Learning Generative Design Methods: Higher Education Students Developing Toolkits

Jaana Kärnä-Behm

Abstract

In order to achieve successful products and services, design research nowadays is searching for new methods that unify collaboration between professional designers and future users. Developing and using these new design methods is also of interest in design education. In this study, design toolkits are developed to practise participatory design with a user-centric orientation. The purpose of this study is to analyse a case in higher education where students of art and design aimed at becoming craft teachers developed toolkits in design situations appointed beforehand. The literature review of the toolkit shows that a diverse and multidisciplinary field of applications has been developed. The data of the study consist of 24 virtual or physical toolkits made by the students as well as their reflections on their work. The results showed that executing a design process where students in a design situation had to enter into the future user’s world creates empathy for designers. Also, various elements connected with the unifying of senses and physical activities were built into the toolkits as well as certain game-like features. The results of this study can be used as basic data concerning making educational insights in design education in higher education.

Keywords
art and design, higher education, design education, participatory design methods, craft, toolkit

Introduction

Nowadays amongst designers, there is an ever-growing interest in methods involving users in product and service design (Helminen et al. 2016, 176). User-centred design, also known as human-centred design, is a multidisciplinary approach that
relies on a user’s involvement during the design and development process (Mattelmäki 2005; Millet & Patterson 2012). The goal is to introduce an understanding of the user’s needs into design work and transfer it into the product specifications (Mattelmäki 2005, 29). Recent design research practice has shown that there is now a wide spectrum of tools and methods to do design research based on a collaboration between non-designer participants, one of these methods being toolkits (Sanders & Stappers 2014). The current article promotes the toolkit method to strengthen and enrich the design ideation and activities connected to design education in the context of higher education in art and design.

Toolkits are usually based on making and as such they ‘give people—designers and non-designers—the ability to make ‘things’ that describe future objects, concerns or opportunities’ (Sanders & Stappers 2014, 6). Empirical insights into toolkit design have usually been driven by technology and primarily portrayed from an information technology perspective (Franke & Schreier 2002, 232). The innovative methods in user-focused design research are creative and participatory, such as workshops in participatory design, collages and camera studies. These methods, necessary at the early stage of design, in particular, are intended to understand future users’ feelings, pleasure, values and dreams (Hanington 2003; Mattelmäki 2005, 31). Moreover, examples from the industry as well as consumer markets that use toolkits are numerous, although empirical studies in design research are scarce (Franke & Piller 2003, 404). In the context of design research, a toolkit is connected with a design process with the aim of collecting all kinds of information needed in the design process (see von Hippel & Katz 2002, 827). Toolkits ‘bring visions, ideas and concepts (scenarios) for the future’ (Sanders & Stappers, 2014, 8). As such they are connected to learning by doing (von Hippel & Katz 2002; Franke & Schreier 2002, 228).

The toolkit applied in the study is a design toolkit in order to collect user-specific knowledge needed in the design process (see Hippel & Katz 2002, 827). In the empirical part, students create toolkits that according to the beforehand appointed design situation are useful in producing information, ideas and insights for the future user (Sanders & Stappers 2014, 10). The user-centred orientation, from which the students approach and carry out the design assignment, has especially an educational focus; by executing the toolkit design assignment, students are able to have first-hand experience of making design research focusing on the future user (see Table 1). The participants are art and design students who aim to become craft teachers. In the Finnish context, the craft is a school subject having nowadays a broad meaning without making a fundamental distinction between artistic, crafting and technological approaches (Kokko, Kouhia & Kangas 2020, 1). Still, craft refers strongly to the process of making and on based on this, craft education is determined in the National Core Curriculum as a subject in which ‘multiple materials are used, and activities are based on craft expression, design and technology’ (FNBE 2014). In the context of design, craft education is promoted as design-based learning related to the solving of authentic problems, for example, problems in our daily lives, and the shaping of environments. (Pöllänen 2009; Seitamaa-Hakkarainen 2010; Kangas et al. 2013). In such a design process, as well as participatory design in general, the significance of the future user has an essential role in producing reportable results for directing the definition of the design problem and the decision-making about it (Mattelmäki 2005; Sanders & Stappers 2008).
The objectives of this article are 1. to introduce toolkits as a generative design method in design education, and 2. to analyse a case in which students of art and design developed toolkits in a design situation set beforehand. The article is organised as follows: a literature review of the concept and method of toolkits in various eras of design is first given and followed by a description of the method and settings applied. The findings of the study are then reported and last, in the conclusion, the implications along with issues for future application of the toolkit method in higher education of art and design are discussed.

### Toolkits as a Method for User Innovation and Design

The challenge, especially with product design, is that people are seldom aware of their needs, or have an inability to formulate these needs explicitly (Franke & Piller 2004, 404). The difficulties in determining users’ requirements have led to research regarding the possibilities of directly integrating future users into the product development process (Humphrey et al. 2014, 182). It is even a fact that the most radical innovations often come from users who are non-designers rather than professionals or manufacturers, which is notable also in the methods and practice of design research (Franke & Schreier 2002, 226). In various design contexts, toolkits can assist with idea generation (Clatworthy 2011, 26; Lockton, Harrison & Stanton 2013) and are also widely used in service design (Baek &

### TABLE 1

Objectives and actions/decisions from the point of view of the students in the toolkit design assignment

<table>
<thead>
<tr>
<th>The toolkit as a design assignment</th>
<th>Objectives</th>
<th>Actions/ decisions for the group to make</th>
</tr>
</thead>
<tbody>
<tr>
<td>The purpose of the design assignment</td>
<td>To learn and have first-hand experience of the design situation with a user-centred focus in the educational context.</td>
<td>To formulate elaborated design criteria and the aim of the toolkit according to the beforehand appointed design case.</td>
</tr>
<tr>
<td>Execution of the design assignment</td>
<td>To design a physical or a virtual toolkit according to the group's choice based on a case given beforehand.</td>
<td>To decide the form and content of the toolkit based on a case and the making of the toolkit.</td>
</tr>
<tr>
<td>The role of the future user in the design assignment</td>
<td>To understand the significance of the future user’s role in a participatory design process.</td>
<td>To define the future user more closely. For example: age, gender, hobbies, and other background details.</td>
</tr>
<tr>
<td>The role of the student in the design assignment</td>
<td>To assume oneself to be the designer/researcher unifying the toolkit method in a design process.</td>
<td>To define what kind of knowledge is intended for the design process and what kind of tasks included in a toolkit would serve the purpose.</td>
</tr>
<tr>
<td>Evaluation of the design assignment</td>
<td>To evaluate the applicability of the toolkit method to various design situations as well as in design education.</td>
<td>The group evaluates the usefulness of the toolkit as a design method from the point of view of applicability in design as well as in future teaching projects.</td>
</tr>
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Lee 2008; Floyd & Vernon-Dotson 2009). In the most favourable cases, toolkits enable fluent communication between the user and the designer/researcher (Helminen et al. 2016, 167).

The phenomenon of shifting certain innovation tasks from the manufacturer to the future user by means of toolkits for user innovation was first theoretically analysed by Eric von Hippel (Franke & Schreier 2002, 227-228). In user innovation toolkits (von Hippel, 2001; von Hippel & Katz, 2002) the core is to transfer users’ use-specific knowledge to provide information for developers. Toolkits can also be coordinated sets of (user-friendly) design tools that enable users to develop new product innovations for themselves (von Hippel & Katz 2002, 821; Svensson and Hartmann 2018, 279). As such, users can ‘create a preliminary design, stimulate or prototype it, evaluate its functioning in their own use environment, and then iteratively improve it until satisfied’ (von Hippel & Katz 2002, 821).

There are several kinds of toolkits used for variable purposes and in different design situations. The purpose of user toolkits is to give manufacturers and companies better access to information regarding customers’ needs by allowing customers to actively articulate their requirements (von Hippel 2001; Hippel & Katz 2002; Humphrey et al. 2014, 182; Helminen et al. 2016, 164) or even prototype their ideas (von Hippel 2001; Helminen et al. 2016, 164). In user innovation toolkits, users’ choices are restricted by the solution space and/or the module library to assist the user and the developer in speaking the same language. The idea is also to offer future users ‘an equal possibility to “prototype” their ideas’ (Thomke & von Hippel 2002; von Hippel & Katz 2002; Helminen et al. 2016, 163). The ‘prototype’ idea was followed in the product design of sports footwear with the aim of developing and testing an online collaborative design toolkit for the personalization of running shoes to deliver an enjoyable, satisfying experience for a consumer wishing to personalise his/her shoes when ordering them. The YourStep toolkit, a web-based service, consisted of collecting personal data connected to running, such as users’ measurements, colour preferences, etc. in order to personalise the running shoes to be purchased (Head & Porter 2011).

In toolkits for innovation and design, customers’ heterogeneous preferences, as well as problems in shifting this information from the customer to the manufacturer, can be better taken into account (Franke & Piller 2004, 403). In participatory design, Sanders and Stappers (2014, 7) refer to generative toolkits that can be used by non-designers, usually future users, as the front end of design so that these users can imagine and express their own ideas about how they want, for example, to live, work or play in the future. As a tool in the design process, they give non-designers a means by which to participate as co-designers in the design process. As a concrete tool, toolkits can be made of 2D or 3D components, such as pictures, words, shapes or objects like buttons, wires, etc. (Sanders & Stappers 2014, 7). With the aim of developing a user innovation toolkit, toolkits all including physical building blocks but still varying in their solution space were constructed and examined in the context of shopping centre design (Helminen et al. 2016). Participants implemented their ideas for the shopping centre of their dreams. In the study, it was found that a physical toolkit, being a material artefact but not a ready-made object that needs to be created through the action of participants, facilitates the transfer of information from the user to the researcher (Helminen et al. 2016, 175).
Research Design and the Context of Designing Toolkits

Sanders & Stappers (2014) conceptualise the design process in four phases in which the first is the pre-design phase followed by the generative, the eva l uative, and finally the post-design phases. As a design method, toolkits are used in the early front end of the design process and are generative in nature. The purpose is to produce ideas, insights and concepts that may be designed and developed (Sanders & Stappers 2014, 10). In collecting user knowledge for design in this study, the toolkits made by the students are made with the idea that they are to serve as a dialogue between the future user and the designer/researcher. This introduces an understanding of the user’s needs into the design situation and transfers this knowledge into the product specifications (Mattelmäki 2005; Sanders & Stappers 2014).

The empirical part of this inquiry was carried out in the context of art and design higher education in the 2018 and 2019 spring terms. Our Bachelor’s degree in Education includes a compulsory course named Teaching design (5 credits), where the aim is to learn methods and tools suitable for teaching design, especially within basic education. In the course, various methods and materials that support teaching design are created, adapted and tested. The course consists of lectures, design exercises as well as collaborative project work. There were three other teachers and the author supervised the toolkit project as one part of the course.

The toolkit applied in this study is typically a design toolkit (see Hippel & Katz 2002, 827), which can be defined as a range of materials and tasks for the future user to perform (like tasks and materials stimulating the senses, interviews, etc.) in order to collect the information needed in the design process. Toolkits are usually used in the early front end of the design process (Sanders & Stappers 2014, 10). In our project, the toolkit was created to collect user information, such as values and appreciations, from non-designer future users in a design situation set up beforehand. Due to tight time limits, the design assignments, formulated as four separate cases, were imposed by me as a teacher on the course. The execution of the toolkit could be a physical or a virtual one according to the group’s choice since that did not have an effect on the content required. Unifying physical materiality in a design process, that is to feel, touch or build with concrete material, has proved to be a usable method, especially with non-designers (Helminen et al. 2016; Mäkelä & Löytönen 2017). In the introductory lecture to the design assignment, it was clarified that a physical toolkit can consist of some concrete tangible material or tools that for the user enable actions of making, such as drawing sketches or building constructions (see also Sanders & Stappers 2014, 6), whilst a virtual toolkit is usually used with a computer or with a mobile phone.

According to the design assignment given to the students, the toolkit had to be designed and implemented mainly in three- to five-person groups. As content was demanded by the design assignment, the group had, first, to start with target setting and creating the design criteria for their toolkit. This included, for example, (i) what kind of knowledge is desirable for the user to achieve. They also (ii) defined the product to be designed using the toolkit although the product did not have a significant role here: it was more important to focus on the future user and formulate a toolkit to collect the user knowledge. In addition, (iii) the content and form of the toolkit had to be specified as well as (iv) a description of the situation in which the toolkit designed is going to be used. Last (v), each group reflected on
the extent to which the toolkit method was applicable to teaching design in basic education, and they also evaluated the design and making process as a whole. The design assignment was deliberately constructed so that there were certain gaps. For example, some senses (sight, sound, etc.) were missing. By restricting the use of all senses, the author wanted to see whether it had some effect on the realisation of the toolkit. The beforehand-imposed design assignments as cases were:

Case 1. A child starting his/her school next term with a special characteristic of finding concentration difficult. (n = 6).
Case 2. A young adult studying the welfare era. (n = 6).
Case 3. A visually impaired adult living in his/her own apartment. (n = 6).
Case 4. An elderly person living in a service flat. (n = 6).

The data of the study consist of 24 toolkits, six for each case. The toolkits (if a virtual one) and descriptions of their contents were saved on Moodle, a virtual learning environment used in the course. The toolkits could not proceed to the testing stage because the design situation was a fictional one and the aim was to give the students methods and ideas for the teaching of design that would also be useful in their own future teaching. Still, based on each group’s presentation in the evaluation, other students estimated the toolkits verbally. In evaluation, the students also considered the toolkit method from the point of view of applying learning design in the context of basic education. The objectives, as well as the actions/decisions of the design assignment from the point of view of the students, are described in Table 1.

**Results**

The analysis of the findings of the toolkit design process is next conducted starting with exploring the realisations of the toolkits more closely. As seen in Table 2, most of the toolkits were implemented as virtual realisations (n = 10) based on working with a computer or in some cases with a mobile phone. In Case 2, most of the toolkits were virtual. Virtual realisations were composed as visual sketches and as descriptions of contents implementing the toolkit. The sketches outlined the

<table>
<thead>
<tr>
<th>Case 1. A child starting his/her school next term with a special characteristic of finding concentration difficult (n = 6)</th>
<th>Virtual (V)</th>
<th>Physical (P)</th>
<th>Both (V + P)</th>
</tr>
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<tbody>
<tr>
<td>2</td>
<td>2</td>
<td>2</td>
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</table>

| Case 2. A young adult studying the welfare era (n = 6) | | | |
|---|---|---|
| 4 | - | 2 |

| Case 3. A visually impaired adult living in his/her own apartment (n = 6) | | | |
|---|---|---|
| 1 | 3 | 2 |

| Case 4. An elderly person living in a service flat (n = 6) | | | |
|---|---|---|
| 3 | 2 | 1 |

| Total (n = 24) | | | |
|---|---|---|
| 10 | 7 | 7 |
visual design of a toolkit and were made with computer graphics. A virtual option was argued mainly because of its ability to be updated for various design situations, as well as to be shared with other users in the future. Virtual toolkits included questionnaires as well as solution spaces where the user has to choose between, for example, colours, materials, pictures or other visual elements. In some virtual toolkits, multimedia elements, like sounds, were included.

The toolkit as a combination of both virtual and physical elements (V + P) was typically used in a design situation in which the group, in addition to the digital form, also wanted to connect sensual elements or physical activities, such as exploring concrete materials, adding scent elements or operating in real-world space \( (n = 7) \). Where physical (P) toolkits \( (n = 7) \) were concerned, most ended up in Case 3 mainly as a consequence of the impaired vision of the future user. Properties to be sensed were also aspired to in Case 1. This and other cases are next analysed in order to describe them more fully.

In Case 1, the solutions produced started by attempting to overcome the child’s concentration difficulties either by paying attention to the elements and routines which facilitate concentration or by creating environments or instruments which facilitate concentration or transitional routines when leaving home and going to school. Reassuring a child is the aim of one piece of training in which the toolkit is thought to give information and support the planning of a special kind of place to calm down in the school environment. The information was gathered from the sections on materials, colours, forms and the most favourable place in school. Information from the literature on the case supplied useful background information when designing the toolkits. In two toolkits, the aim of the project was chosen to be the designing of a child’s own working place. In one of these toolkits, an optimal working space is sought by cutting down elements that hamper concentration and by searching for a suitable level of pleasantness. In Case 1, a game-like element was included. In a toolkit concentrating on the interior design of a child’s room, for example, choices like the materials and colours desired for the space by the user are sought and rewarded with the help of a funny robot character.

In Case 2, a young adult studying the welfare era, the toolkit was intended mainly to support the design of a space. The user’s preferences, for example in decor, were analysed either before, or in connection with the use of the toolkit. In this case, a toolkit as a type of mobile application was also created. The application aimed to be as user-friendly as possible and contained a feature that allows easy access to results. The application produces choices based on user preferences, collects subjects of interest to the user, and gives some guidelines about interior design. The use of the application is aided by means of certain themes. After collecting and handling the results, the application offers some advice about interior design and also offers help to designers. It was notable that toolkits created to support the design of a space in this case included many multisensory elements—such as a choice of room fragrance (Figure 1).

In Case 3, concerning a visually impaired adult, the design of the toolkit was experienced as rewarding especially in those cases where the students had first-hand knowledge of disabilities and their various effects on daily life. In one of the toolkits, the design criteria created were to help design storage cabinets needed in a domestic context so that they formed a unified design. In another toolkit designed in this case for visually disabled persons, other normally working senses like the senses of hearing and touch were unified to form a multisensory space (for more on multisensory space, see Kärnä- Behm 2019). The toolkit contained
stimuli such as the sounds and sights of a forest, a city and a beach. The aim of using this toolkit is, based on the choices of the user, to proceed to design an interior product. In one toolkit named ‘Colourbox’, the aim was to seek the best colour alternatives and contrasts for a visually disabled person’s home living. Background information about visual impairment was gathered for this toolbox and also a visually impaired person was interviewed. The interview discussed the problems of independent dwelling for a visually disabled person and the colours and lighting that helped such a person. For the process, a special design path was constructed (see Figure 2), which also included testing the collected information.
The toolkits designed in Case 4, an elderly person living in a service flat, were to assist in the interior design of an occupant’s room in a residential care home or to assist in designing various storage solutions for his/her belongings. In one toolkit the target was not defined in any more detail than, ‘with the use of various senses to analyse the occupant’s interests and preferences and to help define the challenges that disorder causes and how this disorder might affect his/her daily life’. In this case, especially, and in light of the fact that the subject was an elderly person, an attempt was made to include in the toolkit elements that awoke memories. In half of the toolkits, a fictional person was created to facilitate the design process. In another toolkit formed as a virtual realisation, a movement from simple and concrete elements emerged, like choosing colours or materials in a solution space created for more conceptualised and wider purposes. The group described that the purpose of the toolkit was to try and compose qualities or themes from the pictures chosen by the user, for example, peacefulness, a tropical atmosphere, etc., that, as a starting point of the design, could be utilised in the interior design. Furthermore, the group brought out that in the use of a toolkit, one must be prepared for the fact that the themes might also bring out negative memories. It was important to observe and pay attention to this fact.

**Students’ reflections**

The character of craft as a design of physical products is widely shared in the current craft era and craft education (Ihatsu 2002; Kojonkoski-Rännäli 2008; Pöllänen 2009, 2020). This was reflected in the student’s written comments that they did not initially realise that they were actually designing a design tool and not a product. In spite of this, the toolkits as a whole were seen to direct the design process towards a user-centred orientation so that it would be easier for the designer to understand the user’s needs and preferences. In the students’ reflections, it was strongly brought out that the practice and application of the method increased their ability to acknowledge empathic issues in design. The inference of what it feels like to be another person and how this affects our daily life and the surroundings to be designed is one of the main issues in empathic design (Wright & McCarthy 2008; Postma et al. 2012). This was for its part facilitated in the toolkits by defining the background of the future user more closely. Toolkits were seen as useful in event planning and product design as well as in situations where decision-making was complicated or required an awareness of the whole picture.

According to the students, toolkits are useful, for example, in basic education because they allow children and young people to understand better what kind of difficulties, say, visually disabled persons can encounter in their daily lives. After designing the toolkit students thought that by initially clarifying the end user’s views, preferences and opinions their needs could be better taken into account at the beginning of the design process. The students pointed out that in Finland when the school subject ‘craft’ focuses more on the significance of planning in the making of craft objects in the future, then the toolkit as a design method would be a very useful instrument. Some value was also seen in designing a product for customers outside of the school.

The most popular realisations in toolkits were virtual ones. When students discussed their choice of the toolkit, it was clear, especially in basic education, that the virtual toolkit was seen as successful equipment for pupils with varying backgrounds. With virtual toolkits, the production of ideas and content for some design situations would not need to be dependent on verbal delivery or drawing skills. On
the contrary, it was mentioned that virtual realisation could somehow facilitate the work of the teacher. In these cases, the toolkit was understood to be more a method used by the teacher with the students in a certain design task in basic education. Another challenge in applying the toolkit method, especially in basic education, was according to students that it is a fairly laborious method requiring time resources and a lot of planning.

Conclusion and Discussion

Empirical insight into the toolkit as a design method is few but desirable (Hippel & Katz 2002; Franke & Piller 2003; Sanders & Stappers 2014). The objectives of this study were to explore the toolkit method in design education and to analyse a case in which art and design students developed toolkits for a previously decided design situation. In our Teaching design course, the fairly restricted time resources allocated meant that the toolkits were verbally estimated in evaluation by other students but were not tested in actual practice. One must, however, emphasise that more than testing something, the goal was a pedagogical one: the toolkits were designed and made to familiarise students with user-centred orientation in design as well as offer ideas and insights when carrying out similar projects in their own future teaching of design.

The toolkits designed by the students were heterogeneous in quality and some of them, especially those made first, were restricted to being mainly a questionnaire with an interview. Also in the spring 2018, it emerged that some of the toolkits were focused more on being instruments for the designer than offering insights and values from the future user, or that these two functions overlapped. Instead of the user’s own productivity with materials, the toolkits also included elements such as choosing colours, forms and materials for specific design space. The nature of the student-designed toolkits may have been affected by the introductory lecture in 2018, where examples of virtual toolkits with solution space and module libraries were dealt with in more detail than physical toolkits. As a consequence, on the second implementation of the course, in spring 2019, more detailed information about the design assignment as well as possibilities of toolkits in relation to materialisation and the use of senses, was offered. Mäkelä and Löytönen (2017, 255; see also Helminen et al. 2016; Sanders & Stappers, 2014, 6) highlight the significance of materiality in learning design, especially in higher education. In the toolkit project, the students had to think about materials in relation to the future user, for example, what kind of material would serve the purpose of the toolkit in their case and how would the material chosen affect or direct the design process.

Clatworthy (2011, 23) has stated that design students are likely to be more adventurous and enthusiastic about using toolkits than students of other subjects. The author did not reject the implementation connected with the design assignment, so the students were allowed to use any form of toolkits they thought would be most applicable. As a result, various elements of physical activities, as well as game-like activities, were included in the toolkits. Games are nowadays connected to participatory design either as a metaphor or as the concrete formatting of participatory practice, providing ‘a sensitivity to the way tools and techniques must be brought together in a participatory mindset’ (Brandt et al. 2012, 173). These game-like activities are very useful in promoting future applications of the toolkit method. As a whole, and according to the students’ reflections as well, the design and making of a
toolkit as learning by doing process opened up their eyes to the possibilities of the method in participatory design and their future teaching projects.

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**References**


