

Take Waste and Make

Guidelines for workshops to find new applications for industrial waste material

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Abstract: To find new applications for industrial waste material is environmentally and economically desirable. However, generating such ideas is done under conditions that are normally unusual for product developers: It has a specific input, but a very large solution space. This study explores the workshop format as such and more specifically effective set-ups for workshops aiming at finding new applications for waste material. To explore this, four different workshops were carried out. Given its possibilities to incorporate different expertise, ideas from various fields could be generated, increasing the chance of finding a suitable application area. The participants' task was to generate new ideas for a re-use of discarded PVC cable sleeving. The workshop format made it possible to evaluate variations in the preconditions. In addition to direct observations in the course of the workshops, outputs from the workshops were analyzed and compared to their preconditions.

The workshops resulted in ideas from a broad spectrum of areas, providing a good basis for future product development. It was found that the choice of participants and stimuli were essential for the workshops. This article elaborates upon the connections between the workshop's set-up and the obtained results.

Key words: *Industrial waste, Product development, Creative workshop, Cross-discipline*

1. Introduction

Closed-loop production has been proposed to enable sustainable use of material resources [5,6,12]. This implies a continuous use of material resources, where the material itself never goes to waste but rather back into new production. However, most of today's discarded goods do not end up in new production but in landfills or incineration plants [2,3]. This indicates a need to better connect production with waste management and to encourage designers to use discarded material to a larger extent in a systematic way. This is a challenge since there are reasons why "waste material is waste material" (e.g. the lack of beneficial applications, unsecured flow of materials, variations in quality, uncertain acceptance).

With this in mind a project has been initiated by Chalmers University of Technology¹, the industrial recycling company Stena Recycling² and the engineering consultancy firm Semcon³. These three partners together initiated the project "From Industrial Waste to Product Design" (IWtoPD), which was accepted for funding by the Mistra Closing the Loop initiative⁴ in 2012 [11]. The project targets specific fractions of industrial waste that Stena Recycling receives today but cannot reuse or recycle. These waste materials are proposed as starting points for product development projects, conducted by students from the international Masters program in Industrial Design Engineering at Chalmers. By systematically observing and helping students engage in product development processes focused on reincorporating waste material into production, the project intends to shed light on the existing barriers to achieve this at an industrial scale. In turn, methodological recommendations for overcoming these barriers will be derived. These recommendations may assist industries in addressing the negative effects of the current Take-Make-Waste [10] paradigm by becoming successful in "Take Waste and Make" activities.

1. Department of product and production development, division of design and human factors, the More by Less research group.
2. Scandinavia's largest recycling company, with an annual turnover of one billion EUR and over a thousand employees.
3. Department of Human factors engineering.
4. Mistra is the Swedish foundation for strategic environmental research.

The IWtoPD project started during the fall semester 2012. One of the first things done was a study [14] that identified and analyzed 57 examples of products developed mostly from waste and successfully put on the market. Noticeably, none of these cases included descriptions of their development methodology. According to Ordoñez et. al., it seems as if this area within design is currently focused on “demonstrating the fact that it can be done” in an appealing way rather than “demonstrating how to do it” in a systematic way. Many of the products observed were hand made and unique, bringing them closer to “product art projects” rather than to what could be a future new standard for industrial production.

Finding new applications for industrial waste material is environmentally and economically desirable. However, generating such ideas is done under conditions that are normally unusual for designers: There is a specific input (the waste material itself), but a very large solution space (the result could be any type of product). This differs from traditional product development processes [8,9,15,17] that start from an ideation, understanding or exploration phase that is focused on describing and understanding a product’s use or the user needs to be satisfied by the particular product to be developed. Traditional design tools (e.g. surveys, field observation, mock-ups, prototype testing) are adequate for these tasks. However, the starting point for idea generation when using waste material is within a completely different context. Firstly, there is no decided type of product or service to be developed; which makes the problem even more open-ended than traditional development projects. Secondly, this undefined product or service must incorporate a specific waste material. In addition, the material properties are often not well known since they have been altered by previous use. This sets different initial requirements for the design process, demanding alternative tools and methods.

This paper details the initial stages of the first master thesis done within the IWtoPD project. The two students involved were facing the difficulties of elaborating a product proposal starting from a waste material, as previously described. As a way to facilitate idea generation for this new type of product development process, they decided to explore the workshop format due to its potential for involving different expertise.

2. Aim

This study explores the workshop format as such and more specifically effective set-ups for workshops aimed at finding new applications for waste material, hereinafter referred to as waste material workshops. By conducting and evaluating such workshops in practice, the aim of this study is to generate a deeper understanding of the challenges they convey and to provide methodological support for overcoming these challenges.

3. Research method

Initially, elements that constitute a creative workshop were mapped. Based on Engelbrektsson’s description of method constitution [4], five different categories were identified: participants, activities, stimuli, context and moderation. An iterative research process (figure 1) was then applied in order to generate recommendations on how to arrange effective workshops aiming at finding new applications for waste material with respect to these five categories.

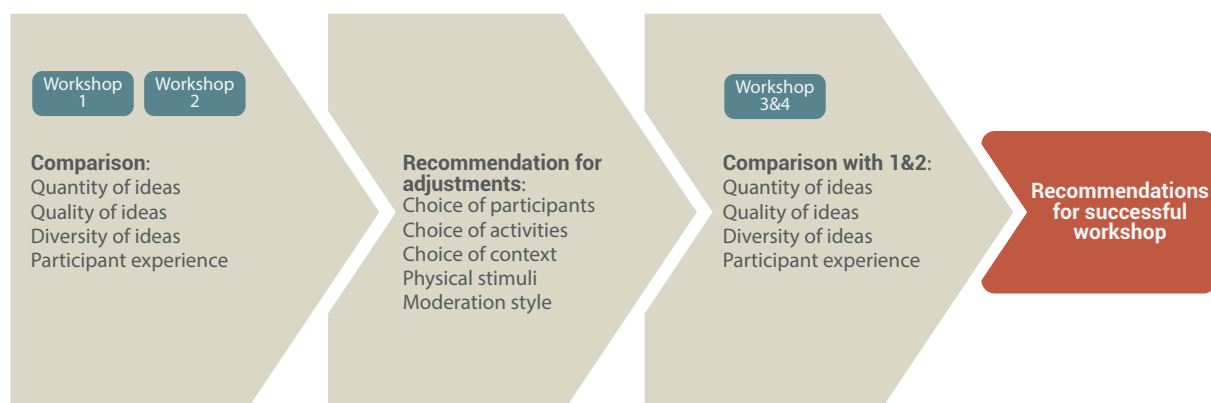


Figure 1. Research process

In four different waste material workshops participants were given the task to generate new ideas for reapplication of discarded PVC cable sleeves, which was the fraction of waste material addressed in the study. The performance of each workshop was then judged based on four criteria: (1) Quantity of ideas generated, (2) Quality of ideas generated, (3) Diversity of ideas generated, and (4) Experience of the participants. By comparing workshop per-

formance, conclusions could be drawn regarding effective workshop set-ups, e.g. how to best choose participants, activities, stimuli, context and moderation style for waste material workshops (see table 1 for criteria definitions and motivation to use them as relevant parameters).

Table 1. Performance of workshop: definition & Motivation

Criteria to evaluate workshop performance: Definitions and Motivations		
	Motivation	Definition
Quantity of ideas	IWtoPD project is characterized by the lack of ideas on possible application areas. It is thus important to generate high quantity, increasing the chance of finding useful ideas.	Quantity is measured by the number of ideas, and assessed in relation to active time during the ideation phase.
Quality of ideas	Only useful ideas will have a positive impact on the environmental situation. It is thus preferable to identify many ideas that have high probability to be realized.	Quality is measured by the number of promising ideas as percentage of total ideas, and the subjective judgement of overall maturity of ideas.
Diversity of ideas	Due to the undefined boundaries of an IWtoPD-project's solution space, it is important to investigate a high variety of potential domains in order increase the chance of finding the best one.	Diversity is measured by the number of domains touched by the ideas.
Participant experience	Creating a relaxed and creative environment will have a positive effect on idea generation, it is therefore important to evaluate the overall experience of the workshop.	Participant experience is assessed qualitatively through feedback gathered from each participant. Scale of measure is negative/mixed/positive.

During a first iteration two workshop set-ups were tested in separate workshops, workshop 1 and 2. The workshops were very similar in regards to the choice of participants, stimuli, context and moderation. Participants, context and moderation were chosen according to recommendations found in existing research on creative workshops [13,7,16]. Stimuli were chosen with the intent to provide the participants with relevant information needed to generate usable ideas. The workshop set-ups' main difference was the activities carried out, as this was assumed to have a large impact on the workshop performance. The activities of workshop 1 were chosen with the intent to create a competitive environment that would spur the participants' idea generation. The activities of workshop 2 were chosen with the intent to create an environment that encouraged interaction and discussion between participants.

After evaluation of the first two workshops, a second iteration consisting of two parallel workshops was carried out. The set-up of these workshops was optimized based on the experiences from the first ones. The performance of workshop 3 and 4 was then compared to the performance of workshops 1 and 2, which in turn made it possible to generate final recommendations regarding how to successfully arrange waste material workshops.

4. Workshop 1 and 2

4.1 Set-up

The set-ups of workshop 1 and 2 are listed in table 2. Both workshops were arranged as cross-disciplinary waste material workshops because cross-disciplinary environments tend to generate creative and innovative ideas, as well as taking leaps into unexpected directions and open up entirely new fields [7]. For waste material workshops in particular, cross-disciplinary environments can be beneficial in regards to diversity of ideas.

The workshops started off with a short introduction about the material properties of PVC cable sleeves, origin of

the material, possible manufacturing methods, existing products etc. This information was previously gathered by the moderators/researchers as the initial phase of their project with this waste material. The introduction was done to provide the participants with enough background information to generate ideas that are within reason. Knowledge on the possibilities of the material was also expected to spur creativity.

The choice of location for workshop 1 and 2 was addressed as any other ordinary workshop. In both cases the most important aspect to focus on is to create a safe, relaxed and creative environment that will facilitate idea generation [16]. The workshops were arranged in typical conference rooms with low risk of external distractions.

Moderation was handled in an unobtrusive and encouraging manner, allowing the participants to freely choose the direction of the idea generation. The risk would otherwise have been that the more extensive background knowledge of the moderators would have influenced the character of the generated ideas.

Table 2. Set-up of workshop 1 and workshop 2

Workshop 1				
Participants	Activities	Stimuli	Location	Moderation
Three engineering students from different disciplines	Focus on competitive activities	A short introduction to material properties and current applications.	A typical conference room	Unobtrusive but encouraging.
Workshop 2				
Participants	Activities	Stimuli	Location	Moderation
Three engineering students from different disciplines	Focus on interaction and discussion	A short introduction to material properties and current applications.	A typical conference room	Unobtrusive but encouraging.

As described in section 3, the activities performed in workshop 1 were different from the activities performed in workshop 2. In addition to the activities, workshop 1 included a scoring system where the participants competed against each other in terms of total amount of ideas.

Workshop 1 activities:

Quantity before quality - Participants are asked to generate as many ideas possible in a limited time frame, share the best ideas with each other and then iterate.

Forced relationships - Cue cards, containing visual and/or verbal input to be incorporated into a new idea, are presented to the participants.

Brainstorming bash - The participants take turn in suggesting a crazy and outlandish idea that the other participants have to transform into an applicable idea.

Workshop 2 activities:

Mind narrowing brainstorming - Participants use inspiration from stereotype cards containing pictures of famous persons or characters to generate ideas, individually and in groups.

Flip it! - All participants are asked to generate the worst idea possible and present it to the group. The group is then asked to point out why the ideas are bad and discuss ways to transform them into good ideas.

Role-play - Each participant assumes the role of another participant and tries to generate ideas from the new perspective.

After these activities the workshop ended with a round up where the participants got a chance to clarify and discuss the ideas. The main purpose of this round up was to give the users a sense of closure and provide an overview of their results.

4.2 Workshop output

In regards to the quantity of ideas, workshop 1 proved to be superior by 27 ideas in total (see table 3); while the

quality of the ideas proved to be higher in workshop 2. Not entirely unexpected, due to the different themes of the activities in the two workshops. For instance, one of the participants spawned the rather vague idea ‘acoustic product’ while another participant came up with ‘sound absorption panels’. Although these ideas were similar to each other, their level of maturity was different. Judging by this, and similar examples, the set-up of workshop 2 seemed to favor ideas of higher quality.

In addition, the competitive nature of workshop 1 created a momentum among the participants, which however could not be sustained for the whole duration of the workshop. One of the participants commented on how the focus sometimes shifted from generating applicable ideas to generating ideas to win the competition. Workshop 2 on the other hand received a generally more positive feedback; the participants’ experience seemed to be quite positive and can be suspected to have had a constructive effect on the workshop output in general.

In retrospect, both workshops reached a similar level of diversity in its ideas (table 3). The ideas of both workshops covered 7 domains: construction & traffic, textiles, food & hygiene, sports & leisure, surface material, interior design and transportation products. This was surprising, as different backgrounds and fields of expertise were represented in each workshop. However, the participants were noticeably generating more ideas close to their own field. For instance, a participant representing IT contributed with most of the computer related ideas, e.g. keyboards and vibration absorption panels, and the architecture student presented a lot of architectural solutions such as furniture and heat isolations.

4.3 Analysis of workshop performance

Overall, both workshops can be regarded as successful in generating new application areas for discarded PVC cable sleeves. As can be seen in table 3 however, each of the workshops had its strengths and weaknesses.

Table 3. Performance of workshop 1 and workshop 2

Performance of workshop				
	Quantity of ideas	Quality of ideas	Diversity of ideas	Participant experience
Workshop 1	117 unique ideas (55 minutes) 2,13 ideas/minute	- 30 promising ideas (25,6 % of the ideas) - Low maturity level of ideas	7 domains	Mixed
Workshop 2	90 unique ideas (45 minutes) 2 ideas/minute	- 26 promising ideas (28,9 % of the ideas) - Medium maturity level of ideas	7 domains	Mostly positive

Regarding quantity, workshop 1 worked slightly better than workshop 2 with more ideas generated per minute. During workshop 1 it was observed that the competitive theme of the activities was driving the participants to come up with many ideas. In particular the first activity, Quantity before quality, delivered what its name promises. It could also be noted that the order of activities was an important factor. It was clear that the participants needed more methodological stimuli such as changes in perspectives or suggestions of unexpected topics during the latter activities.

When it comes to quality however, the roles were changed and workshop 2 performed better. Besides generating a slightly larger fraction of promising ideas (i.e. the ideas that perservered initial screening, that were considered feasible given the background information for the material), the most significant difference was in the maturity level of the ideas generated. Many ideas from workshop 1 were very vague and undefined, meaning that they needed additional refinement and that shortcomings of the ideas often were revealed during this refinement. The main reason behind workshop 2’s superior quality of ideas was the theme of the activities. The activities in workshop 2 focused more on interplay between the participants, alteration of generated ideas, and initial evaluation of generated ideas.

Both workshops resulted in ideas of a rich diversity. In each workshop ideas from 7 unrelated domains were generated. The cross-disciplinary groups of participants surely played a large part in this. Another factor contributing to this was the activities that used stimuli to enable exploration of new parts of the solution space.

The experiences of the participants in workshop 1 were mixed. Although they stated that the competitive theme of the workshop contributed to their productivity, they also had less fun¹ because of this. Workshop 1 also included activities such as Brainstorming bash, which were perceived as less fun since each participant was inactive during certain intervals. Based on the feedback collected after the workshops, the participants of workshop 2 seemed to have had a more positive experience.

In both workshops, the importance of stimuli was observed. The participants frequently asked questions about the waste material's potentials and limitations. The short introduction and the material samples were, although appreciated by the participants, not enough. In addition, activities with physical stimuli such as cue cards were effective creativity boosters.

4.4 Lessons learned for next workshops

Retrospectively, the workshops showed that the quantity of ideas generated is a relatively unimportant criterion for waste material workshops. As the output of the workshops demonstrates, the workshop with most ideas generated did not provide more qualitative ideas. The quality of the generated ideas is much more important, particularly ideas that are mature and have a higher probability of being realized. With this in mind, it can be concluded that the setup of workshop 2 was superior to workshop 1. However, the overall impression after these workshops is that there is room for improvement also in the workshop 2 set-up.

The quality of the ideas can be improved in a number of ways. First, the number of low quality ideas generated can be reduced by providing richer background knowledge to the participants, and by presenting clearer goals to them. Although the short introduction to the waste material (PVC cable sleeves) in workshop 1 and workshop 2 was appreciated, the participants still generated ideas that would have been impossible to realize using this material. Also, goals like "generate as many ideas as possible" should be reassessed. In addition, activities focusing on interaction between the participants, mutual spurring of ideas and initial evaluation of generated ideas should be promoted, as they worked well in workshop 2.

Regarding participants, cross-disciplinary teams proved to be efficient and should be kept. The variety in competence was critical for generation of diverse ideas. In fact, participants with even deeper specific competences than students could be preferred. This can be beneficial when generated ideas are evaluated initially, resulting in more mature and realizable ideas. Particularly knowledge about the waste material was frequently requested during the initial workshops.

Another problem related to the participants being students was that they had no genuine interest in the output of the workshop. Their mind-sets were that of participants in an experiment rather than that of stakeholders. Inviting more professional participants could reinforce the interest in the workshop output, and thereby increase the maturity of the generated ideas.

The workshops clearly showed the importance of stimuli. While the activities themselves may act stimulating (changing roles, perspectives, etc.), physical stimuli are of equally high importance. It is essential to present the right stimuli to the participants, which may help them to understand the waste material itself and envision the solution space more easily.

Both the location of the workshops and the style of moderation seem to have worked adequately for workshops of this kind. Here no clear improvements were identified.

1. Fun is an important factor for the results of creative work [1], and it is also important for the survival of a method, i.e. if the method is boring people do not want to use it [15].

5. Workshop 3 and 4

5.1 Set-up

Based on previous findings from workshop 1 and 2, a number of adjustments were implemented in workshop 3 and 4. In addition, some details were found to be beneficial and were directly inherited into workshop 3 and 4. Overall the following changes were implemented:

- A much more extensive background presentation preceded the workshops.
- Cross-disciplinary teams of professionals with deep expertise and genuine interests in the outcome attended the workshops.
- Each workshop had a material expert participating, with deep knowledge regarding PVC.
- More physical stimuli were used and it was packaged in a more visually appealing way (Figure 2).
- The activities performed involved more interaction and discussion between participants.
- The scoring system for most generated ideas was removed.
- The order of the activities was more consciously chosen. The idea was to initially take advantage of the participants' high energy level and drain the ideas of a more ordinary character as efficiently as possible, whereas the subsequent activities focused more on interaction, fun and short evaluations.



Figure 2. “The material box” contained all physical stimuli and working material needed for the workshops, including material samples. These samples consisted of PVC-cable sleeving, copper and aluminum granulates extracted from the recycling process. The box also contained pictures of products based on similar materials and cue cards needed for the second method.

The set-ups of workshops 3 and 4 were identical (table 4). The workshops were however performed in parallel, meaning that they each had unique participants, a unique moderator and were carried out in different locations. The agenda of the workshops were:

1. A more extensive background seminar that introduced the research perspective, the industrial perspective and practical information about the task ahead.
2. “Quantity before quality” - Participants are asked to generate as many ideas possible in a limited time frame, share the best ideas with each other, discuss them and then iterate.
3. “Cue cards” - The participants are presented with cue cards containing visual and/or verbal input to be incorporated into new ideas. This method was a combination of the methods Forced relations and Mind narrowing brainstorming used in workshop 1 and 2.
4. “Flip it!” - All participants are asked to think of the worst idea possible and to write it down. The ideas are then gathered and replaced with ideas from another group. The participants are then asked to point out why the ideas are

bad and together discuss ways to transform them into good ideas.

5. Workshop round up where the participants got a chance to clarify and discuss the ideas.

Table 4. Set-up of workshop 3 and workshop 4

Workshop 3&4				
Participants	Activities	Stimuli	Location	Moderation
- Professional participants with diverse expertise and interests in the outcome. - One participant was an expert on the material	- Focus on discussion and evaluation	- Extensive background seminar - Material Box, - ‘Random’ stimuli during activities,	- Lighter locale	Unobtrusive but encouraging.

5.2 Workshop output

The result from workshops 3 and 4 turned out to be fairly similar. This was expected as they shared the same set-up. However, when comparing these workshops with workshops 1 and 2, differences can clearly be observed. The quantity in workshops 3 and 4 was noticeably lower than earlier where as quality seemed to have significantly increased (table 5). The overall experience of the latter workshops was very positive.

Table 5. Performance of workshop 3&4 in comparison with workshop 1&2

Performance of workshop				
	Quantity of ideas	Quality of ideas	Diversity of ideas	Participant experience
Workshop 1&2	188 unique ideas (Workshop 1: 55 minutes, Workshop 2: 45 min,) 1,88 ideas/minute	- 42 ideas (22,3 % of total) made it through initial screening - Low-medium maturity level of ideas	7 domains	Mixed
Workshop 3&4	156 unique ideas (60 x 2 minutes) 1,3 ideas/minute	- 48 ideas (30,7 % of total) made it through first screening - high maturity level of ideas	7 domains	Positive

5.3 Analysis of workshop performance

After workshops 3 and 4 were completed, their performance was compared to workshops 1 and 2 in order to explore the performance of the new set-up.

Although the quantity of generated ideas was concluded as a relatively poor criterion for workshop performance after workshops 1 and 2, the productivity of workshops 3 and 4 was still measured. As seen in table 5, the productivity had decreased for workshops 3 and 4, as only 1,3 ideas/minute were generated in comparison to first workshops’ 1,88 ideas/minute. This is however not surprising as a goal of the new workshop set-up was to reduce the amount of useless ideas.

In regards to quality of the generated ideas, workshops 3 and 4 were successful. The fraction of promising ideas was 30,7 %, in comparison to the first two workshops that resulted in a passing rate of 22,3% (table 5). In the development process that succeeded the four workshops, these promising ideas were later evaluated once more, in

order to identify the ideas that should be developed into early concepts. Among the 45 ideas that made it through this evaluation, 62 % were generated in workshops 3 and 4. In addition, the ideas from workshops 3 and 4 generally had a higher level of maturity. Overall it seems that the set-up changes implemented in workshops 3 and 4 worked as intended, increasing the number of potentially realizable ideas.

The ideas generated in workshops 3 and 4 showed the same level of diversity as workshops 1 and 2. This is not surprising as no particular changes in the workshop set-up were made with the purpose of increasing the diversity of the ideas. An interesting observation from these two workshops is however that despite the professional background and expertise of the participants, the generated ideas touched the same 7 domains as workshops 1 and 2. This indicates that there is a fixed, albeit vaguely defined, spectrum where realizable ideas can be found for this type of project.

The experiences of the participants in workshops 3 and 4 were more positive than those of workshops 1 and 2. In particular, the exclusion of the competitive elements created a more relaxed and creative atmosphere. Furthermore, the mind-sets of the participants were also a bit different in workshops 3 and 4. The identified problem in workshops 1 and 2, where the participants had little genuine interest in the outcome, was not observed in these workshops. It seems that the choice of professional participants together with the extensive introduction to the topic contributed to this particular aspect of performance. Additionally, many comments were received about the elaborate design of the material box indicating that it contributed to the professional mind-sets among the participants.

6. Discussion

To find new applications for industrial waste material is environmentally and economically desirable. However, generating such ideas is done under conditions that are normally unusual for designers. In a regular idea generation session during product design, the typical aim is to develop a product of a specific type. Here the aim is instead to come up with any product, as long as it incorporates a specific waste material.

In this paper, the workshop is assumed to be a suitable approach to this specific product development challenge; since it enables different actors to cooperatively address this demanding task. There are of course many other methods available that could also work. The point of this study is however not to determine the best possible method, but rather to explore the promising method of workshops. Workshops are widely applied in 'regular' development processes, and recommendations on how to successfully arrange them are easy to find. This study however aims at generating recommendations for how to set up workshops with the specific aim of generating new application areas for waste material. Nevertheless, an important observation regarding the choice of method can be made after having carried out four workshops. Among the ideas that were selected to be refined into concepts after the workshops, about half could be categorized as "low hanging fruits". Many of the promising ideas were more difficult to generate, which in turn justifies the use of such extensive methods as workshops. While a lot of the more easily accessed ideas probably could be generated during an informal brainstorming session, the more formal use of various activities and stimuli seem necessary to access the more veiled ones.

As stated in section 2, important criteria for a successful workshop of this kind were assumed to be quantity, quality, diversity and participant experience. After the completion of four workshops, it can be concluded that it was not as challenging as assumed for the participants to generate a large quantity of ideas. It is clear that the quality of the ideas is much more important. This is rational, considering that the main reason behind a material being wasted is not that there are no ideas for its re-use, it is rather that there are no good ideas for how to re-use it. Regarding diversity of generated ideas, this criterion is considered important also in retrospect although the conception after the workshops is that there is a similar challenge in achieving high quality here as well. It is not difficult to generate ideas in a multitude of domains; the challenge is to generate good ideas in a multitude of domains. Why all the domains that appeared in the different workshops were the same is hard to identify based on the workshop results. Perhaps, the particular material can only be applied in these domains, or perhaps the domains are so broadly defined that they include all possible applications. Finally, the participants' experiences of the workshop are very important, although that goes for any type of workshop. Specifically for a waste material workshop, however, it is central to make the participants feel comfortable and confident regarding the somewhat unusual topic.

A workshop can be set up in a variety of ways, depending on how each methodological component is chosen. In this study, five components of a workshop were considered: participants, activities, physical stimuli, location and moderation. While location and moderation are important aspects of any workshop, they were assumed to be of less importance in relation to waste material workshops. Location is seemingly the workshop

component that is of least interest in this context. A location that is suitable for any workshop should be suitable also for a waste material workshop. When it comes to moderation, there are a number of interesting alternatives. The workshops in this study all had the same form of moderation; a dedicated moderator that kept the activities on track without interfering in the actual work. Another option could have been having an expert in waste material, who could act as more obtrusive moderator, making sure that the unrealistic ideas are kept to a minimum. The opposite would be a possibility as well, i.e. conducting more experimental workshops with no moderation at all. Overall it is a question of what level of structure is preferred. In that sense, the moderation in the workshops for this study was considered the most adequate to facilitate promising idea generation.

The focus of this study was however to explore the other three workshop components. After having carried out workshops including different groups of participants, activities and physical stimuli, it can be concluded that each of these components is central for setting up a successful waste material workshop.

The set-up used in workshops 3 and 4 were superior to the set-ups of workshops 1 and 2. Although mono-disciplinary groups of participants were not applied in this study, the observations of the workshops clearly demonstrated the advantages of choosing a multi-disciplinary group of participants. Many of the generated ideas of higher quality were in fact refined by participants from different disciplines during the workshops. Further, it was advantageous to have a material expert among the participants. As waste material workshops have such a specific point of departure (i.e. the waste material itself), the presence of an expert in that material helps reducing the time spent on working with ideas that have no chance of being realized. Basically, all changes in the set-up that were incorporated into workshops 3 and 4, seem to have worked out well and can be recommended for future waste material workshops.

In this study, an explorative approach to waste material workshops was applied. The reason for this was that the area is relatively unexplored. As stated in the introduction, the examples where waste material has been turned into new products rarely include any description of methodology, let alone any prescriptions. When evaluating the conclusions it is important to keep in mind that only four workshops have been carried out in this study. More experiences of this kind should be documented and used for comparison. It is also important to remember that waste material workshops is just one piece of the puzzle; there is a lot more to be learned in the area of making products out of waste. Thus, two important subjects for future research are:

- How to effectively generate ideas for new application areas of waste material? More experiments, similar to the one in this study, need to be carried out in order to learn more about how to methodologically support this activity.
- How to effectively industrialize such an idea? When promising ideas are generated, a lot of work is still needed in order to take the product to market introduction. This may convey specific challenges that are not present in an ordinary product development process.

7. Conclusions and recommendations

This study highlights the relevance of how participants, activities and physical stimuli are selected for waste material workshops.

The group of participants in a waste material workshop should be multi-disciplinary, and preferably consist of persons with a genuine interest in the workshop's outcome. The presence of different competences is advantageous for producing high quality ideas, as each person may contribute differently to every generated idea. It is also recommended to have an expert in the particular waste material among the participants, as the waste material itself and its properties are decisive factors for the feasibility of the ideas.

The activities during waste material workshops need to be chosen so that they enable participant interaction and refinement of each other's ideas, thus taking advantage of the multi-disciplinary group. Furthermore, an extensive introduction to the waste material workshops is a valuable starting-point. Not only because it helps the participants to learn about the particular waste material and to understand the intention of the workshop, but it also conveys a sense of dedication among the participants.

The use of physical stimuli is important in waste material workshops. The stimuli can be of various kinds and used for different purposes. It can help the participants to understand the waste material as such and how it can be shaped into new products. It can also be used to enable the participants to change perspectives or to help them envisage different areas of application for the waste material.

Overall, this study demonstrates that waste material workshops may be a promising approach to finding new application areas for waste materials, thus turning them into valuable resources. A large quantity of ideas was generated in various domains, and several of these ideas were judged as having the potential of becoming successful products. The most promising ideas generated during the workshops are currently being refined into concepts, where one or two of them will be chosen to be developed into products heading for the commercial market. This will be the true test of the workshop approach, as market success is needed in order to generate positive economic and environmental effects in the long run.

8. References

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