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KNITWEAR: FROM CLOTHING TO FURNITURE

Regina Raycheva, Desislava Angelova
University of Forestry, Sofia, Bulgaria
e-mail: r_raycheva@ltu.bg; d.angelova@abv.bg

ABSTRACT

The paper is focused on a tendency, clearly defined these last years, of the application of knitting technique in furniture design. Traditions and contemporary knitting techniques are researched, as well as materials used. Analysis is made of their implementation in furniture. A number of examples are researched in an attempt to classify the application of knitwear in different furniture types, their function, as well as the most often used techniques and materials. By means of selection, classification, visual identification and comparative morphologic analysis, the potential of this technique is revealed.

Key words: furniture design, knitingr, knitted techniques.

1. INTRODUCTION

In this paper, we are trying to analyze a phenomenon, clearly observed lately: modern designers are increasingly interested in textiles in general and knitting more specifically. Knitting has an emphatic impact on our memory, by bringing traditional craft look to our interiors in the over-technical world of today. In fact, there is a considerable shift from knitting a jumper to knitting a piece of furniture: a change of scale, as well as of purpose. But the image is so grounded in our psyche, that it is inevitably 'doing the job' of bringing a cozy vision to our mind. A great difference in scale and look between hand-knitted and machine-knitted pieces exists – as we shall see; therefore, both types are considered in the paper. By analyzing the trend towards textile materials and their features, we found that knitwear enables designers to achieve a new look, shapes and texture, due to its properties.

2. OBJECTIVE AND METHOD

The objective of the paper is to study the trends and the techniques, in order to answer the question "Does knitwear give new possibilities, is it a frugal trend in perspective?" The research is done by means of selection and case studying, after which the finds are classified in different groups and represented as illustrated tables. On the basis of examples, conclusions are drawn, concerning the potential of knitting technique (both manually and industrially) for the vision of modern furniture as well as patterns in structure. The employed methods are: study, visual identification and morphologic analysis of selected examples. In this way, following the trends and classifying the properties gives us an overview of possibilities for design: *structurally*, *esthetically* and *functionally*. The study is aimed at practicing designers' development research or PhD students' research, trend-spotting journalists, etc.

3. EXPOSE

3.1. TECHNIQUES

Knitting

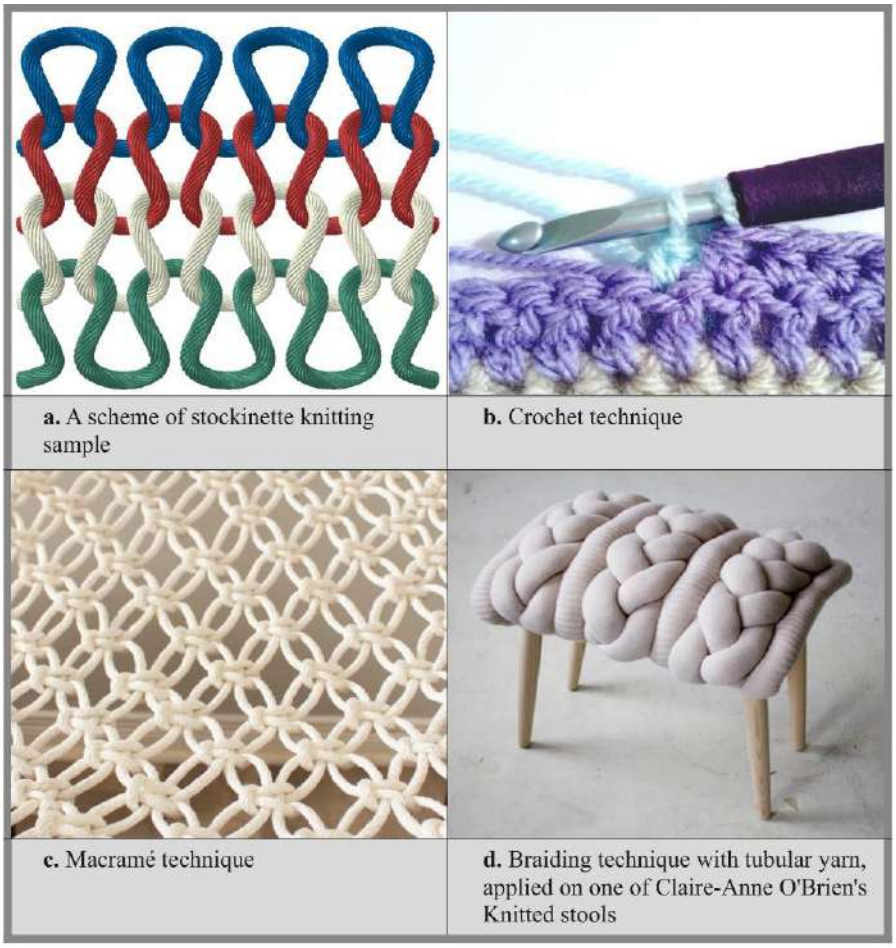
"Knitting is a method by which yarn is manipulated to create a textile or fabric for use in many types of garments. Knitting creates multiple loops of yarn, called stitches, in a line or tube. Knitting has multiple active stitches on the needle at one time. Knitted fabric consists of a number of consecutive rows of intermeshing of loops." (Knitting, Wikipedia) It is important that the knitted

fabric (Table 1.a) is highly stretching; it can be soft or tough, chunky or fine, according to the yarn used. Knitting can be performed in rows, with right and wrong side, which means knitting goes one direction to make the right side, then back, to make the wrong side. Another option is to knit a tube, where there is a spiraling endless right side; this knit is of importance for poufs and other circular accessories. The knitting technique itself allows a wide range of pattern variations, which are, shall we say, 'micro-three-dimensional'. They include groups of stitches that produce the pattern, on the one hand, and on the other, being elastic allow to be used to cover furniture items, like spherical poufs, or other, more complex shapes. Structurally, knitwear fabric needs a 'core' to put on; therefore, it fulfils the role of upholstery. Being soft, it is more like a cover or a throw used for household purposes. Industrially machine-knitted pieces are another case; they can be very resilient, light, shape-fitting, and are particularly appropriate for exterior spaces. It is important that knitting is used both for making the upholstery parts as well as to produce long tubular yarn to be further woven to interesting effects.

Crochet

"Crochet (Table 1.b) is a process of creating fabric by interlocking loops of yarn, thread, or strands of other materials using a crochet hook. The name is derived from the French term *crochet*, meaning 'small hook'." (Crochet, Wikipedia) With furniture, circular crochet allows to closely fit round shapes. The finished fabric has a grain surface, thus providing interesting texture, especially when thicker yarns or strips are used.

Table 1: Knitting and knotting techniques



a. A scheme of stockinette knitting sample

b. Crochet technique

c. Macramé technique

d. Braiding technique with tubular yarn, applied on one of Claire-Anne O'Brien's Knitted stools

Knotting (macramé)

"Macramé (Table 1.c) is a form of textile produced using knotting (rather than weaving or knitting) techniques. The primary knots of macramé are the square knot (a variant of the reef knot) and forms of "hitching": various combinations of half hitches. It was long crafted by sailors, especially in elaborate or ornamental knotting forms, to decorate anything from knife handles to bottles to parts of ships". (Macramé, Wikipedia) As we can see, the connection of this technique with fishing nets is close. In furniture design, the best known example is Marcel Wanders' Knotted Chair (on Table 6), where the net used to shape the seat and back is hardened by epoxy resin. "A thread constructed of aramid and carbon fibers, is knotted into the shape of a chair and then impregnated with epoxy resin and hung in a frame to dry, leaving the final form in the hands of gravity. The Knotted chair was a result of Droog's 1996 Dry Tech I project." (Knotted Chair)

Braiding

"A braid (Table 1.d) (also referred to as a plait) is a complex structure or pattern formed by interlacing three or more strands of flexible material such as textile yarns, wire, or hair". (*Kyosev, 2014)* "Compared with the process of weaving, which usually involves two separate, perpendicular groups of strands (warp and weft), a braid is usually long and narrow, with each component strand functionally equivalent in zigzagging forward through the overlapping mass of the others." (Braid, Wikipedia) Different types of braids exist, but we can mention here the kumihimo round braid, made with 8, 12, 24, 32 etc. strands. "Kumihimo is a Japanese form of braid-making. Cords and ribbons are made by interlacing strands. Kumi himo is Japanese for "gathered threads". (Kumihimo, Wikipedia) Braiding is interesting for furniture, because it can further be used as oversized yarn to weave the surfaces of different pieces.

Industrial 3D knitting technology

"A basic common definition of 3D fabric is that these types of fabrics have a third dimension: in the thickness layer. In 3D-fabric structures, the thickness or Z-direction dimension is considerable relative to X and Y dimensions. Fibers or yarns are intertwined, interlaced or intermeshed in the X (longitudinal), Y (cross), and Z (vertical) directions" (Badawi, 2007). Pelin Gurkan Unal defines one of the types of 3D fabric as: "The 3D weaving process designed to interlace three orthogonal sets of yarns. The weaving shed operates both row-wise and column-wise. This produces a fully interlaced 3D fabric where all three sets of orthogonal yarns interlace on a specifically designed 3D weaving machine." (Unal, 2011) 3D knitting is widely used in the sports shoes industry and knitwear garments; it is much stronger than common knitwear, and does not run 'ladders' when cut or broken, which is very important for items that are stretched.

3.2. MATERIALS

Materials for knitted furniture include yarns of natural and artificial origin (wool, etc.) as well as the more exotic ones, such as strips of unspun wool; synthetic fibers; electric cables; metal wires used for knitted nets (for example, the Penelope chair by Charles Pollock for Castelli); paper yarn, etc.

Knitting yarns cover a wide range, both by texture and color. Tracy Purtscher gives the following advice: "The most appropriate type of yarn to use for Dimensional Tuck Knitting is a smooth, round, multi-plied yarn. Yarns such as these are ideal because of their high degree of stitch definition and the cohesive fabric they create." (Purtscher, 2017)

Solid-colored natural yarns (wool) are used for furniture, accentuating the visual properties of wool. Outdoor furniture typically is manufactured with products made of manmade yarns (nylon etc.) due to the fact that they do not decay and can withstand moisture.

Lately, more scaled-up materials are used, such as knitted tubes and knitted strips. Oversized materials tend to change the role of knitwear, both as soft upholstery and bearing structure. One such material, called "Ohhio Braid (…), is a cotton tube filled with hollow fiber. It is machine-washable, durable, and pet-friendly." (Ohhio Braid, Description). The manufacturer offers a number of accessories for the home, arm-knitted with this yarn (among them, dog- and cat-beds).

Industrial 3D-knitting uses both natural and manmade fibers.

Color is of great importance for designers of knitted furniture. The British designer Melanie Porter achieves a patchwork-like look by upholstering vintage armchairs in matted knitwear with different color and patterns. Industrial knitted tubes have the great advantage of achieving very fine detailed specks of mélange colors, at the same time keeping the overall scale of their textured weavings, for example the yarn Rope Cord, Composition: 100% polyolefin, developed by the Italian company Paola Lenti. (Paola Lenti)

3.3. STRUCTURE

The structure of knitted upholsteries has two aspects: purely as a soft cover; or as a structural knit or weave. Classification that follows is done according to morphology and form-building:

1. The 'pouf' principle is a core structure: poufs; bean bags are made with a different degree of deformation. The core gives shape to the furniture piece.
2. The 'knot' principle means knitwear without core/structure: Pieces are knitted from scaled-up tubular yarn; thus, the oversized knit creates the structure with fewer oversized stitches or loops. Separate knots are also made, to the same effect.
3. The 'in-woven' principle is when upholstery is knitted or woven into hard structure that may be a metal lattice; the yarns may be knitted tubes filled with foam or polyester patting; and in this case the softness and the specific look is the goal. The vision is of a 'chunky' object. The metal bearing structure provides the overall shape, contour or silhouette.
4. The 'membrane' principle means that a metal or wooden frame secures support contours, on which knitted upholstery is fastened. This may be dubbed a 'tent' or 'membrane' principle using stretched knitted panels. The elastic property is the goal, usually very strong artificial fiber is appropriate for exterior use.
5. The 'hammock' principle consist in securing two or four support points to fix the knitted panel, the rest of the structure hangs freely under the weight of the sitter.

3.4. ESTHETICS: FINE OR THICK?

The choice of fine or thick yarns gives designers a totally different starting point for their models. The esthetic approach is a result of structure. For instance, one approach is of a cover over a core. This is typical of the knitted poufs. A core could have the fill of the so-called 'bean bags': tiny polystyrene balls, or

treated cereal seeds. They produce amorphous, free-flowing shapes, plus the possibility to deform under the sitter's weight. Good examples are: The Slumber Poufs by Casalis and Nest Cushions by Zilalila.

Fig. 1. The Slumber Poufs by Aleksandra Gaca for Belgian company Casalis

Fig. 2. The hand-knitted Nest cushions by Zilalila, a Dutch company

Both show a three-dimensional expressive knit pattern (although Slumber is made of 3D industrial knit, while Zilalila's Nest cushions are hand-knitted), to which their interesting vision is due. The other approach uses thick material that became oversized, so that looking at a piece we get a magnified view of the structure. This specific look gave rise to oversized yarn materials (see the Ohhio Braid Yarn) and unusual instruments for knitting: Dutch designer Bauke Knottnerus knits his Phat Knit Series with long tubes, together with another helper.

A contrasting esthetics to the above examples relies on minimalist membranes. This means structures made of thin stretchy material, to reach a hammock-like vision. The material is either held by the corners or by the whole contour by a rope or solid linear element. In 2017, IKEA launched 3D knitting in the form of its PS 2017 armchair, by designer Sarah Fager. Swedish designer Jonas Forsman used 3D-knitting techniques to make his foldable Shift Chair for the Dutch brand Moooi as comfortable as possible. Benjamin Hubert's Tent chair for Moroso is a minimalist single piece of knitted nylon, with no seams. "The combination of stretch, support, transparency, padding and three-dimensional form in one seamless knit makes Tent one of the most advanced pieces of upholstery constructed to date." (Zeitoun, 2017) With the Cradle collection the designer incorporates soft padding in hollow canals in the knitted panel. Each chair in the range is constructed from a metal frame, an upholstered seat and a mesh textile backrest, "providing the unique comfort of a hammock, without the hassle of awkwardly climbing in and out." (Smith, 2016)

Fig. 3. Benjamin Hubert. Cradle Chair, Layer, 2016

Fig. 4. Benjamin Hubert. Tent Chair for Moroso, 2017

Fig. 5. Jonas Forsman, Shift Chair, Moooi, 2015

Fig. 6. IKEA's PS Armchair, design Sarah Fager, 2017

3.5. FUNCTION

In knitted furniture, softness, tactile and physical features are very important because, like garments, furniture is in direct contact with man. Here we have a whole range of properties, important, because they demonstrate how furniture design transfers approaches from sports footwear and clothing industry. Here we have selected some of the properties of knitwear: thermo-insulating (wool); lightweight (outdoor use); breathing surface: air can access human skin (office chair backs); formfitting (covers any shape); seamless (no cutting and sewing is needed); transparent (used for office screen dividers); thin tent-like membrane shapes; reduced waste during production; expressive, but minimalist design; support, flexibility and breathability; decorative potential of the surface: knitwear takes almost all types of color patterns, that can be changed by customers by using digital technique; bright color and micro-three-dimensional surface bring visual interest. The properties here listed are in fact closely connected with function, on one hand, and esthetics, on the other hand; actually they are inseparable, because one leads to another.

4. CASE STUDIES

The following 7 tables summarize the examples the authors selected, classifying them according to their structural principle, and visually arranging them into groups; with basic data and morphologic comment for each one.

Table 2: Knitted furniture with core

Structural Type	Knitted furniture with core (hard/soft fill)			
Picture (Source)				
Product Name	Picot	Slumber	Cisean, Olann collection	Nest cushions
Year of Design	2013	2013	2012	2011
Author	CRS Paola Lenti	Aleksandra Gaca	Claire-Anne O'Brian	
Manufacturer	Paola Lenti, Italy	Casalis, Belgium	Claire-Anne O'Brian, Ireland	Zilalila, The Netherlands
Morphology, Stylistic Features, Type of Knit, Construction and Details, Materials	The pouf presents a core filled with polystyrene spheres, covered with a fixed cover, hand-crocheted with 'Rope': a wool braid, specially developed by the company. The aesthetic of the hand-crocheted cover is the key element, bringing texture, and in this way adding interest to the object, which is not big: D 52cm; h 33cm.	Made of a three-dimensional stretch kid mohaire fabric, these footstools deform when seated upon, because they are filled with synthetic balls. The top of the pouf case is shaped like animal ears, because of the natural elasticity of the fabric which gives it memorable individuality. The properties of the fabric result directly in an unusual shape.	Cisean poof has two points of interest: first, the designer used two layers – the first one for cover, the second one for texture. Second, the texture is provided by an oversized knitted tubular yarn, which is woven into a basket 'two-by-two weave', with a really great effect. The core padding is made with natural materials (coconut fiber and goose feathers), which makes this small piece a luxurious item.	The trick of this bag, hand-knitted of natural wool, is the large stitched vertical seam: it is sewn perpendicular to the other edge of the cushion cover, thus achieving a 3D form. This gives the otherwise amorphous bag shape and at least one vertical edge to support your back. Apart from the surface knitted effect, the felt handle with the company logo also provides detail.

Table 3: Knitted furniture with core

Structural Type	Knitted furniture with core (hard/soft fill)			
Picture (Source)				
Product Name	Artichok	Stormy Rose	The Million Loops Lounge Chair	Sandared
Year of Design	2008	2008	2016	2018
Author	Monika and Kasia Gwiazdowska	Monika and Kasia Gwiazdowska	Maria Camarena Bernard, Aakanksha Sirothia	Synnöve Mork
Manufacturer	Monomoka Studio, Poland	Monomoka Studio, Poland	RISD student workshop	IKEA
Morphology, Stylistic Features, Type of Knit, Construction and Details, Materials	A flower shaped and colorful pouf made of a 156 crocheted orange and yellow polyester yarn shapes catches the eye and brings interest to any interior. The floral shape, detail and colour give this pouf its unique vision.	Stormy Rose pouf made from 78 knitted petals of black and blue polyester thread. This time the petals of the rose look more chaotic and disorderly. The color is unusual, the knit is fine, the detail is abundant, to an attractive overall effect.	Bright-colored and looking very much like a bean bag, this hand-crocheted chair offers rich detail on the back, with a definite 50-s flavor. The piece is a students' work, and shows the interest of young generations to techniques typical of the past.	This pouf opts for a knit pattern giving it the characteristic spiral lines on the surface. Filled with polyurethane foam, with polyesther yarn cover, it also features a special surface to prevent sliding from the bottom side, allowing stacking of several poufs.

Table 4: Knitted furniture made of oversized material

Structural Type	Using oversized material: knitted tubes and wool strips			
Picture (Source)				
Product Name	Knotty Floor Cushion	Phat Knits	Chunky	The Cabaret chair
Year of Design	2015	2008	2016	2012
Author	Sasha Fefelova	Bauke Knottnerus	Veega Tankun	Kenneth Cobonpue
Manufacturer	Kumeko, Germany	Bauke Knotternus, The Netherlands	VeegaDesign, UK	Kenneth Cobonpue
Morphology, Stylistic Features, Type of Knit, Construction and Details, Materials	Soft cotton jersey tubes stuffed with high resilient foam are plaited and filled with polyurethane foam flakes. The oversized knitted material is plaited to achieve the overall shape of the cover. The aesthetics relies on the typical diagonal basket weave texture.	The piece is knitted using giant needles (actually PVC tubes) and oversized soft tubes yarn. The structure is achieved by the yarn itself, because of its huge size. The vision is of a magnified image of knitwear, the human figure seems under-scale and strange. Used as floor cover, the material is memorable.	This chair has two features: oversized stuffed tube for upholstery, and structure on four support points, secured by the wooden legs. Only the weaving material is knitted, to give elasticity to the whole construction. Texture is blown up to an extent to be visually read as a separate structure. Additional securing was made under the seat with yellow cords.	The individual vision of this chair is achieved by fabric tubes, woven over a steel frame. Texture is the key element that catches the attention of the viewer. With larger pieces, this approach brings interest to the transparent chunky elements. The model exists in an indoor and outdoor version.

Table 5: Knitted/knotted self-supporting structure without core

Structural Type	Knitted/knotted self-supporting structure without core			
Picture (Source)				
Product Name	'Knitted army' collection	Phat Knits series	Black and White Knot Floor Cushion	Footstool
Year of Design	2012	2008	2016	2011
Author	Andrea Brena	Bauke Knottnerus	Neta Tesler	Jan Rose
Manufacturer	Andrea Brena, Italy	Bauke Knottnerus studio, The Netherlands	Knots Studio, Israel	Jan Rose, The Netherlands
Morphology, Stylistic Features, Type of Knit, Construction and Details, Materials	The collection revives the art of arm-knitting and crochet. The shape is half-spherical, open, and reminds us more of a basket, than furniture proper. Color is a strong point: a typical manner of using mélange yarn, used for knitwear, gives a memorable vision with a furniture piece, once more playing with oversized scale.	A memorable experiment, the series of oversized furniture pieces each resemble knitting in blown scale. In fact the structure is achieved by several stitches of the knit. The knitted pieces are actually made using giant knitting needles (more accurately PVC tubes), manipulated by two people. The softness of the huge tube is provided by stuffed foam materials.	The imagery of oversized knots is used by the Israeli designer to produce sitting /decorative cushions, pillows and stools. The sculptural quality is due to the oversized yarn, namely tubes, stuffed with foam filling, using a unique tying technique, where wooden rings are also taking part. The graphic play of stripes brings additional interest.	Rose presents a piece of furniture made of knitted high-tensile stainless steel thread. (Etherington 2011) The unusual steel yarn catches the attention of the customer. The car tyre imagery is also comfortable, because it has a hole in the middle and allows the sitter to feel well. The circular donut shape turns out to be universal for furniture design.

Table 6: Knitted/knotted mesh-looking pieces

Structural Type	Knitted/knotted mesh-looking pieces		
Picture (Source)			
Product Name	Knotted Chair	Dragnet Lounge Chair	Niny Macrame chair
Year of Design	1996	2009	
Author	Marcel Wanders	Kenneth Cobonpue	Souwan Kongkhunthian
Manufacturer	Cappellini, Italy	Kenneth Cobonpue, The Philippines	Yothaka, Thailand
Morphology, Stylistic Features, Type of Knit, Construction and Details, Materials	This chair has already become designer classic, and has encouraged analogues. Knotted Chair is made from lengths of hand-braided aramid and carbon fibre cord, which are impregnated with epoxy resin to provide rigidity and hung in a frame to dry, "leaving the final form in the hands of gravity". (Knotted Chair, Droog) The vision is therefore of a hammock. Airy and delicate look is achieved using a decorative macramé technique.	This collection inspired by fishing nets and is available in bold red and black; both in indoor and outdoor versions are offered. The transparent vision is strongly reminiscent of a garden. The imagery of fishing net in the water is strong. A very original idea is the zigzagging line of the frame's front, repeated in the ottoman, developed for this chair.	This is a minimalist metal chair for the contract market. The surface of the seat and back is made with macramé technique. The seat is covered with a cushion. The macramé mesh plays the role of elastic and decorative membrane, thus achieving a garden image.

Table 7: Furniture with soft materials knitted into hard structure

Structural Type	Furniture with soft materials knitted into hard structure			
Picture (Source)				
Product Name	Biknit	Bertoia Loom Chair	Ami	Rapunzel
Year of Design	2011	2015	2015	2018
Author	Patricia Uquiola	Clément Brazille	Francesco Rota	Kenneth Cobonpue
Manufacturer	Moroso, Italy	Clément Brazille	Paola Lenti, Italy	Kennethcobonpue, The Philippines
Morphology, Stylistic Features, Type of Knit, Construction and Details, Materials	A wood structure made of ash wood carries a steel frame, knitted with oversized cords. The stockinette knit-stitch is enlarged to become a feature of the upholstery, thus creating a unique image to be used as an accent in an interior. The model has a chair and a chaise longue version.	Bertoia Loom Chair is a remake of Harry Bertoia's Diamond Chair. This is done to pay homage to the American designer on the occasion of the centenary of his birth in 2015. The metal structure is woven with textile tubes, thus illustrating the logical use of the soft material as 'pile' woven in the base metal structure of the chair.	Using the polyester Chain tubular knit, the designer plays with the scale of the weaving material, by creating a point of interest in the interior due to its texture and color. A manufacturer with strong tradition in carpets and textile, Paola Lenti of Italy favors minimalistic design with maximum effect of the unique signature textile materials, specially developed for their products.	This piece furthers the designers' expertise with rattan weaving, but with a change of material into textile tubular materials. The effect reminds us of his garden and exotic pieces, but is a more homely and cozy indoor version.

Table 8: Furniture with soft materials woven into hard structure

Structural Type	Soft material knitted into hard structure			
Picture (Source)				
Product Name	Vermelha chair	Loop	Looped Pile Seat	The British Wool Chair
Year of Design	1998	2011	2016	2011
Author	Fernando and Humberto Campana	Sophie De Vocht	Ana Mosseri and Elaina Runge	Claire-Anne O'Brien
Manufacturer	Edra, Italy	Casamania, Italy	Ana Mosseri, Elaina Runge	Claire-Anne O'Brien, Ireland
Morphology, Stylistic Features, Type of Knit, Construction and Details, Materials	The Vermelha chair has the strong image of a pile of ropes, seemingly chaotically thrown on the floor. In fact this chair was hand-knitted over its metal structure with ropes into pile upholstery. The designers state that they were inspired by the 'construction' the ropes formed, when left on the table. (Vermelha Chair, MOMA)	The Loop chaise long is a hybrid between a pile carpet and a furniture piece (Chin, 2011). Using a traditional carpet-making tufting technique, the piece ends in a train of large oversized loops, not unlike the dress of a flamenco dancer, to which image it owes its exotic look.	"Students from the Furniture Design and Textiles Departments at Rhode Island School of Design (RISD) were challenged to rethink how soft materials are used in furniture design". (Wong, 2016) The result of this research came out as a basket-like shape covered in oversized piles, with an invitingly cozy and lively vision.	The Irish designer has made "The British Wool Chair" for an exhibition at British Wool Week in October 2011 and was knit in Rowan British Sheep Breeds Yarn." (Williamson, 2012). The amazing thing about the design is the direction of knitting of the tubular details: they are not knitted longitudinally, but laterally; obviously to achieve greater stretching and the unique striped pattern.

Table 9: 3D-knitting/tent/membrane construction

Structural Type	3D-knitting/tent/membrane construction			
Picture (Source)				
Product Name	Cradle collection	Tent chair	PS 2017 armchair	Shift Chair
Year of Design	2016	2017	2016	2015
Author	Benjamin Hubert	Benjamin Hubert	Sarah Fager	Jonas Forsman
Manufacturer	Layer Studio in collaboration with Moroso, Italy	Moroso, Italy	IKEA, Sweden	Moooi, Denmark
Morphology, Stylistic Features, Type of Knit, Construction and Details, Materials	Hubert combines two different types: the membrane type for the back and the pouf type for the seat. "The seat of the chairs is made of soft, cushioning foam, which absorbs the impact of sitting and helps support the user's weight, like the foam sole of a shoe when running." (Williamson, 2016)	The Tent Chair is made from a single, seamless piece of recycled nylon that is stretched over a steel frame. (Morby, 2017) The knitting technique allows for the padding to be integrated into the seat's main fabric. Stretched out, the fabric is held in place by guide ropes, used in sailing; which makes the membrane vision even more pronounced in this model.	3D-knitting uses computer-controlled machines to knit fibres into complex, seamless shapes based on a digital design. The technique was originally developed in the garment industry and sports shoes but is gradually finding a new role in the world of furniture. The vision is minimalist, light and transparent, permeated with air; lines are graphic, surfaces are thin and elegant.	The aim of the designer was to create space-saving furniture in response to ever more diminishing living space in cities. (Hobson, 2016) The fabric is knitted in the shape of the chair back "with a heavier yarn that is suitable for furniture" (Hobson 2016); thus eliminating the need of cutting and sewing. Another advantage for the 3D fabric is that it allows the transformations in the folding chair; this leaves a wide range of further possibilities.

5. DISCUSSION

A possible approach for furniture designers is to *pick up techniques and ideas from other areas, in this case textile*, with which a close connection is observed.

Techniques are mixed together: patchwork and knitting; knitted tubular yarn and weaving or braiding or knotting. Oversized yarn is knitted to achieve construction fabric. Large-size knots are made (like Keltic knots, macramé knots, etc.). The oversized raster texture of knitted fabric is used to create interest and accents in interior, as well as 'craft' look, the customer's memory is played with. "Most of us can still remember times when grandma knitted peacefully for someone in the family" (Teicu, 2013); the technique itself suggests coziness, warmth and protection. Also, the surprise to see the technique used on furniture brings even more interest.

The technique covers a large range of *functional interior products*. Furniture is represented by poufs, bean bags, floor cushions, chair pillows, stools, small tables, sofas, hammocks, cradles, child swings, hanging chairs, armchairs, and chaise longs. An additional feature is that the industrial 3D knitted furniture can transform easily, like in folding chairs. Accessories are also a large choice: lighting fixtures, crocheted bath pockets, knitted bed throws, dog- and cat-beds, carpets, covers and blankets for the bedroom.

Designers, who experiment with this technique, are quite a lot: Marcel Wanders, Fernando and Humberto Campana, Patricia Urquiola, Benjamin Hubert, Claire-Anne O'Brien, Melanie Porter, Francesco Rota, Kenneth Cobonpue. A lot of design students, especially textiles design students, readily experiment and hit on interesting solutions with furniture; this opens a potential for educational and experimental purposes.

Knitted furniture may be qualified as one-off, individualistic, hand-crafted or machine-made; the products are memorable and attractive, with a great potential for color and shape, of detail, of texture with micro- and macro-sculptural effects. Industrial 3D-knitting technology allows for creating transparent products, all shapes possible, because it is highly elastic and stretchy.

6. CONCLUSION

In the cases considered, we have seen that knitting is implemented by designers both by way of experimental hand-crafted unique pieces and by using machine-knitting technology for mass-production. Hand-knitted and machine-knitted pieces differ considerably, but both have their role in modern design. Hand-knitting results in spectacular crafted pieces, many of them oversized, eye-catching, colorful, textured, and can be used as individual accents indoors and outdoors. Machine-knitted pieces look minimalist, modern, unusual and avant-garde and futuristic, because of their membrane character. In both cases design is very specific and with strong individuality. It allows a wide spectrum of shapes: from spherical, drop-like, amorphous and 'shapeless' to hammock-like, membrane-like and minimalistic. Texture gives high expressivity and brings pattern and color to interiors. Materials used complement the possibilities with a wide range of yarns, manmade fibers, natural unspun wool, knitted strips, different knitted tubes, ropes, etc. Techniques include hand crochet and arm-knitting, knitting/ crocheting with tools, machine knitting, knotting, and also weaving, using knitted tubular materials. Textile-manufacturing companies (carpets) are typically interested in such type of furniture. The knitted pieces allow the use of a mixture of traditional craft techniques and ultra-modern ones, such as 3D-knitting, and are widely featured in designer sites and revues. The trend allows for many experiments and has even further development, when combined with computerized 3D knitting machines allowing individualized designs.

We can conclude that designers, who are always looking for inspiration, are equipped with yet another opportunity for demonstrating their creativity: the knitting technique. The great designer production in the last years proved to be a fruitful source for refreshing new ideas and has high potential for further development in the direction of unusual sculptural upholstery, soft and hard shapes; light membrane pieces of furniture; transformable furniture, colorful and graphic surfaces and patterns. The high esthetic values and tactile properties make it a great choice for one-off pieces; the machine-knitted varieties are appropriate for mass-production of light, resilient furniture pieces, both indoors and outdoors.

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