Shape and Surface: The challenges and advantages of 3D techniques in innovative fashion, knitwear and product design

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Abstract. The presentation wants to show what kind of problems fashion and textile designers are facing in 3D-knitwear design, especially regarding fashionable flat-knit styles, and how they can use different kinds of techniques and processes to generate new types of 3D-designs and structures. To create really new things we have to overcome standard development methods and traditional thinking and should start to open our minds again for the material itself to generate new advanced textile solutions.

This paper mainly introduces different results of research projects worked out in the master program “Textile Produkte” during lectures in “Innovative Product Design” and “Experimental Knitting”.

1. Introduction
With regard to knitted fabric – especially knitted products - 3D techniques have been an integral part of the development process since the very first beginnings of textile production. The creative process for the designer starts with the yarn, unlike in textile products which refer to already existing textile fabric. This especially concerns the intersections of fashion- and textile design. Digitalization and modern CAD applications made the development and design of many products easier; they lead, however, to stringency in product development, which allows for only little or no creative encounter or involvement of the designer in the technical development process. This is then inevitably – just like with many textile products – no longer any kind of fundamental re-development but merely an update or a variant of an already existing one.

All fashion and textile designers in creative industries are familiar with graphic programs like Illustrator or Photoshop, but only few have some knowledge of knitting techniques, which are needed to create new ideas for fabric, shape and surfaces in knitwear. So the results and developments are dependent on a multitude of factors like the interpretation of the technician. That circumstance bears various risks with regard to the realisation and outcome of a design, its final look, and it makes the design not always satisfying for the designer neither the technician.

2. Challenges and Advantages of the different techniques: Seamless Technology for flat knit designs?
Especially the seamless technology for fashionable flat knit styles offers several problems for the development of new ideas. On the new X-bed machines it is possible to work out knits in double or multiple layer techniques, but the machines are expensive, not always available and not easy to handle.
Furthermore, an experienced knitting technician is required to do the programming for the machines and to let them run. So, as mentioned above, in most cases the design is not only made by the designer, but in cooperation with a technician who sometimes is thousands of miles away in an out-sourced place of production.

The narrowings and fashion marks needed in the machine programs and their position in the style panel are, on the one hand, part of the aesthetic appearance of a product and, on the other hand, very important for the correct fitting and shape. This is a big challenge for designers of fashionable products who have to combine these aspects with trendy yarns, patterns and shapes, because there is a lack of training programs and communication tools (like model libraries). This circumstance often leads to a gap in communication, and battles with the technical department about possibilities and frustration with the outcome of ideas.

Nevertheless, more and more advantages of the complete garment production like minimum waste yarn and post-operations, lean logistics, the possibility of European production and other sustainable aspects are focused by industry, and promise a growing potential in the future, adding to the increasing importance of the fully fashion production.

If design skills and technical know-how are perfectly connected, generating products with fully fashioned technique and whole garment knitting can lead to beautiful and perfect fitting, seamless shapes and structures (Fig. 1).

Figure 1. Left: Fully fashion dress, Hannah Seidelmeyer, “Feel the Yarn” contest, Pitti Filati, Florence, 2013; middle and right: fully fashion dress, Marina Keberlein, “0°”, “Wool School” contest 2012

Strategies to start creative processes: Let us start with the yarn
To introduce knitwear design for weft-knit styles to students, it is better not to start with a sketch but with the yarn and a material concept on hand-knitting machines or by hand, to get access to the material and “other” ways of creative developments. The goal is not only to make simple plain fabric, but to play with stitches, constructions and structures, yarn combinations, tensions etc. to get a feeling for knitwear and to discover new design strategies. “Trial and error” and results from overcoming obstacles are an important part of design development.
Figure 2. Students in the workshop of Niederrhein University of Applied Sciences.

Things to be discovered by the students, during lessons and workshops:

For the shape of a style panel seams und cutting of materials can be avoided by combining different stitch and fabric structures, yarns etc. even if narrowings and fashion marks are not used, like in the fully fashion technique (Fig. 3).

Figure 3. “Form follows function”: Combing various knitting constructions with different properties, Sarah Stober, 2012 and knitted pleats (left picture: Stober 2012).

To use small models (e.g. size 1:4) to test various proportions, material combinations and draping effects of test swatches (Fig. 4).

Figure 4. Artworks of students for the project “Knitted Wool Couture”, 2012 (picture: Windgassen/2012)
There are a lot of variables in the knitting process which can lead to unexpected 3D innovations: different yarn types and subtleties, strength parameters, yarn tension, a coincidentally “wrongly” distributed thread guide or an error in programming, lead to movable surfaces or other astonishing effects as shown in the following projects.

**Case study: Experimental flat knitting with an “unusual” yarn: Diolen 150 BT, by PHP Fibers GmbH (sustainable Polyester)**

For the “Apparel Show” at the fair “Techtextil/Texprocess” in Frankfurt/Germany in May 2015, the goal for the participants was to show that typical technical materials can be used for clothing as well. An interesting sustainable material was found to work with: Diolen 150 BT, a biodegradable high-tenacity polyester on PLA basis, made from renewable resources of company PHP Fibers, Germany. It is a shiny white yarn for warp knitting, actually used in the automotive interior for safety belts and air bags and not for clothing. It was perfect for the project. The task for the students was to create something new with it. They were not asked to make simple plain fabric, but to work with the properties of the material, like stiffness, to implement it in a clothing concept.

The project team started with some knitting tests by hand, on hand-driven and computerized (Stoll CMS 302 TC) flat-knitting machines. Because of the harsh handfeel of this polyester type it took some time until the results were satisfying. The students “played” with tension, knitting constructions, tested different finishings and combinations with wool or other materials. As expected before: in the end some very different surprising results with 3D effects appeared:

“La Onda del Hielo – Moving surfaces”

Master student Sophia Krinner did tests by using Diolen in combination with tuck stitch ribs in a loose knitting tension. The resulting fabric showed a kind of chain reaction on the surface if tugged at one end. The ribs started moving and the whole surface changes. The student felt inspired to use this special property of the material to develop the couture dress “La Onda del Hielo”, a dress with a moving surface while wearing it (Fig. 5).

![Figure 5. “La Onda del Hielo – Moving surfaces”, Sophia Krinner, 2014.](image)

“Fading Crystals – Ultrasonic welding for flat knit styles”

Another partially surprising result occurs, when new joining technology, as for example in this case ultrasonic welding, on the surface of coarse knitted clothing or other – yet untypical – materials is used. Master student Theresa Brinkmann, did experiments with structures on the surface of different stitch constructions, pleats and pleat optics and finally received special pleats with a look like knitted “petinet” effect by using the right emboss tool and correct parameters like pressure and timing on the welding machine. The result: a couture dress with a voluminous 3D-bottom part (Fig. 6).
Figure 6. “Fading Crystals”, Theresa Brinkmann, 2015 (pictures. left Brinkmann 2015, middle and right Ilskens 2015).

Case study: Experimental flat knitting with wool combining yarns with different subtleties and using of felting techniques to gain volume

Other student projects dealt with structures and volumes, by using different yarn types in one style, and/or the possibility of felting wool in different ways:

“Moonbotica”:
Following the semester topic “metamorphosis” master student Verena Winkelmann created the knit project “Moonbotica”, outlining the development from cocoon to silk moth as a chunky sweater with “growing” stitch sizes from the bottom to the top. The pattern is 100 % wool hand knitted and hand felted. The felted bottom part characterizes the soft but compact cocoon. Towards the upper part the structure breaks open and spreads in a heavy chunky knit to distinguish the detailed pattern of the silk moth’s wings [1]. For this part the student used woollen tops instead of yarn (Fig. 7).

Figure 7. “Moonbotica”, Verena Winkelmann, 2013 (right picture: Berns/Winkelmann 2014)

“Knitted Wool Couture” Wool School - Cooperation Project for the “Campaign for Wool” in 2012 - project partner “Woolmark International” and fashion brand “Marc Cain”:

“The Wool School Project” was part of “The Campaign for Wool” in 2012 that is a global endeavour initiated by its patron, His Royal Highness The Prince of Wales, in order to raise awareness amongst consumers about the unique, natural and sustainable benefits offered by wool. The goal for the HSN students: To develop something different to what people would expect and to show a much more-in-depth involvement with the material than in classical fashion design. Volume and many different 3D-surfaces and structures appeared in untypical yarn combinations and felting techniques like needle punching and the usage of felt yarns, to create “Knitted Wool Couture” (Figs. 8, 9).
Figure 8. Combination of an Nm 30/2 yarn with woollen tops by Caroline Liehr (left panel) and a felting structure in different subtleties and tops by Julia Tschukin (right panel).

Figure 9. Needle punching structure (by Marina Keberlein, left panel) and artworks of students for the project “Knitted Wool Couture”, 2012 (right panel) (pictures: Bendt & Windgassen/2012).

The winning outfit in this project and contest impressed the jury with its architectonic shape and volume (Fig. 10).

Figure 10. “Crazy, Sexy, Wool”, winner model of Caroline Liehr and Maia Kesseler (pictures Shabati, Windgassen and Bendt 2012)
Results of another master research project, exploring the potential and outcome of knitting felt yarns and non-felting yarns together in one pattern, show interesting, structured “cloqué” effects, after finishing/washing processes, e.g. in jacquards with various backings (Fig. 11).

![Figure 11. Felted woolen samples of master research project (Sarah Grobe).](image)

To start with the fabric:  
Warp knitted lace meets silicon - a basis for a new textile 3D product design:

The possibility to use different open stitch structures of warp knitted lace for a new type of 3D-textile material in the shoe sector was developed by master student Ariane Ehring with the project “Grow” in the course “Innovative Product Design”. It is inspired by bionic structures as can be found in “coral reefs, stone reliefs and on the skin of reptiles. Natural textures are imitated with artificial and synthetic materials. For the realisation of the collection different coloured silicon and laces have been developed. Due to the variations in the open structure of the lace fabric it is possible to create multiple surfaces” [2] (Fig. 12).

![Figure 12. “Grow” by Ariane Ehring, 2014.](image)

3. Conclusion

Nowadays knitting technology offers an amazing range of possibilities for designing including 3D-materials and styles. Unfortunately, only little of it is used in the textile and clothing industry. One problem master student Miya Budaeva found out in her master research project, on the usage of seamless technology in the fashionable flat knitting sector was that product developers in industry, fashion and textile designer do not have enough technical knowledge to work with and that they are not aware of the advantages and possibilities of whole garment technologies.

The second problem is that under consideration of cost saving aspects, production- and development facilities – especially in the fashion industry – have increasingly been globally re-located
and standardised during the last 30 years. Hence, the ideas-generating designers can very often no
longer accompany the creative developing process together with the technicians that do the machine
programs. Especially in knitwear this is a problem because really new knitwear developments cannot
be generated without a more-in-depth involvement with the material, knitting and finishing tests and
creative guidance.

So, to change something for the future and to generate more innovative designs and materials, there
should be more technical training and exercises with materials during the education and studies of
designers and product developers at universities. And this means not only from the vantage point of
fashion. Knitwear offers comfort, flexibility, seamless shapes and fabric constructions with a lot of
functional potential like, e.g., the plating technique for applications in sports and work wear or for
medical and protection garments.

The development of creative tools like pattern libraries, maybe connected to standard design
programs, should be promoted and the textile- and creative industries should be more aware of the
advantages of seamless production – like, e.g. sustainable aspects. This offers the opportunities to a
creative, sustainable and innovative 3D-knit design world.

References
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