Integrating repair into product design education: Insights on repair, design and sustainability

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integrating repair into product design education: insights on repair, design and sustainability

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abstract: with the pressure of growing environmental problems, the world is changing and so is the paradigm of design. accordingly, the calls for change in design education have been increasing throughout the literature day by day. as the designers of the future, students must be prepared for alternative scenarios. this paper describes an assignment which is a part of the master’s degree design course at linköping university. in this project, repair is integrated into product design education aiming to explore insights about repair and sustainability. the requirement of the assignment for each student was to visibly repair one or more products in an aesthetically pleasing way by using different design perspectives such as artistic, industrial and critical perspectives. in the end, the students have repaired fifteen different types of products including a bicycle, leggings and a motorcycle part. aiming to find out the insights of this process and articulate each students’ views, a focus group session was conducted. as a result of this focus group session, fifteen insights were developed such as the concepts of brokenness, designed repair and the collaboration/social aspect. all these insights emphasize the richness of the repair as a subject area and how it can be used in product design education to teach sustainability principles. repair is an inevitable part of a product’s life and it should be understood and applied to its maximum extent if we are to transition to a circular economy. the value of this research for academics and researchers is in providing a case of incorporating repair into product design education. for design practice, its value lies in showing concrete examples as well as insights from diverse repair processes.

keywords: repair; product design; circular economy; design education

1 introduction

the current paradigm of product design education serves the linear system and perpetuates a throw-away mentality. the linear economy is based on continuous economic growth and does not allow alternative perspectives to survive. this hegemonic approach has brought us to a global ecological crisis, so we certainly need different ways of thinking and alternative systems such as circular economy to overcome it (ellen macarthur foundation, 2012; van den berg & bakker, 2015; bocken, de pauw, bakker & van der grinten, 2016; ghisellini, cialani & ulgiati, 2016). having the
power to control the product lifespan, influence business and consumer behaviour, designers play a significant role in mitigating today’s environmental problems (Ramirez, 2007) and in the transition towards a circular economy (Andrews, 2015). Design students, the design discipline and accordingly the whole society can benefit from teaching that explores current problems and requires them to articulate prospective solutions.

Students, as the future designers, must be prepared for the alternative scenarios and be equipped with relevant knowledge to be able to deal with environmental issues. This need can be seen from the increasing calls for change in design education throughout the literature (Findeli, 2001; Ramirez, 2007; Norman, 2010; Scheer, Noweski & Meinel, 2012; Andrews, 2015; Wever, Charnley, Brass & Harrison, 2015). Some educational resources, courses and projects exist that aim to incorporate sustainability and circular economy into the product design education (Ramirez, 2006; Doğan, 2012; Lofthouse, 2013; Ellen MacArthur Foundation, 2015; Doğan, Turhan & Bakırlıoğlu, 2016; Bakırlıoğlu, McMahon, Eyto & Río, 2018). However, the number of these projects is not enough, and we have not come across any course that focuses on repair or visible repair.

This paper describes an assignment that aims to integrate repair into product design education and to explore insights about repair and sustainability. The assignment, called “Beautiful Repair”, is prepared as the first part of a master’s degree studio course which consists of three assignments and an exhibition. Beautiful Repair assignment explores how repair can enhance the character, value and aesthetics of a product. The other two parts study different aspects of repair. The second part focuses on the social aspect of repair for which the students organised a Repair Café at the university. The third part focuses on system thinking, designing a system of repair and exploring how repair can be a part of a system. The course is compulsory for first-year students in the product design programme. There are fifteen students with diverse backgrounds such as electrical engineering, philology, and business & management. The duration of this assignment was thirteen weeks. The requirement of the assignment for each student was to visibly repair one or more products in an aesthetically pleasing way by using different design perspectives such as artistic, industrial and critical perspectives. Students were instructed in the fundamental aspects of the circular economy, system thinking and the environmental problems. They had the freedom to choose the product they want to repair and the repair method. Throughout the process students were guided, relevant examples were shown, and their works were scrutinized. Both teachers and students critiqued each individual project during the studio classes. Finally, the students have developed fifteen visible repair projects (Figure 1). They have repaired a diverse range of physically damaged products including bicycle, leggings, and motorcycle part. Each project corresponding to each student can be seen in Table 1.

Table 1. List of projects of the students who participated in the course.

| Student | Project Name          |
|---------|-----------------------|
| 1       | Clockwork             |
| 2       | Red Bicycle           |
| 3       | Leggings              |
| 4       | Ceramic Concrete      |
| 5       | 3DP comb              |
| 6       | Doll Stroller         |
| 7       | Kintsugi Plates       |
| 8       | Paper Lampshade       |
| 9       | Bicycle Lamp          |
| 10      | Cutlery               |
| 11      | BMW Cup               |
| 12      | Headphones            |
| 13      | Watch Strap           |
| 14      | Glass Lampshade       |
| 15      | Motorcycle Part       |

2 Methodology

The purpose of this paper is to explore the insights related to product repair and lay some foundations for integrating sustainability aspects into design education. In order to explore and find out the insights of this process and articulate the individual’s views, a focus group was considered the most appropriate method for this research. This research method enables a deeper understanding of individual insights through “live encounters” with the participants (Stewart & Shamdasani, 2014, p. 12). The focus group session was conducted with the students and lasted around two hours. We did not focus on too many questions but concentrated around the theme and insights that created an interactive discussion rather than a within-group survey (Stewart & Shamdasani, 2014).
Figure 1. The students have visibly repaired a diverse range of physically damaged products including bicycle, leggings, motorcycle part, etc.
A natural and comfortable atmosphere was achieved that students were encouraged to express different points of view and did not feel pressurized (Litosseliti, 2003). Involving all the students created an extensive discussion and probing environment and particularly enhanced the potential diversity of perspectives and ideas generated. A wealth of insights was provided by the students and each insight was discussed according to its relevance to each repair project.

Content analysis was used to analyse the collected data (Weber, 1990). The respondents’ answers with similar meanings and connotations were grouped into clusters. Each cluster was coded under a relevant title. Then we defined how each cluster answers the research objective, which is to explore and define the insights related to visible product repair. With the help of this definition process, the clusters were organised into categories. Finally, fifteen insights have been created including brokenness, nature of repair, value/cost etc. (Table 2).

Table 2. Fifteen insights related to product repair were developed.

| Repair Insights                                      |
|-----------------------------------------------------|
| 1 Nature of Repair                                  |
| 2 Brokenness                                        |
| 3 Designed Repair                                   |
| 4 Designer’s Role                                   |
| 5 Perspectives of Repair                            |
| 6 Product Category                                  |
| 7 Repair Technique                                  |
| 8 Value – Cost                                       |
| 9 Reproducibility of Repair                         |
| 10 Impact of Repair on Future Damage and Repairs    |
| 11 Less/All/More Material                            |
| 12 Aesthetic Language                               |
| 13 Fixing versus Something New                       |
| 14 Collaboration / Social Aspect                     |
| 15 Storytelling / Design Activism                   |

3 Repair Insights

3.1 Nature of Repair

This insight questions what can be called repair. How far we can go with the repair in terms of changing the object’s look or altering the way it is used? What is the difference between repair and upcycling? Repair refers to the act of bringing a damaged or faulty object back to a usable condition. This damage can be related to functional or aesthetic defects. The aim is eliminating the problems that disturb or intervene with the usual ways a product is used. Upcycling, on the other hand, can be applied both on the material level or the object level. For the object level, it is the process of transforming discarded, faulty or out of order objects into something of higher value in their second life (Sung, 2015).

For example, Student 1’s object was an operating clockwork as it can be seen in Figure 2. The clockwork was functional, but it was missing the clock face and the handset. Instead of only creating a new clock face and the handset, the student created a whole new product and changed the way it works. In her new design, the clock face turns to show the time without the handset (Figure 2). The clock face completes one turn in 12 hours and the dots between the numbers represent each quarter of the hour. Similarly, Student 14 reconstructed the broken glass lampshade and created a new product (Figure 3). She used the broken glass pieces after sanding the edges. She designed and 3D-printed a body part and joints. Then, she used joints and red wires to attach glass pieces to the body. These two products can be considered as upcycling rather than repair because both products are reconstructed and redesigned although the function of the objects is the same after each intervention.
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3.2 Brokenness

“What is broken? In which ways is it broken? What makes a product broken? And are there different kinds of brokenness? Is it incomplete or missing a part, or has it lost its value and needs a new aesthetic update?” were some of the questions that came up during the discussion related to this insight. If the product is functioning well but has some ripped parts, can we call it broken? Students had the freedom to decide “what broken is” and “what repair is” themselves so this provided a range of products which are broken in different ways. Out of the fifteen products that students repaired we can see different kinds of brokenness, including products with physical damage, incomplete products and obsolete products. Additionally, these categories can refer to aesthetic or/and functional issues.

| Table 3. Categories of different kinds of brokenness. |
|-------------------------------------------------------|
| Complete                                              | Aesthetic Issues | Functional Issues |
| Incomplete                                            | 1                |
| Physical Damage                                       | 3, 6, 12, 14     | 2, 3, 4, 5, 6, 7, 8, 9, 11, 13 |
| Obsolete                                              | 10               |

Figure 2. Two photos on the left are the clockwork without a clock face before the repair and one photo on the right is the clockwork after it was repaired by Student 1.

Figure 3. Student 14 reconstructed the broken glass lampshade and created a new one by using the broken glass pieces and 3D printed parts.
Student 1’s clockwork repair was briefly explained above. It did not have any damaged parts, but it was not working because of the missing part. Accordingly, this project goes to the incomplete and functional issues categories in Table 3. On the other hand, Student 10 worked with cutlery. The cutlery goes under the obsolete and aesthetic issues categories in Table 3 since it did not have any physical damage or functional issues. Users did not want to use the cutlery because of aesthetic concerns as they were not matching.

3.3 Designed Repair

“How do you determine how to repair something? How do you get a designed repair? What are the similarities and differences between the repair process and the design process?” were some of the questions that came up during the discussion about the design process. During the repair process, one works on an already designed product with damaged parts and most of the time needs to make new design decisions. Technical and aesthetic features of the product, as well as the repairer’s skills and knowledge, need to be considered while making these design decisions. The designed repair process differs according to the materials and methods used. Some repair methods are easy to apply so that a product can be repaired more than once and enables experimenting. In the 3D comb, watch strap and headphones projects, students produced more than one repair solutions. However, there were other cases where the repair method was time-consuming and expensive. For example, Student 1 had one chance to complete the repair of the clockwork.

3.4 Designer’s Role

The designers’ role has been shaped according to the conditions set by the linear system and throughput-based economy. It is changing as the system transitions towards a circular one. This study underlines the designers’ role in the repairing process, which is bringing a product back into use beautifully, critically or functionally. Their role is transforming objects and people’s mindsets with creativity and innovation.

3.5 Perspectives of Repair

Artistic, industrial or critical are some of the different perspectives that can be used to visibly repair products. The perspective can be decided from the beginning or might be formed during the process depending on the nature of the damage, design of the product and the repair methods. For example, Student 2 repaired his bicycle with an industrial perspective then he painted the repaired part artistically also because of a functional requirement. The hinge of the folding bike was broken and got thin and weak due to rusting. With the help of the experts in the workshop, he created a new hinge by welding nuts to the remaining part of the hinge and machined a metal axle to go through these nuts (Figure 4). He drilled through the nuts to remove the threads before welding them to the bicycle. Finally, he painted the newly created hinge to prevent it from rusting again. By purposely selecting a contrasting colour, the student highlighted the repair. Here, the functional repair and the aesthetic repair are thus somewhat separated from each other.

Figure 4. Student 2 repaired the hinge of his bicycle with an industrial perspective then he painted the repaired part to prevent it from rusting.
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Student 4 adopted an artistic perspective from the beginning of the project. He repaired broken ceramic cups by covering them with concrete and shaping them with cylindrical moulds (Figure 5). Then, to highlight the broken parts he used kintsugi which is a traditional Japanese repair method of mending ceramic products with gold and silver powder. He explained why he used these two different materials with the contrasting meanings with these words: “I liked the idea of using cement, a strong a sturdy material, to contrast the fragility of ceramics and create something that identified with longevity rather than fragility.”

3.6 Product Category
Students had the freedom to choose any product they wanted to repair visibly, in other words, there was no single product category focus in this study. This created a diverse product spectrum from electronic products such as headphones to textiles such as leggings and enriched the results of the study. As the visible repair was one of the requirements, all the products they chose were physically damaged.

3.7 Repair Technique
Repair techniques differ according to various factors such as product category, damage, product’s material, and design. Certain repair techniques can be defined referring to certain product categories and damage types, but these methods cannot be limited to a certain number because of the unique character of each damage and repair. During the focus group discussion, some repair techniques were mentioned including mechanical repair techniques, electrical repairs, electronic repairs and visible repair.

3.8 Value – Cost
In today’s consumerist society, repair is usually expensive and time-consuming. On the other hand, buying something new has been made cheap and easy. Under the value-cost category, the students discussed the value that repair creates and how the repair process makes us understand an object’s value. Student 7 explained how the repair process, the time and labour she spent on the project enabled her/him to realise and appreciate the value of the work spent to design and manufacture a product. Student 8’s paper lampshade is also a good example of how alternative valuation processes can be achieved and embedded into products through repair. It is a torn paper lampshade that she and her daughters repaired with handmade paper flowers. This resulted in an enjoyable bonding time between the family members and improving the emotional value of the product. During a studio critique session, she declared that: “This could be the cheapest and a valueless object for anyone else, but it is one of the most valuable objects in my house after the repair.”

3.9 Reproducibility of Repair
Similar damages and problems can reoccur after the repair. In that case, a repair method and material that the user can access and apply by himself/herself should be chosen to increase the use life of products. For example, Student 6 repaired a doll stroller which had signs of previous repairs such as glue residue and tied threads. It is a fragile rattan object. It was broken and has been repaired many times. As it can be seen in Figure 6, she wove the broken parts with synthetic knitting yarn. Two factors make this repair reproducible. First, the thread as a repair material is easily accessible if not available in the user’s house. Second, the method does not require many skills and is easy to apply.
The student also did not weave all the sides, left some parts empty for the user to weave himself/herself. These features of this repair invite the user to try and complete the repair.

![Image of a repaired doll stroller with weaving and synthetic knitting yarn.]

Figure 6. Student 6 repaired this doll stroller by weaving the broken parts with synthetic knitting yarn.

### 3.10 Impact of Repair on Future Damage and Repairs

When one repairs a product, the result has an impact on the possibility of future damage and repair of the product. The repair might make the product prone to damage or might make it stronger. Similarly, the completed repair might make it easier or harder to repair the product afterward. For example, Student 5’s plastic comb reparation enables the product to be repaired repeatedly. This plastic comb had some of the teeth broken and missing. She designed a tooth and a body that a couple of teeth can be inserted through (Figure 7). This body makes the teeth stable then it is attached to the broken comb through its remaining teeth. She produced one plastic version of this design with 3D-printing and one wooden with laser cutting. The teeth are modular so when one of them breaks, the user can dismantle and change it. This feature enables the product to be repaired in the future if a similar problem happens again.

![Image of a repaired plastic comb with a heart-shaped tooth.]

Figure 7. Student 5 designed a tooth and a body then 3D printed these parts to repair this comb.

### 3.11 Less/All/More Material

Students repaired all the products by adding extra material or a product part. However, we discussed in the focus group session that one does not always need to add material to repair an object. Sometimes to repair a thing we need to take away material. Turning trousers with ripped knees into shorts by cutting the lower parts off can be given as a common example of this case.
3.12 Aesthetic Language
Visible repair stands out and differs from the overall look of the product in terms of aesthetics as it is made from a different material or it is in a different colour. It creates a different aesthetic language than for example the shiny and fragile surfaces of some of the currently available products. Rather than trying to hide the damage this language focuses on creativity and encourages thoughtful assessment of the damage and repair.

3.13 Fixing versus Something New
How can we compare fixing something to buying something new? What changes when we fix an object or buy a new one? Is repair a choice or is buying something new the only choice that users have? Every choice we make and every action we take has different consequences on the environment. We know and are currently experiencing the consequences of overconsumption and exploitation of people and the environment. However, we do not know how repair changes us as individuals, our society and environment.

3.14 Collaboration / Social Aspect
Repair usually enables social interaction whether you find a repairman, ask someone who has the skills to fix your object or you attend a Repair Café and meet a lot of people. In this project, the collaborative aspect of repair led to two types of gains that are learning from collaboration and bonding through repair. In the former, students collaborated with the technicians in the workshop and requested an expert opinion outside the university and learned from these collaborations. In the latter, students asked each other or their family for help and ideas. For example, Student 8’s paper lampshade repair is valuable in terms of emphasising the bonding through repair. It is a great example of bringing people together as she included her children in the repair process.

3.15 Storytelling/ Design Activism
Making repair visible is design activism in a society where replacement is the norm. Visible repair takes people’s attention, and this has both advantages and disadvantages for spreading the message. It has an advantage because by taking people’s attention, a conversation might start which is a great way to create awareness. It has a disadvantage because of the negative stigma attached to repair. Some people do not want to use visibly repaired objects because they are ashamed of repair in their value system, which is related to poverty, lack of resources, etc. This point was discussed in Student 3’s project critique sessions. She mended some leggings that have the same damage inside of the thighs. She used bright coloured thread and sashiko technique which is a traditional Japanese decorative embroidery (Figure 8). The discussion was about wearing these leggings and whether she would wear them or not. She said that she wanted to wear them, but she had some concerns and hesitation. A person might be ashamed of wearing visibly repaired clothes depending on the place of the repair, in this case the thigh area. It might require more courage to wear these leggings with visible repair on the inner thigh rather than wearing bottoms with visible repair on other parts such as knees or in front of the legs.

Figure 8. Student 3 mended the leggings that have the same damage inside of the thighs by using bright coloured thread and sashiko technique which is a traditional Japanese decorative embroidery.
4 Discussion

In this part, some suggestions for the integration repair into product design education is discussed. Repair has both advantages and disadvantages for incorporating it in product design curriculum. It is a hands-on activity and an effective way to encourage students to work with their hands and create prototypes. However, it is important that instructors place emphasis on all stages of the repair process. Students need guidance on the three phases of a designed repair process including discovery, idea generation and implementation (Terzioglu, 2017). For example, Students 11 and 12 spent most of their time on the implementation phase and neglected the first two phases. Their final repair solutions would have been more creative and aesthetically pleasing if they had spent more effort on the idea generation stage especially on sketching and visual representation.

Another aspect that should not be overlooked is the central role of studio discussions considering sustainability principles and dimensions of repair. Design solutions that are proposed by the students can be evaluated according to the different dimensions of repair during studio discussions. It is crucial for students to share their process if they are to benefit fully from the assignment and provide relevant solutions in terms of sustainability. For example, Student 15 worked on repairing a keyboard. He had some difficulties with repairing it throughout the assignment process and did not attend most of the studio discussions. Close to the end of the process, he said he failed to repair the keyboard and decided to repair another product, which was a cracked plastic motorcycle part. Repair has different risk factors compared to designing a new product. Failure is a part of the nature of the activity. Eventually, Student 15 felt that he needed to change the product, but the failed example could have been interesting to discuss. He repaired the part without getting any feedback because there was not enough time left. He welded small pieces of wire mesh in Figure 9 to the broken part after aligning the cracks. Then he filled the cracks in the front of the object with candle wax which he mixed with red food colouring (Figure 9). Candle wax and food colouring are not proper materials to fix a plastic motorcycle part. They did not provide any structural, functional or aesthetic advantage. This example shows that it might be hard for the students to comprehend the dimensions of repair such as aesthetics and functionality. It also emphasises the importance of studio discussions and following the stages of the repair process.

5 Conclusion

This paper describes a product design course prepared to integrate repair into product design education in higher education. Fifteen master’s degree first-year students visibly repaired one or more objects by using different design perspectives. At the end of the project, fifteen different insights about repair were developed and discussed in a focus group session. All these insights, including brokenness, perspectives of repair, and collaboration/social aspect, were explained with examples in this paper.

This project helped us to explore the complexity of repair as a subject area and through the insights we understood repair’s dimensions further. Repair is part of our daily life. It should be a part of the product design process, and accordingly of all products. However, there is not enough research on repair and integrating repair into product design education. This research is valuable for design practice as it provides concrete examples and insights from repair processes. It is valuable for academics as it shows an example of incorporating repair into design education. The insights developed in this research can be explored further, whereas some of them can be taken into consideration in future research about product repair.
Repair ought to be part of design education, at the very least for those design curricula that cover product design. Educators in those programs might choose to implement this exact same assignment. Based on our experiences we would propose the following pointers:

- The reflection session, in which you generate the themes overarching the individual repairs, is as important as the longer process in which the students generate their repairs. It generates a large part of the learning, if the objective is to truly reflect on the relationship between design, repair and sustainability.
- In order to generate such overarching insights, students should be given maximum freedom in choosing objects and repair techniques, as well as in defining what is broken and what constitutes repair.
- Combining this assignment with other repair related assignments, such as hosting a repair café, strengthens the learning further.

If a full repair exercise is beyond what is feasible for a program, the examples of repair in this paper, combined with the perspectives generated, should still be an effective basis for a shorter lecture or workshop exploring the notion of design and repair.

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References

Andrews, D. (2015). The circular economy, design thinking and education for sustainability. Local Economy, 30(3), 305-315.

Bakirlioglu, Y., McMahon, M., Eyto, A.D., & Rio, M. (2018). Training the next generation of designers for a sustainable future: Action research on the circular design internship. In Proceedings of DRS 2018 International Conference: Design as a Catalyst for Change (pp. 2008-2018). 25-28 June 2018, Limerick, Ireland.

Bocken, N.M., de Pauw, I., Bakker, C., & van der Grinten, B. (2016). Product design and business model strategies for a circular economy. Journal of Industrial and Production Engineering, 33(5), 308-320.

Doğan, Ç. (2012). Product design for sustainability: Development of a new graduate course in industrial design. METU Journal of the Faculty of Architecture, 29(2), 313-329.

Doğan, Ç., Turhan, S., & Bakirlioglu, Y. (2016). Evolving Paths: Undergraduate Design Education through Graduate and Generative Research with a Particular Focus on Sustainability. The Design Journal, 19(4), 585-604.

Ellen MacArthur Foundation (2012). Towards the circular economy Vol. 1: An economic and business rationale for an accelerated transition. Retrieved November 10, 2018, from https://www.ellenmacarthurfoundation.org/publications/towards-the-circular-economy-vol-1-an-economic-and-business-rationale-for-an-accelerated-transition

Ellen MacArthur Foundation (2015). Circular economy and curriculum development in higher education. Retrieved July 2, 2018, from https://www.ellenmacarthurfoundation.org/assets/downloads/higher-education/EMF_HE-Curriculum-Brochure-17-JUNE_SINGLE5.pdf

Findeli, A. (2001). Rethinking design education for the 21st century: Theoretical, methodological, and ethical discussion. Design Issues, 17(1), 5-17.

Ghisellini, P., Cialani, C., & Ulgiati, S. (2016). A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems. Journal of Cleaner Production, 114, 11-32.

Litosseliti, L. (2003). Using Focus Groups in Research. London: Continuum.

Lofthouse, V. (2013). Social issues: Making them relevant and appropriate to undergraduate student designers. Design and Technology Education: An International Journal, 18(2), 8-23.

Norman, D. (2010). Why design education must change. Retrieved November 10, 2018, from https://www.researchgate.net/profile/Donald_Norman/publication/235700801_Wir_brauchen_neue_Designer_Why_Design_Education_Must_Change/links/54a2b47e0cf256bf88bb0d448.pdf

Ramírez, M. (2007, July). Sustainability integration in industrial design education: A worldwide survey. In Proceedings of Connected 2007 International Conference on Design Education (pp. 1-5). The University of New South Wales, Sydney, 9-12 July 2007.

Ramírez, M. (2006). Sustainability in the education of industrial designers: The case for Australia. International Journal of Sustainability in Higher Education, 7(2), 189-202.

Scheer, A., Noweski, C., & Meinel, C. (2012). Transforming constructivist learning into action: Design thinking in education. Design and Technology Education, 17(3), 8-19.

Stewart, D.W., & Shamdasani, P.N. (2014). Focus Groups: Theory and Practice (Vol. 20). Thousand Oaks, CA: Sage.
Sung, K. (2015). A review on upcycling: Current body of literature, knowledge gaps and a way forward. In Proceedings of The ICECESS 2015: 17th International Conference on Environmental, Cultural, Economic and Social Sustainability. Venice, Italy, 13-14 April 2015.

Terzioglu, N. (2017). Do-fix workshops: Understanding users’ product repair experience. In Proceedings of PLATE 2017 Conference. Delft, Netherlands, 8-10 November 2017.

Van den Berg, M.R., & Bakker, C.A. (2015). A product design framework for a circular economy. In T. Cooper, N. Braithwaite, M. Moreno, & G. Salvia (Eds.) Proceedings of the Product Lifetimes and the Environment Conference (pp. 365-379). Retrieved November 22, 2018, from http://www.plateconference.org/product-design-framework-circular-economy/

Weber, R.P. (1990). Basic Content Analysis. Newbury Park, CA: SAGE Publications.

Wever, R., Charnley, F., Brass, C., & Harrison, L. (2015). Preparing designers for a circular economy goldrush; exploring the implications for education. In Proceedings of Global Cleaner Production and Sustainable Consumption Conference. Sitges, Barcelona, 1-4 November 2015.

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