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EMPOWERMENT THROUGH PRODUCT DESIGN: DIGITAL TEXTILE PATTERN DESIGN FOR GRIP DEVELOPMENT IN HEALTHCARE

Wenche LYCHE and Arild BERG
Oslo and Akershus University College of Applied Sciences

ABSTRACT
In the meeting of textile pattern design and 3D-printing techniques, there is the potential for developing inclusive products for healthcare. There is a great need for this from both patients and healthcare providers. There is also an educational need to examine how design education can facilitate the development of such skills because digital solutions have opened up new opportunities. The research question asked how textile patterns and surface designs can help empower patients through their grip on surfaces. One of the main objectives was to apply knowledge from material testing to create a design manual that explains the capabilities of design and printing in 3D textile patterns for inclusive product design in healthcare contexts. Experiments were carried out at two product design education centres, one in Norway and one in the United Kingdom, with 3D printers, laser cutters and waterjets that can print patterns and designs. Fabric was used to explore how to increase the aesthetic value for users through, for example, hand feeling, anti-slip features and a sense of joy in surfaces. The study shows how teachers can collaborate across disciplines to leverage each other's expertise and how product design students can participate in tasks that give them insight into the textile world and new knowledge of digital-based textile printing and pattern construction for an improved user experience of health products.

Keywords: Creativity, textiles, pattern design, ergonomics, 3D printing

1 INTRODUCTION: TEXTILE COMPETENCE IN HEALTHCARE

In the meeting of textile pattern design, surface design and 3D-printing techniques, there is the potential to develop inclusive products for healthcare [1]. There is a great need and opportunity for this from both patients and healthcare providers [2]. In an educational context, there is an emerging field of design for health and wellness, which is focused on human-centred design. As digital solutions have opened up new opportunities, there is also an educational need to examine how design education can facilitate the development of such skills. Within this educational context, this study relates to an existing course in ergonomics in product design education at HiOA in Norway, where digital knowledge has to a certain extent been implemented but where there is still much to develop. Discussion of this particular context will also be relevant for other educational institutions [3].
For customised products relating to human beings and product function, the knowledge needed has often been associated with students' understanding of ergonomics, the physical and psychological relationship of the design product with the user, and universal design. Students should know the theory and principles of sustainable design and design methodology, including user-oriented product design. They should know the methods for analysing needs and problem areas associated with the use of products and systems. Students can define problems and develop solutions more effectively if there is a high degree of user involvement. They should know how to acquire user insights and apply them in the various model types throughout the design process, including the mock-up and functional prototypes. Students need to be able to plan and carry out design projects and to develop skills in model building and the materialisation of ideas, including both 3D modelling, documentation and presentation and the use of material databases and scientific searches.
Students must be able to acquire experience in sorting and extracting essential information by researching and analysing materials, industrial construction, model construction and surface structures.

They must be able to build on a knowledge and understanding of materials and material properties as well as manufacturing and industrial processes. As a general competence and as part of their professional development, students must be able to understand and have practical experience in managing the interaction between users and environmental products in the design process and be able to exchange views and experiences with resource people and specialists. Students should be able to reflect on their development in the learning process and adjust this under supervision. In addition to this relevant knowledge, it is also important that students receive up-to-date information concerning 3D printing and its relationship to these topics, information that, on the one hand, is linked to students' creative potential and, on the other, is related to the needs of industry and labour [4]. This balancing act is examined in this study.

2 BACKGROUND: 3D PRINTING IN SOFT MATERIALS

Within the field of design, many digital opportunities have been explored relating to textiles [5–9]; however, there is a need for more studies on how digital technology can be used to develop textile pattern designs with gripping surface features that provide products with an improved grip and added aesthetic value. State-of-the-art creative processes involving 3D printing are emerging. While there have been many studies on user-specific product design and function-oriented products, more studies are needed on pattern designs and surface designs that exploit the great potential for the development of gripping surfaces on healthcare products where many surfaces, whether wood, metal, ceramic or plastic, are often without design or pattern [10]. Students, teachers and industry will benefit from expertise and deep knowledge on the tactile, aesthetic and practical value of developing new and innovative products involving the interplay of technology and practical solutions [11].

Creative 3D printing in soft materials can be related to how textile-related design education has, for a long time, focused on the use of digital techniques in production. Textile technology and industrial tailoring have a long tradition, beginning with the jacquard cards and the first weaving machines of the Industrial Revolution [12]. Today, a completely different revolution is happening through new opportunities in 3D printing. An important challenge is to connect 3D drawings with the material qualities of the production equipment (Figure 1). Wire qualities have not always been exploited to the full when 3D drawings have been based on other types of materials. There is therefore an urgent need to explore the connections between digital drawing and the quality of a product when it is materialised.

2.1 The zone of proximal development (ZPD)

Vygotsky is a relevant pedagogical philosopher to analyse in this study because he offers a pedagogy that brings the student forward to unknown areas at the same time as building on existing knowledge [12]. The teacher can enable this to happen in a good way, as explored in this study. Vygotsky presents the theory of 'the zone of proximal development'. This is the zone between what students can do on their own and what they can do with the help of others. Vygotsky stresses that learning happens in social interaction with others and with the tools available for performing a task. He thinks that students learn more with others than alone. When students are challenged from their existing level of competence and get a feeling of mastery in their exploration of the new, this is what creates interesting learning, enabling students to achieve new levels and, under their own motivation, raise their skills and understanding. The teacher should be the one that leads the way by introducing new methods and a new mindset. From an educational perspective, this can be challenging because it is about pushing boundaries and simultaneously challenging each student's individual competence level, which can vary greatly in a large class. As a teacher, you can be a support by letting students support each other. The methods should be clear so that the proximal zone is open for exploration, and the goal should be for students to activate their own progression and thus take joy in their work. By constantly challenging existing competences, there is the hope that insight experiences will occur. According to Vygotsky, this encourages students to become more independent and to understand professional content in their own way in a social setting. Consequently, the following research question for this study was formulated: How can students learn to design textile patterns and surface designs for healthcare products that empower patients through their grip on surfaces?

3 METHODS: MATERIAL EXPERIMENTS

There were three objectives for the research: (a) to perform material experiments in order to create a user manual that explains the parameters needed for designs and prints in 3D textile patterns; (b) to interview faculty and students about their experiences of this approach as well as their experiences of collaborative learning, using the perspective of Vygotsky's zone of proximal development; and (c) to apply knowledge from material testing to create a design manual that explains the capabilities of design and printing in 3D textile patterns for inclusive product design in healthcare contexts. Experiments were carried out at two product design education centres, one in Norway and one in the United Kingdom, with 3D printers, laser cutters and waterjets that can print patterns and designs. The documentation shows how to design a pattern that would normally be printed on a fabric in a one-dimensional design. In the study, the pattern was 3D-printed in other materials and was both decorative and functional, with reinforced gripping surfaces. A 3D print and silicone cast were used to enhance the quality of the products and to explore how to increase the aesthetic value for users, including hand feeling, a sense of anti-slip and a sense of joy in surfaces.

4 FINDINGS: CREATIVE MATERIAL PROCESSES IN 3D PRINTING

The study shows how teachers can collaborate across disciplines to leverage each other's expertise and how product design students can participate in tasks that give them insight into the textile world and new knowledge of digital-based textile printing and pattern construction for an improved user experience of health products. It explored how to perform material experiments to create a user manual that explains the parameters needed for designs and prints in 3D textile patterns. The study involved participatory design with faculty and students to explore the creative process in 3D printing in soft materials, and this experience of learning through collaboration was analysed from the perspective of Vygotsky’s zone of proximal development. The knowledge gained from these initial explorations of material testing was used to create a design manual and learning outcomes that explain the capabilities of design and printing in 3D textile patterns for inclusive product design in healthcare contexts.

4.1 Creative textile processes in 3D printing in education

Figure1: Creative connections from the unknown to the known

The first part of the exploration was based on students’ close relationship to everyday products and how this can be used in new ways. The idea was that this would be transferred to 3D printing, with the process moving from something that was known to something that was unknown. It was important that there should be learning during this process. A piece of lace with a circular pattern, a familiar and traditional handicraft product, was used as the example of a patterned gripping surface (Figure 1). If this were a finished product such as silicone, it could be attached to products in the home or in hospital corridors as an aid for better grip. The lace was placed in different places (e.g. the palm of the hand, a coffee box, a computer mouse and a shower head) to create a better grip.

The project was developed with examples of how a better grip could be designed in a stair environment, considering how to place it to coordinate with and support footsteps and how to move the hand in line with the steps (Figure 2). By turning the problem upside down, it was asked whether silicone patches provide the best solution or whether it would be better to make a silicone glove to put on the hand in order to always have a firm grip regardless of the product (Figure 2). For some, this is a better solution, in which case it would be possible to make decorative gloves that do not seem to be utilities but that are nonetheless functional and incorporate a grip. This would be an example of universal design. This was further developed with other materials, including polypropylene, to examine the relationship to 3D printing in this material.

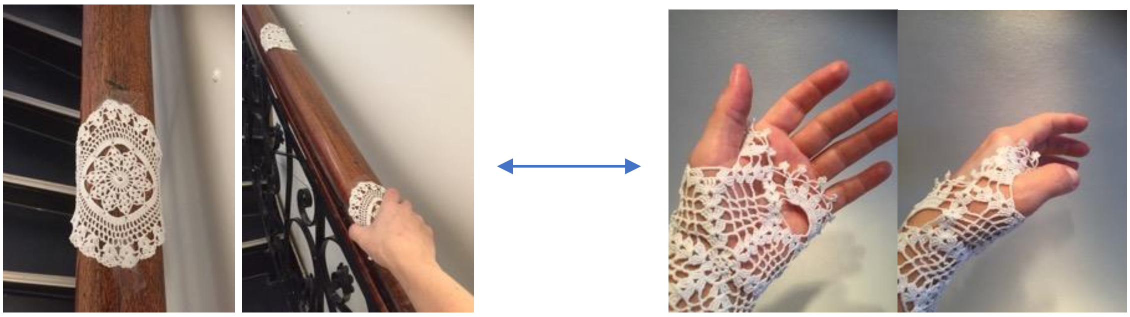

Figure 2: Providing an assistive environment and bringing the necessary assistance to a glove

4.2 Creative ergonomic design processes in the sports industry

When designing and developing a great grip for elite users in Nordic skiing, the inside of the palm is crucial because skiers use their arms so much in their performance. The inside of the palm of the hand is rubbed thousands of times in a cross-country race, and blisters can easily occur. Therefore, in order to prevent blisters, it is essential to collaborate with elite users concerning the grip, fabric and inside palm construction to avoid too much fabric inside the palm when the fingers are closing in on the pole. This means that development and testing are necessary concerning the effects of rubbing on fabrics and leathers. A bended design is required, which must be tested in the field (in a cold environment), as well as an understanding of pattern construction and how to provoke the fingers to bend inwards when putting on the glove. Grip enhancement in leather, together with an effective grip construction, is therefore a solid solution. Often the construction of gloves is carried out in factories, often in low-cost countries, but working together on-site with the producers can be a lot more efficient with respect to communication and saving time. The prototypes should be made and tested by elite users, and as the products change over time through feedback, new prototypes may become necessary. The thorough testing of one tear is very normal in order to optimise the end results for elite users who require only the very best gear. This will then inspire other skiers to use the same glove, and bigger target groups can then be developed.

4.3 Creative 3D printing in glass

A research collaboration was established with University of Wales Trinity Saint David. Material examples were explored by one of the authors (Lyche) (Figure3). This included collaboration with a a colleague there, Shelley Doolan, who in her PhD focused on developing a model of practice for the synthesis of CAD and CAM processes with traditional craft practices. The field explored was 3D CAD in arts applications relating to glass, such as lost-wax and kiln casting, fusing and slumping, cold working and finishing, slip casting / mould making and waterjet cutting. Such skills give students the competence to provide technical and design advice to industry partners from a diverse range of sectors. Collaborative research and development projects can enable students to establish longer-term collaborative relationships with companies and to deliver a number of project targets.

4.2 Creative 3D printing in health contexts

Design creativity in relation to 3D printing in a health context is a relevant topic for design education. The materialisation of 3D drawings has to a certain extent already occurred in the health industry [13–15]. For example, when a violation is localised in an x-ray examination, there is currently equipment producing an individualised open plaster form that allows for air to the skin while providing the support needed around the fracture. This production method allows for creativity, aesthetic expression and an opportunity to print letters instead of abstract patterns. Other parts of the body than the hand have also been explored, including specially designed soles that utilise the advantages of 3D printing and a unique manufacturing process adapted to the individual user. Further a workshop was initiated with health professionals who were presented the printed 3D materials developed at University of Wales Trinity Saint David (Figure 3).

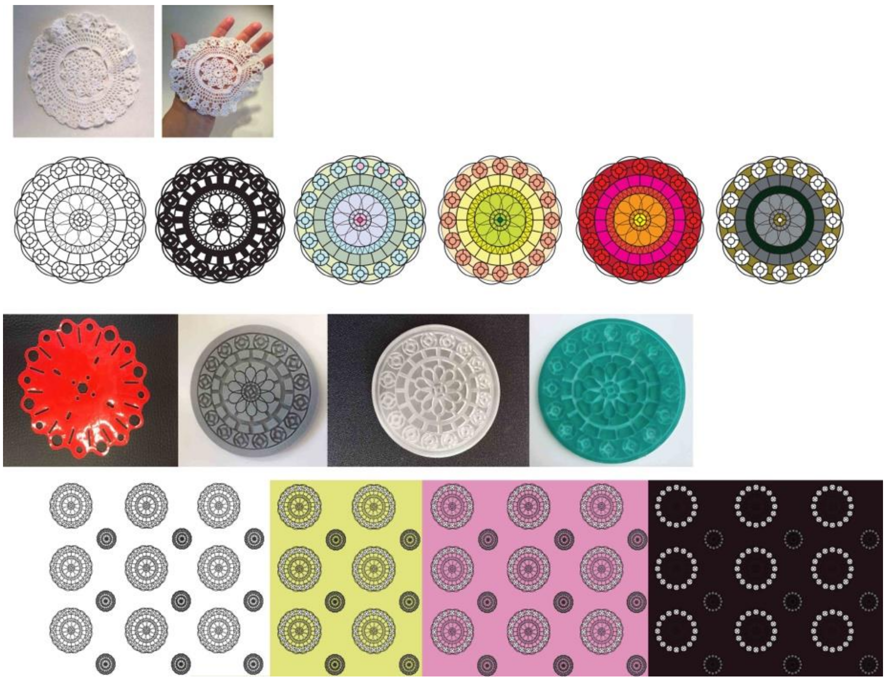

Figure 3: 1st line top: Original lace in cotton - handmade by the grandmother of one of the authors (Lyche). 2nd line: Original lace drawn in illustrator, 3rd line from left to right: A: Simplied lace cut in Dycem lasercut. B: 3D print mold of lace- used to make silicon sample. C: Liquid 3D print mold of lace- used to make silicon sample. D: Silicon sample from liqiud 3D mold. Bottom line: Surface pattern design made from original lace with different color settings. All designs by Lyche.

In the workshop among the participants there were visiting researchers both from health and design from OpenLab located at the University Health Network (UHN), Canada's largest research hospital. The material was presented to discuss possible use in a health context. The ideas that emerged in this workshop was that the sticky surfaces could be used in houses for elderly people to avoid slipping, or to more easily open the lid of a jar. It could be used on the floor space to help disoriented people. In rehabilitation people could learn to walk again by finding flowers on the floor. The material could also be designed as informative stickers and cue finders for people with mild cognitive impairment, such as reminders of starting to brush the teeth when arriving at the bathroom. The surfaces might as well be used to avoid slippy surfaces in airplanes as well as on handles on mountain bikes. In general the concepts could expand further by discussing them with other health professionals such as occupational therapists and nurses.

5 DISCUSSION: CREATIVE 3D PRINTING IN A DESIGN CONTEXT

The study shows concrete examples of how the creative use of 3D printing can increase aesthetic value for users and enhance the tactile qualities of products in relation to the feeling in the hand. Anti-slip surfaces do not have to look boring or ugly; they can, on the contrary, be an opportunity to design an experience involving a sense of joy in a product that combines visual aesthetics with function. What you see and feel through touching can be enriching. Through the material experiences, learning outcomes have been identified in order to create a user manual on 3D-printing strategies for students and teachers. Through participatory design with staff and students, Vygotsky's zone of proximal development was explored in a creative 3D-printing design context. The manual for 3D printing explains its capabilities in general, while this study has a specific focus on product design for healthcare.

5.1 Conclusion: New learning outcomes in ergonomics and 3D printing

The research question asked how textile patterns and surface design can lead to healthcare products that empower patients through their grip on surfaces. The conclusion has resulted in learning outcomes that can be used as a manual for the use of 3D printing. These learning outcomes are relevant for the first cycle of product design in higher education [11] and are particularly relevant in considering contemporary subjects such as ergonomics and function [16]. The first learning outcome is that a student who experiences a process like the one described in this study will know about the possibilities of 3D printing and how they relate to creativity in the everyday environment, as well as how to use technological processes to transform ergonomic evaluations into user situations and products. The second learning outcome is that design skills can be enhanced by performing material experiments to create user-specific manuals that explain the parameters needed for designs and prints in 3D-material patterns. The third learning outcome is that students can apply their knowledge from material testing to create a design manual that explains the capabilities of design and printing in 3D-material patterns for inclusive product design in healthcare contexts. The final learning outcome is that general competences can be enhanced by using collaborative learning and participatory design with faculty and students to explore students' own competences, as identified in Vygotsky's theory of the zone of proximal development [12]. The study shows how researchers can collaborate across institutional frameworks to leverage each other's expertise and how product design students can participate in tasks that give them insights into the textile world and new knowledge of digital-based textile printing and pattern construction that can lead to an improved user experience of health products.

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