Potentials and Constraints: Digital Design- and Manufacturing Tools for the Creation of Individualized Street Furniture

Florian Zwangsleitner

Technische Universität Berlin/Germany · f.zwangsleitner@tu-berlin.de

Abstract: Street furniture has a strong impact on the quality of a site. However, standardized and ready-made objects, which often lack the ability to contribute to the creation of distinctive places, are frequently used. In particular where unique solutions are required, landscape architects should be substantially involved in the development of street furniture. Digital design- and manufacturing tools can enable an efficient approach for the development of outstanding elements. In order to benefit from the potentials of these tools, the mastering of the required software applications, an understanding for the machines of implementation and a thorough knowledge of the materials to be used are mandatory. The outcomes of a student workshop indicate that designers need to be aware of the strengths and weaknesses of the different digital and analogue design tools available, and then select the most appropriate according to the assignment. To keep up with the ongoing digitalization, teaching in landscape architecture needs to be developed accordingly. Digital tools should however not restrict design creativity through constraints in handling the application software.

Keywords: Digital manufacturing, landscape architecture, parametric design, individualized street furniture, teaching

1 Introduction

The paper addresses the relevance of individually designed street furniture and the typical challenges for its implementation, as well as special features emerging from digital design- and manufacturing tools in teaching and practice. The focus is on seating areas made out of concrete.

Corresponding to landscape architect Sophie BARBAUX, the relevance of the design of urban furniture "cannot be ignored at a time when urban planning concerns us more and more, with demographers announcing that in 2026 84 % of the population of industrialised countries will be living in large cities" (BARBAUX 2010:7). According to her, the urban space nowadays "often resembles a motley collection of heterogeneous objects that doesn`t make any sense". She states that the quality of the design of urban furniture is one of the key elements in the city`s transformation in order to become a place of sharing and hospitality, in "a world that is too often standardized" (ibid.:8). The knowledge of designers, architects and- as the topic is related to the public open space- landscape architects is needed to conduct the process of transformation.

Street furniture has a strong impact on the quality of a site. It is expected to increase urban liveability, enabling more frequent and more comfortable outdoor activities. Well done, an urban seating accommodation is more inviting, pleasant and encouraging a more positive relation between its users (BROTO 2012:7). Seating in particular should be "a place for meetings, planned or random, for pausing alone or with others, and even a rallying point or a place for discussions... Combined with a table, it allows one to picnic outside or to work even with

Journal of Digital Landscape Architecture, 3-2018, pp. 336-343. © Wichmann Verlag, VDE VERLAG GMBH · Berlin · Offenbach. ISBN 978-3-87907-642-0, ISSN 2367-4253, e-ISSN 2511-624X, doi:10.14627/537642036.

a computer, thanks to WiFi technology" (BARBAUX 2010, 22). Extending beyond its initial purpose, seating elements also "give rhythm to and punctuate landscape layouts" and therefore play an important role for the spatial composition of a place (ibid., 22). Multifunctional street furniture can extend the usability of public spaces and aesthetical impressive design can enhance the attractiveness of entire regions.

In order to satisfy these multifaceted tasks and expectations, many prerequisites need to be fulfilled. They range from the quality of features experienced by our senses, such as visual, haptic, olfactory or acoustical properties to the appropriate integration within the surrounding landscape design as well as functional, economic and ecological reflections and considerations in terms of comfort, safety, accessibility, durability and robustness. Furthermore all these basic prerequisites have to be consistent with existing regulations and fulfil the expectations of the client.

Due to limited project budgets or reasons of maintenance, clients often prefer standardized, ready-made street furniture. By fulfilling aesthetic and functional demands, the lack of the ability to create distinctive sites remains. Standardized furniture offers mainly specific uses and is often disadvantageous, due to functional constraints. Where unique design solutions are required, such an insufficient situation leads to discontent on the part of the landscape architects, that aim to offer "tailor made" solutions, matched with what we call the *genius loci*, the spirit of a place.

Therefore landscape architects should take a leading role on the development of individualized street furniture. However, the development of street furniture is a highly complex task and landscape architects may not be able to fulfil all of the prerequisites mentioned above satisfactorily. It is therefore advisable to collaborate with experts of other disciplines like carpenters, metal-workers, product designers or specialists from the concrete industry. Also associations dealing with barrier-free design or people working in the field of gender studies are potential partners.

2 How Can Digital Design- and Manufacturing Tools Contribute to the Development of Individualized Street Furniture?

2.1 3D Digital Design and Manufacturing

The question presented in this paper is, "how can digital design- and manufacturing tools contribute to the development of individualized street furniture that fulfils the wide range of expectations and prerequisites mentioned above?" A first answer to this question is given by David BACHMANN, a professor of mathematics at Pitzer College in Claremont, California. He states that since we live in a three dimensional world and everything that surrounds us, every living organism, every building, every piece of street furniture- even our own bodies- is three dimensional, we have to learn how to create in three dimensions (BACHMANN 2017, 1). This is, of course, nothing new and has been done for thousands of years, for example by sculpting clay, carving wood or chiselling marble. Also in landscape architecture, architecture and product design, three dimensional model making is a widely used design methodology. However, contemporary designs sometimes need more precision, especially if certain tolerances are needed to be reached (ibid., 1). 3D design- and manufacturing tools offer new possibilities for this by allowing designing at a scale of 1:1 and a direct and precise production through a digital computer model and digital production methods such as CNC milling, laser cutting or 3D-printers. The ability to implement designs from digital 3D-models without 2D abstraction enables a more efficient, automated production process (WALLIS 2016, 185).

3D digital design- and manufacturing tools that are controlled by parametric inputs promote a more process-based design approach that enables systematic design and adaptation. According to Christopher BEORKREM, assistant professor of Architecture at the *University of North Carolina*, this leads to a logic based, responsive form-making (BEORKREM 2013, 8). Therefore the form of the design is not primarily generated by composition and geometries but by the declaration of specific parameters and rules (WALLIS 2016, xxviii). These parameters and rules are influenced by functional goals but also by the strengths and constraints of the machines and tools in use (CNC milling etc.) together with the "material characteristics, such as dimensional properties, durability, deformation, water proofing and weathering, connection types, relative costs, color, texture and finish" (BEORKREM 2013, 9). To efficiently benefit from the potentials of parametric tools, a thorough knowledge and understanding about material properties as well as for the interaction between tool and material are prerequisite.

2.2 Outcomes of a Student Workshop

A student workshop at the TU Berlin was initiated in order to investigate the strengths and weaknesses of the different tools available for the creation of distinctive pieces of street furniture. The aim of the initial phase of the workshop was to find appropriate form designs by using different design methodologies in order to assess which methodology is most suitable for this task. As the quality of the outcomes of student works depended on their individual skills and talents, prior experience and their individual motivation, the results were unforeseen. Never the less, it can be assumed that the possibilities and constraints of the application software have a strong influence on the resulting form design, as the initial results of the students mainly involved complex, asymmetrical and rounded forms.

Another observation was that a large number of students were not sufficiently skilled with the available 3D-software applications in order to develop their desired designs. It may be supposed that the same problem also exists in landscape architecture offices. Through using analogue techniques like model-making by hand for the development of the form design, many students were able to create suitable results more readily (Figure 1). Nevertheless, digital parametric design tools revealed a major advantage: By simply changing design parameters a diversity of variations can be automatically generated, discussed and adapted according to the wide range of demands in a short period of time. However, only a very few students − the ones that already had outstanding skills in a parametric design software application − could benefit from the digital techniques. From these experiences the following tendencies can be derived:

1) Designers − as well as students − should be aware of the strengths and weaknesses of the different digital and analogue design tools available, and then select the most appropriate according to the assignment and their individual skills and preferences. Digital designing tools are not intended to replace analogue techniques but expand the range of creative tools.

2) The use of digital tools requires advanced skills in the application software. Three dimensional digital designing tools offer great opportunities but also constitute a complex

task. Hence we need to give a greater importance to the in depth teaching of relevant software applications. Teaching in many landscape architecture schools already allows students to follow different specialist subject areas. One of these specialist subject areas should focus on digital designing and production together with the necessary software applications. As our working tools and techniques become more and more specialized, another solution appears: By giving a greater importance to an interdisciplinary approach in the education of future landscape architects, they should be able to channel the different skills needed for complex tasks and collaborate with other experts like 3D- design specialists. This interdisciplinary approach includes gaining an understanding of the relationship between different parts of a project, the ability to lead a team of experts with differing skills, and the competence to take decisions whilst recognizing the effects on the project in general.

3) Visual scripting platforms like the Grasshopper software plug in application for Rhino 3D software and other parametric design software applications already allow for an "*infinite customization of the design process without knowledge of programming*" (Bachmann 2017:1). In order to make software applications even easier to handle and more user-orientated in the future, we have to provide feedback concerning required functions to the software developers.

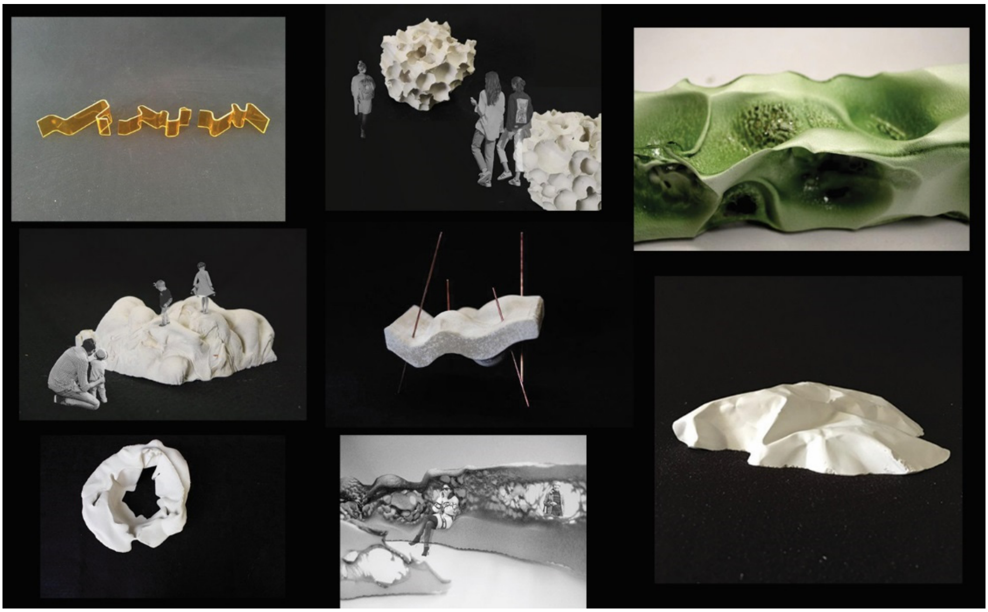

Fig. 1: The collage of models produced in a student workshop shows that the participants were able to develop interesting shapes by using analogue techniques more readily

The workshop continued by transforming the resulting forms into feasible street furniture. Students that created more complex forms faced problems in developing detailed design solutions and an appropriate technical realisation. Furthermore, it was particularly difficult to present these objects through traditional presentation methods such as sections, elevations and plan views. Manual models generally took longer lengths of time to produce and adaptations in the design resulted in the need to start again from scratch. Using 3D digital tools, the problems associated with the initial design phase remained. Some students even failed to transform their idea into a digital 3D-Model because of a lack of handling skills and thorough understanding of the software applications.

In order to solve this problem, the transformation of hand-made models into digital ones through 3D-scanning was considered. However this was not possible at the university due to time and due to budgetary constraints. It can be assumed that professional landscape architects are facing similar problems as it is not yet common to have a 3D-scanner in Landscape Architecture offices.

A solution was found through using photogrammetry with a standard camera and open source software (Figure 2). The results were sufficiently precise to serve as a basis for the further digital development of the product. 3D-scanning and photogrammetry can bridge the gap between analogue and digital design methodologies- thus saving time in creating of complex digital 3-D models. The benefits of model making by hand that many designers prefer- the direct experience of the proportional and haptic attributes as well as the possibility to work directly with the hands without any additional interposing tools- can be combined with the possibility of the precise processing of parametric designing tools to create diverse variations in a short period of time.

Fig. 2: Photogrammetry revealed an alternative to 3D-scanning or complex modelling (Friederike Zillmer, Quentin Derniaux)

After the design phase the students created feasible technical drawings that would allow companies to implement the design. The depiction of objects with complex shapes turned out to be especially problematic. It was also noticed that the formwork construction of many of the objects would be very difficult and thus very costly. CAM/CAD approaches such as CNC milling, 3D-printing or the use of industrial robots were considered alternatives. These approaches provide means that bridge the gap between design and production by operating directly from the 3-D-software application that had been used to generate the design.

They also make complex manual formwork production nearly unnecessary. In his publication Architecture in the digital age, Branko KOLAREVIC stated that digital design- and manufacturing tools "…opened up opportunities by allowing production and construction of very complex forms that were until recently, very difficult and expensive to design, produce and assemble using traditional construction technologies" (KOLAREVIC 2009, 3) Beside the wellknown production methods like CNC milling and 3D-printing, the digital revolution offers designers even more possibilities.

One promising method is offered by Clever Contour, an Austrian start-up enterprise that allows the creation of objects out of concrete without the need for formwork. Hence the costs for objects with complex shapes and one-off elements can be reduced, compared to a conventional implementation through formwork-making. The technology is based on a bending machine that allows a three-dimensional deformation of formwork struts made of plastic. The transformed single thermoplastic struts are lightweight and have a maximum length of 1,40m so they can be easily transported to the site of installation. On site, the struts are joined with a tongue-and-groove connection, covered by thin wire gauze and then covered with shotcrete (Figure 3). Additional manual work may be necessary depending on the features of the object. For example, the addition of reinforcement or the supply of a foundation may be necessary depending on the static requirements of the object. To achieve the desired surface quality, the concrete can be finished according to the common techniques such as sanding, etching, grinding or polishing. The implementation of anchors facilitates connections to other structures and materials such as wood, steel, natural stone or synthetic materials. This combination of automatically generated, digital manufacturing processes and traditional building craft enables an endless number of design variations, functions and forms. One of the greatest advantages of the Clever Contour fabrication method is the interactive production process. Starting from a 3D-model or a 3D-scan, digitally offset lines are laid over the model about every 20cm. These offset lines correspond with the thermoplastic struts that are produced later and form the structural basis of the object. A specially developed plug-in for the Grasshopper software application allows flexible adjustments and control from the design-phase to the final product. The plug-in also gives direct feedback to the designer if the shape and the angles of the design are possible to implement. The bending machine that forms the plastic struts is directly controlled by the plug-in, so no additional programming of the machine is necessary and the entire production process for the supporting structure stays under the control of the designer.

Fig. 3: On site installation of Clever Contour technology (© Clever Contour GmbH)

For the workshop participants that applied the Clever Contour plug in, the iterative design process turned out to be very beneficial. Adaptations in the design caused by considerations at a late stage of the design did not require the need for extensive redrawing. Also, the production of many sectional drawings in order to fully depict complex objects is not necessary as the digital 3D-model constitutes the design drawings and the technical drawings in one. This allows adaptations in the design literally until the end of the production process.

The most innovative student designs are currently being prepared to be implemented as prototypes (Figure 4). The designers and engineers of Clever Contour are reviewing and revising the work of the students based on technical feasibility and static requirements. From this process of revision and realization we expect to gain further information about the advantages of digital tools for the production of landscape architectural objects. One question emerging for further research is how the finishing of the shotcrete needs to be executed in order to create surface properties that are inviting to use for sitting, climbing or lying on. Furthermore it is necessary to compare the price for the one-off objects with standardized street furniture from catalogues.

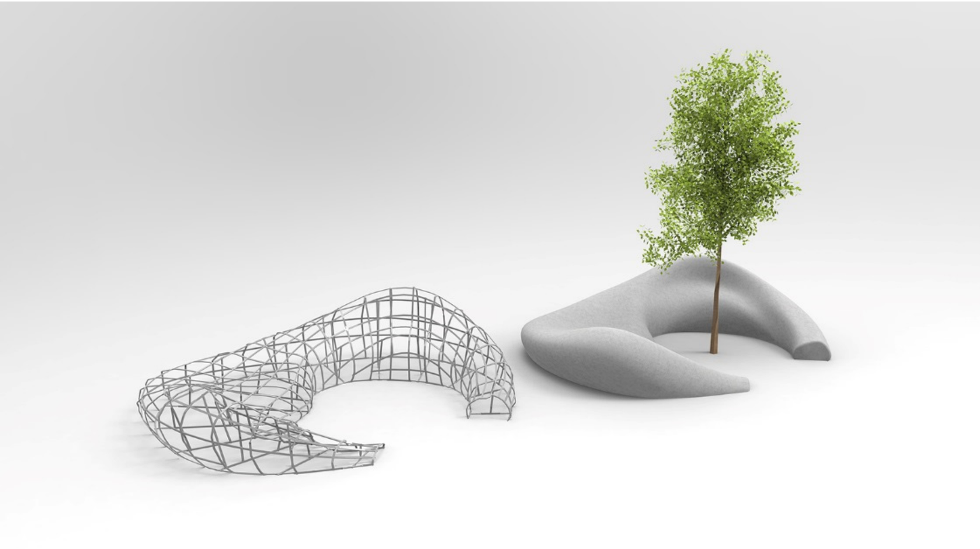

Fig. 4: Proposal for a new piece of street furniture designed by students applying the Clever Contour method (© Clever Contour GmbH, Rosa Sommer, Florian Rüster)

3 Conclusion

Street furniture plays an important role for the quality of stay in public places. However, not only its functions as seating, tables, streetlights, play equipment, rubbish bins or bicycle stands need to be fulfilled, its design and visual appearance can also contribute to the creation of distinctive sites. Multifunctional pieces of street furniture are an invitation to the residents to use urban spaces in a creative, unexpected manner. Decision makers however, often prefer ready-made street furniture from catalogues, mainly due to limited design and implementation budgets. Digital design- and manufacturing tools offer an alternative by simplifying design- and production processes. These tools can for example make the production of complex formwork unnecessary and therefore tend to reduce the costs for the implementation of individualized, one-off concrete street furniture. Another benefit of 3D digital product development is the consequent bonding between the design and the finished product. By using parametric design tools, the possibility to straightforward generate design variations in a short period of time by changing parameters is given. Another advantage is that it allows iterative adaptations to the design throughout the production procedure without revising the complete planning process.

A thorough knowledge of the manufacturing tools and material properties as well as the mastering of the necessary digital software application is however mandatory for designers. One of the outcomes of a student workshop at the TU Berlin was that many students were not sufficiently trained in the specific software applications. In order to meet the challenges of the ongoing digitalisation within the profession it is necessary to give a greater importance to the in depth teaching of relevant software applications. Alternatively, greater importance needs to be given to interdisciplinary teaching methods that enable future landscape architects to cooperate with experts like 3D-design specialists.

Despite all its potentials, digital designing and manufacturing tools do not currently replace traditional design methods and technologies but extend the range of possibilities. Digital conversion techniques such as 3D-scanning and photogrammetry allow analogue and digital model making to be linked within a single design process. Designers must be aware of the strengths and weaknesses of the available tools and choose the most appropriate according to individual skills and the concrete task. Digital tools should however not restrict creativity by constraints of the application software. Our student workshop shows that digital tools influence the form design of objects, which also needs due consideration in the design process. With this in mind, digital designing and manufacturing tools can contribute to the creation of individualized street furniture and thus make open spaces more distinctive and in keeping with what we call *genius loci*- the spirit of a place.

References

BACHMANN, D. (2017), Grasshopper: Visual scripting for Rhinoceros 3D. 1st Edition. Industrial Press, South Norwalk, CT.

BARBAUX, S. (2010), Urban furniture for a new city life. Design Media Pub, Hong Kong.

BEORKREM, C. (2013), Material strategies in digital fabrication, Routledge Taylor & Francis Group, New York/London.

BROTO, C. (2012), Street furniture. Links, Barcelona, Spain.

KOLAREVIC, B. (Ed.) (2003, 2009), Architecture in the digital age: Design and manufacturing. Reprinted, Taylor & Francis, New York/London.

WALLIS, J. (2016), Landscape architecture and digital technologies: Re-conceptualising design and making. Routledge, London, UK.