994) Moving out of the control room: ethnography in systems design. In: Proceedings of the ACM on CSCW, ACM, New York, pp 429–439
Hutchins E, Palen L (1995) Cognition in the wild. MIT Press, Cambridge
Hutchins and Palen (1997) Constructing meaning from space, gesture, and speech. In: Resnick LB, Saljo R, Pontecorvo C, Burge B (eds) Discourse, tools, and reasoning: essays in situated cognition. Springer, Berlin, pp 23–42
Keller C, Keller JD (1993) Thinking and acting with iron. In: Chaiklin S, Lave J (eds) Understanding practice: perspectives on activity and context. Cambridge University Press, New York
Khan F (1993) Cognitive analysis of work organization: a study of carpet-weavers in Kashmir. Q Newsl Lab Comp Hum Cogn 15(2):48–52
Kirsh D (1995) The intelligent use of space. Artif Intell 73(1–2):31–68
Kirsh D (2005) Metacognition, distributed cognition and visual design. In: Gardenfors P, Johansson P (eds) Cognition, education and communication technology. Lawrence Erlbaum, Oxford, pp 147–149
Kirsh D (2009) Problem solving and situated cognition. In: Robbins P, Aydede M (eds) The Cambridge handbook of situated cognition. Cambridge University Press, Cambridge, pp 264–306
Kirshner D, Whitson JA (eds) (1997) Situated cognition: social, semiotic, and psychological perspectives. Lawrence Erlbaum, London
Lave J (1988) Cognition in practice: mind, mathematics and culture in everyday life. Cambridge University Press, Cambridge
Lawrence W (1895) The valley of Kashmir. Oxford University Press, Oxford
Leitner GW (1882) Linguistic fragments discovered in 1870, 1872 and 1879 relating to the dialect of the magadds, and other wandering tribes, the argots of thieves, the secret of trade-dialects and systems of native cryptography in kabul, kashmir and the punjab followed by an account of shawl-weaving…. Punjab Govt. Civil Secretariat Press, Lahore
Mathur AR (2004) Indian carpets: a hand-knotted heritage. Rupa & Co, New Delhi
Merleau-Ponty M (1962) The phenomenology of perception. Smith C (trans). Routledge, London
Moorcroft W, Trebeck G (1841) Travels in the Himalayan provinces of Hindustan and the Punjab, Ladakh and Kashmir; in Peshawar, Kabul, Kunduz and Bokhara: from 1819 to 1825, vol 2. John Murray, London
Murphy KM (2004) Imagination as joint activity: the case of architectural interaction. Mind Cult Act 11(4):267–278
Norman D (1991) Cognitive artifacts. In: Carroll JM (ed) Designing interaction. Cambridge University Press, Cambridge
Oshike EE (2015) Harmonising sketching, drafting and CAD in architectural education in Nigerian polytechnics: case study of Yaba college of technology. Int J Sci Environ Technol 4(1):573–582
Report IICT (2009) Training in innovative designs for the persons involved in talim-writing under human resource development scheme. Indian Institute of Carpet Technology, Srinagar
Roth WM (1996) Art and artifact of children's designing: a situated cognition perspective. J Learn Sci 5(2):129–166
Roy T (2004) Traditional industry in the economy of colonial India. Cambridge University Press, UK
Sajnani M (2001) Encyclopedia of tourism resources in India, vol 1. Gyan Publishing House, India
Saraf DN (1987) Arts and crafts, Jammu and Kashmir: land, people, culture. Abhinav Publications, New Delhi
Saraf DN (1990) Carpets. In: Jaitley J (ed) Crafts of Jammu, Kashmir and Ladakh. Mapin Publishing, India
Schon DA (1983) The reflective practitioner: how professionals think in action. Basic Books, New York
Schon DA (1992) Designing as a reflective conversation with the materials of a design situation. Knowl Based Syst 5(1):3–14
Simon HA (1969) The sciences of the artificial. MIT Press, USA
Thompson J (2003) Looms, carpets and talims. In: Tapper R, Maclachlan K (eds) Technology tradition and survival: aspects of material culture in the middle east and central Asia. Frank Cass Publishers, London, pp 136–143
Varela FJ, Rosch E, Thompson E (1991) The embodied mind: cognitive science and human experience. MIT Press, Massachusetts
Williams RF (2006) Using cognitive ethnography to study instruction. In: Proceedings of the 7th international conference of the learning sciences, Mahwah, NJ, Lawrence Erlbaum Associates