INTERNATIONAL CONFERENCE ON ENGINEERING AND PRODUCT DESIGN EDUCATION
6 & 7 SEPTEMBER 2018, DYSON SCHOOL OF DESIGN ENGINEERING, IMPERIAL COLLEGE, LONDON, UNITED KINGDOM

PARAMETRIC DESIGN THINKING ABOUT DIGITAL AND MATERIAL SURFACE PATTERNS

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ABSTRACT
There is a growing need in contemporary society to understand new and emerging relationships between technology and creativity. In practice-oriented areas of education such as design, many instructors have come to understand the importance of different learning styles and how students benefit when presentation of new material is varied to reach all students. The concept of parametric design thinking enabled by advanced computational processes has recently been identified as a relevant approach to design education. The present research further explores parametric design thinking through two case studies of design workshops in an educational context and how this approach can promote diversity. The first case (Robotised Clay Workshop) documents material exploration and creative and aesthetic possibilities in digitalised clay processes. The second case (Surface Patterns in Textiles: From Tradition to Digitalisation and Back) explores digitalised processes in hybrid textile design. The two case studies contribute to the exploration of parametric design thinking as an educational approach and discuss digitalisation and the relations of body, hand and mind in terms of the Vygotskyan ‘zone of proximal development’. This content was synthesised for a workshop on surface patterns for third-year bachelor design students. The paper identifies some potentials and pitfalls of this pedagogical approach and concludes that students’ awareness of conformity and diversity in the design process can be used as a starting point to explore digital surface patterns, offering students a new way of learning about function, aesthetics and product semantics through parametric design thinking.

Keywords: Creativity, digital design, textile design, ceramic design, zone of proximal development

1 INTRODUCTION: LEARNING SKILLS IN DIGITAL DESIGN

In practice-oriented areas of education such as design, instructors have come to understand the importance of different learning styles [1] [2]. In other contexts too (e.g. health), it has been reported that consumers learn better when new material is presented in varied forms, including workshops [3]. These findings are highly relevant for pedagogical theory and practice in general [4], as well as for design education [5]. In design thinking [6], digital tools are being integrated in new ways, and parametric design thinking, enabled by advanced computational processes, has become increasingly relevant in design education [7]. It seems useful, then, to study this method from a pedagogical perspective. In this context, one relevant concept for engineers and product designers is Vygotsky’s ‘zone of proximal development’ (ZPD). Lev Vygotsky (1896–1934) was a psychologist and social constructivist who promoted the idea that because learning always happens in a social space, this should be carefully considered in pedagogical theory and practice [8] [9]. One of his key ideas was the ZPD, which refers to the range of potential development for an individual in the absence of any direct help, or with as little support as possible—for example, by following the example of others. Based on this theory, Vygotsky promoted the idea that learning should be organised so that the learner experiences the situation as within their capacity and that they can do things without others’ help. By reinforcing the individual’s learning skills and their ability to develop their own learning strategies, this approach accommodates diversity and different learning strategies. The research question addressed in the present study was how parametric design thinking can be used in a workshop setting to explore diversity in design education.

2 METHODS: CASE STUDIES OF DESIGN WORKSHOPS

The methods chosen captured the interaction between theory and practice and between deductive and inductive thinking. The key theoretical assumption that parametric design thinking can be used in workshops to promote diversity in design education [1-5] was explored further in a real setting and based on design teaching situations [10]. This made the study highly relevant at local level and linked practice to existing theory and research. As a central concern was to investigate variations in learning styles and the advantages and disadvantages of teaching approaches, the workshops addressed these issues by investigating how the participating students approached their work in different ways although sharing the same starting point.

2.1 Case study 1: Robotised Clay Workshop

The pedagogical method adopted in this workshop was designed to accommodate different learning styles. The use of 3D printing in clay was relatively new to product design education at the university. The practice had recently been explored within the framework of a research project and was not a compulsory element of any taught subject. In the workshop context, research was gradually transferred to education. The students were introduced to the research project in different ways. The frames and methods were different for each student, and the three students were at different educational stages. In the workshop, parametric design was related to the parameters used for the task and encompassed digital techniques, people, environment and materials within a complex context of relevance to the case study. For each of the three students, their own motivation was central to how the opportunity of 3D printing in clay was introduced. This was based on the idea of student-driven processes, in which each student is required to find their own motivational basis in order to identify a unique problem that they find interesting to study [11].

2.2 Case study 2: Workshop on Surface Patterns in Textiles

In this five-day workshop, third-year students from the bachelor of product design course and students from fashion were asked to experiment with the textiles provided in combination with other materials they had been introduced to earlier, including wood, metal and ceramics. They were asked to explore surfaces in elaborating possibilities in relation to health and wellbeing, inspired by research in the field [12]. The fabrics included wool, silk, spacer fabric and non-woven fabrics. Each morning began with a lecture on textiles' impact and their use in clothing, furniture, exterior and interior design, both in architecture and in advanced technologies like spaceships. The students were divided into 4 groups of 5 and were given sufficient information to equip them with a basic knowledge of the textiles provided. They then began an experimental phase based on the specific characteristics of the textile in question—for example, softness, tightness and stretch. For 4 days, they made use of all the school's workshops before presenting their experiments and analysing their findings in terms of potential applications. Based on ideas related to the ZPD [8]. Their supervisors offered as much guidance as they needed in order to open further opportunities within their design processes. Group work stimulated discussions about creativity and design solutions, and at the end of the week, each student would visualise a concept, using an avatar, by visualising an imagined person, to illustrate a solution for health and well-being. The students' experiments were collated as a library of inspiration for others at the textile facilities. This methodological approach contributed to the dissemination of knowledge and experience sharing among the students. Parametric design thinking was explored by learning to see and encode the surface, relying on it and repeating it as a pattern. Other parametric principles related to form findings with restraints, as in A4 samples.

3 RESULTS: DIGITAL AND MATERIAL SURFACE EXPERIMENTS

Some of the groups transferred their experiments all the way to the end of the two workshops. Based on the concept of ZPD, there were different levels of supervision, resulting in different surface pattern designs.

3.1 Case study 1: Robotised clay workshop

The first case study documented material exploration and creative and aesthetic possibilities of robotised clay processes. The process of 3D printing on clay was relatively new at the department, having recently been introduced within the framework of a research project (Figs. 1 A-C) and was not a compulsory element of any subject. The research looked at infill structures as an aesthetic tool when coupled with glaze surfaces. The three students were introduced in different ways to the use of clay printing. In all three cases, the student's own motivation informed how they engaged with additive manufacturing [11].

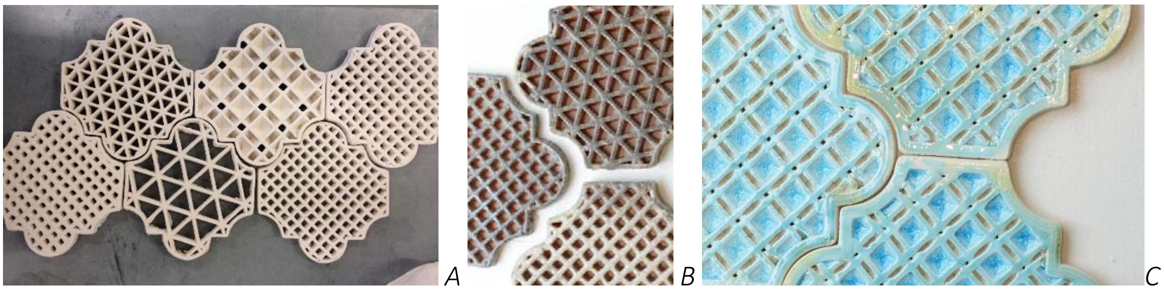

Figure 1. Research project: robotized clay

Since entering the study, a student from the second year of the bachelor degree had shown a curiosity about the machine technique and had a particularly experimental way of working. This student was given the opportunity to create objects for display at an exhibition where the research group would present the results of its work with 3D clay printing. Required to produce final results within a deadline, the student explored the possibilities of the equipment and technology and chose to collaborate with another student who had mastered the drawing programmes at a higher level. In this way, the student quickly gained knowledge and was able to achieve the desired visual expressions.

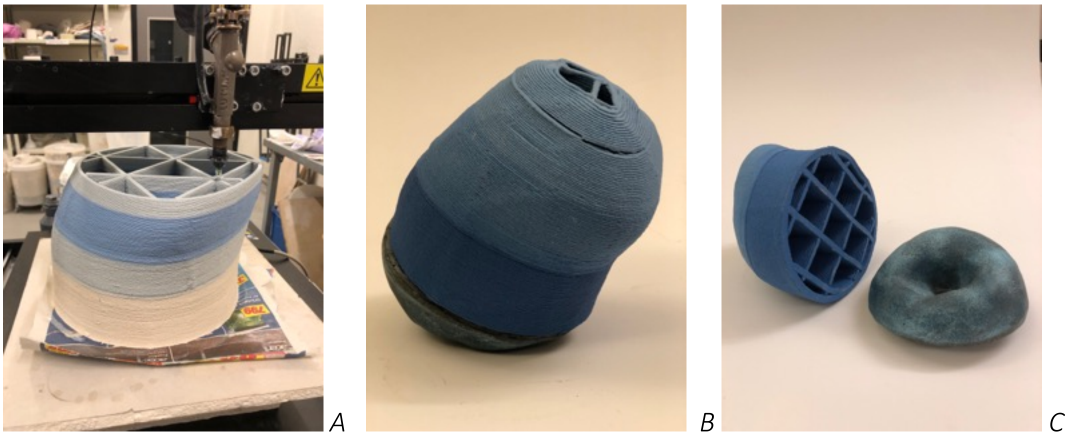

Figure 2. A-C. Robotised clay, student workshop

Another student from the first master level chose to address the problem of how to use clay dug up from nearby ground. This student's learning process was strongly motivated by the material and by nature. This student would, to a lesser extent, have chosen to work with CAD if the project had not been intrinsically linked to exploring the material through clay printing. The student was most interested in the clay's properties and used CAD as a tool to develop forms that explored its possibilities and limitations. The student's focus on materiality and the harmony between form and material was reflected in the subsequent report:

> 3D printing with clay: I have always wondered how it works. Simply, I thought the printer did all the work. Little did I know; 3D printing with clay is craftsmanship—modern craftsmanship. Programme-based crafts. It is so fascinating; so beautiful, in a complex technological programme-based world with a natural, fine-tuned material. The interaction between technology and the properties of the clay can create the most aesthetic objects in a unique technical way, which could not possibly be achieved by a traditional craftsman. Precise and yet non-precise. Perfect, but imperfect. Even an error in the software and the process can provide aesthetic results. (From student's diary notes, 20 September, 2017).

A student from the first bachelor year worked on a personal initiative involving clay printing in the context of 'Experimental Materials and Techniques'. The student had clear frames for the task and chose clay as the material and 3D printing as the technique. The student worked purposefully to explore the opportunities for different aesthetic expressions. As the 3D printing tools had already been tested, the student needed a shorter time than the other two in beginning to experiment with shapes and colour mixes (Figs. 2 A-C). By this time, too, more knowledge was available, both online and in the form of teacher resources. The student was able to access courses through a large digital learning resource, which was used very efficiently to learn the necessary programmes. In his reflection, the student wrote: ‘I notice that I go on a lot longer and learn a lot more when I allow myself to play and explore without too much expectation of a result’.

3.2 Case study 2: Surface patterns in textiles

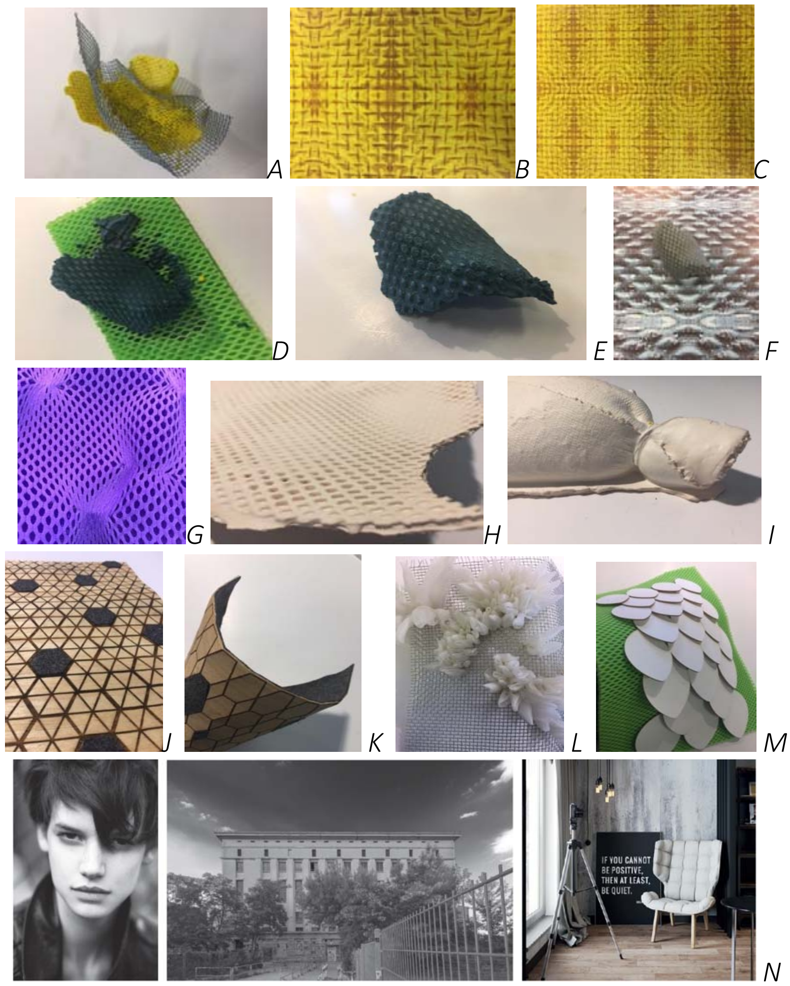

Figure 3 A-N. Surface patterns in textile: from tradition to digitalisation and back. N: Avatar

The chosen learning method was group work in order to achieve a dynamic that would take the tests further through good conversations and creative dialogues. Some students made individual tests without anticipating the outcome and enjoyed being in that creative space. Others felt that it was too challenging not to know what the experiments were intended to achieve, and they were less happy to engage in such a design process. Some expressed this view quite strongly and did not engage, or disappeared. This can also be seen as a test of the individual’s comfort zone in relation to learning and to the ZPD—that is, what students get out of learning with and without help. A supervisor can make them responsible for seeing this while at the same time challenging students to enjoy this space— to take the initiative without knowing what the next step may bring. The following examples describe different results as they relate to different learning styles and to these students’ experiences.

One student tested Yesmonite as an acrylic material that dries quickly; the student also tested metal but avoided fabric (Figs. 3 A-C). Nevertheless, the outcome was a textile that could be used as a surface pattern design. The surface would be of interest in the context of health and well-being—for example, as a new structure or woven fabric wall surface in waiting rooms. Another use of a spacer surface placed Yesmonite in a roll for drying (Figs. 3 D-F). The surface of the fabric was then transferred to Yesmonite, and this surface became an element in a pattern design that could be used for anti-slip surfaces or for directional use in corridors. Students took the spacer fabric into liquid clay, dried it and then fired the fabric away in the kiln so that the ceramic inherited the softness and texture of the textile as a new material. This created a new aesthetic surface, and the participants discussed how it could be used in health and well-being applications. Some students sewed spacer fabric together to create a volume (Figure 3 G-I), and the textile was connected to ceramic or Yesmonite. One student used wool as the soft material, and the laser-cut veneer wood in the pattern was fixed and bonded (Figs. 3 J, K). In this way, woodwork could become softer and fabric became stiffer. The students explored these as new patterns, testing to see which side would bend best and discussing how this could be used on furniture.

In some cases, students stated that they could not see the point of experimenting; to demonstrate, one pushed some silk into metal material and asked 'Are you making some kind of art, or what? I have no idea what this can be used for' (Figure 3 L). This student finished the workshop and did not return, unaware that the others in the group saw this use of soft silk and rigid metal as an exciting development. Someone in the group suggested that it could be used on the ceiling as décor, or as an aesthetic divider in a room. After a few days, one could remove the silk from the metal to find that it had a 3-dimensional structure, like anemones in the sea. Some students worked with a sporty avatar that needed protection, and one worked with a back-plate function (a shield) (Fig 3 M), reinforcing the textile with laser-cut pieces that could be repeated while allowing room for movement. The student wrote about the avatar (Fig 3 N): 'Her name is STEFF, she is a photographer and lives in a big city, she is gender neutral and she works with interior and architecture and enjoys open spaces. She likes to mix the feminine and masculine and is always looking for surfaces with a tactile touch for walling, room dividers and ceilings. She loves different textures together.'

4 DISCUSSION: CONFORMITY, DIVERSITY AND CREATIVITY

Using the case study method [10], the two cases explored the concept of parametric design thinking in practice [7] and the potentials and pitfalls of this approach. The qualitative results were synthesised as an inspiration for a revised version of the workshop on surface patterns for third-year bachelor design students.

The ceramic workshop was not mandatory for anyone, and the students' own motivation was central. This made the work easier and created a positive experience. One disadvantage was only a few students had the requisite competence. The relevant variables include the organisation of what was to be learned at what point in time and the delivery of information and inspiration at the right time in the process. The students said that the project's impact on their experience was as a crafts process, encouraging them to work with 3D printing in clay. They all gained a new understanding of how knowledge of materials and crafts can add to the digital process.

Based on these experiences, the workshop in textiles should be adjusted. A new workshop would be facilitated differently and would not be structured in the same way. For example, it would not involve finished materials in A4 textiles; instead, the groups would be able to choose their own areas of interest, such as wood, metal, ceramics or textiles, and they would choose their own problem [11]. They would also receive more information about the properties of textiles. The teachers could perhaps show more of the possibilities, at least for students who are a little stuck in relation to the process. Referring again to ZPD, this indicates a need to help these individuals to understand the possibilities more creatively [8]. In this study, it became clear that quite a few people found it frustrating to work in unknown territory. At the same time, this may prove useful for the present generation of design students, who may be more used to ready-made solutions than earlier generations. Some stated that they wanted to know in advance exactly what to do, as they disliked situations that they did not fully understand, which made them feel insecure and clumsy. On the other hand, every journey of discovery can be different, and workshops like these can offer students a new and personal method among their design processes. In one week, four lectures provided initial themes and inspirations for the day, equipping them to make an avatar, to make a collage describing the avatar and to justify their design results in terms of health and well-being. For many students, this was probably too much at once. It may be that a week of experiments followed by a couple of days of conceptual development might

yield deeper insights because not everyone loves free exploration, and for some, this did not inspire or engage them.
Digitalisation and learning in a social space relates to body, hand and mind as described in Vygotsky's 'zone of proximal development' perspective [8]. The students said a number of things about the project's impact on their thoughts, ranging from 'confusion, not motivating' to 'inspiring and fun-delightful with new ways of working'. More time should probably have been given to achieving higher quality design by providing opportunities to do things several times. Amongst other things that could be changed, the course should have been available only to those who were most motivated, and there should have been a more thorough introduction. Language-wise, it seems possible that some students had difficulty with the lecturer and supervisor's use of English language. Some of the students did not like being in this situation and others were confident to pursue a design process that too little extent was known in advance. Students learned to have a higher awareness of guidance, where guidance one hand leads to that they can be less frustrated, but that guidance can on the other hand lead to that students can be less likely to test their own ideas or to create their own strategies for exploration. Relevant learning outcomes identified from the study was further that student's get more hand experiences by making craft related to digitised processes. Students get aesthetic experience on how working intuitively can lead to unexpected surfaces although the process may not be fully understood from the beginning. In conclusion, the study of parametric design thinking through digital surface patterns in workshops like these might serve as a starting point for exploring conformity and diversity in the creative design process where students get a higher awareness of their own strategies for creativity.

REFERENCES

[1] Milne A.J. Designing blended learning space to the student experience. *EDUCAUSE*, 2006.
[2] Seitamaa-Hakkarainen P., Viilo M. and Hakkarainen K. Learning by collaborative designing: Technology-enhanced knowledge practices. *International Journal of Technology and Design Education*, 2010, 20(2), 109-36.
[3] Repper J. and Breeze J. User and carer involvement in the training and education of health professionals: A review of the literature. *International Journal of Nursing Studies*, 2007, 44(3),511-519.
[4] Mjelde L. *The Magical Properties of Workshop Learning*, 2006 (Peter Lang, Bern).
[5] Bratteteig T. and Wagner I. Spaces for participatory creativity. *Codesign—International Journal of Cocreation in Design and the Arts*, 2012, 8(2-3),105-126.
[6] Cross N. *Design Thinking: Understanding How Designers Think and Work*, 2011. (Berg. Oxford).
[7] Oxman R. Thinking difference: Theories and models of parametric design thinking. *Design Studies*, 2017, 52, 4-39.
[8] Vygotsky L.S., John-Steiner V. and Cole M. *Mind in Society: The Development of Higher Psychological Processes*, 1980 (Harvard University Press).
[9] Morgan D. and Skaggs P. Collaboration in the Zone of Proximal Development. In *Design Education: Collaboration and Cross-Disciplinarity, Proceedings of the 18th International Conference on Engineering and Product Design Education*, Aalborg University, Denmark, September 2016 (The Design Society).
[10] Yin R.K. *Case Study Research: Design and Methods*, 2009 (Sage, Thousand Oaks, CA).
[11] Robinson V. *Problem-based Methodology: Research for the Improvement of Practice*, 1993 (Pergamon Press, Oxford).
[12] O'Mahony M. *Advanced Textiles for Health and Wellbeing*, 2011 (Thames & Hudson, London).