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Applying DATEMATS Methods and Tools to Experimental Wood-Based Materials: Materiality in an Ideation Process

Tarja-Kaarina Laamanen and Pirjo Kääriäinen

Abstract This chapter provides an overview of the DATEMATS Experimental wood-based materials workshop and student projects, and a more detailed description of one team's ideation process. The workshop was held at the Chemarts facilities of Aalto University, Finland, in January 2022. A total of 19 students from four different universities and from the fields of design and engineering participated in a five-day workshop creating innovative applications for interior panels made of cellulose waste. The company challenge was given by Honext from Spain.

1 Introduction

Chemarts is a community and learning environment that combines design expertise and chemical engineering in the field of bio-based materials. Its overarching thematic structure is based on sustainability, learning about sustainable materials, and exploring concurrent real-world challenges. These themes are driven by the complexity of the problems, and no solutions are known beforehand. The goals of the learning are connected to new knowledge and solutions beyond traditional disciplines or at the edge of disciplines. Chemarts applies the 'learning by doing' approach, in which a hands-on, early stage explorative process of making materials is central (Laamanen and Kääriäinen, accepted). Learning by doing utilizes the learner's natural ambition to learn in concrete, real environments. It enables learning through the inquiry process and knowing how (Kivinen and Ristelä 2002; Laamanen and Kääriäinen, accepted). In Chemarts, material exploration is the starting point for material-driven idea generation, experiments, and concept proposals.

Due to the above-mentioned ambitious goals, Chemarts courses are typically several weeks long (see Laamanen and Kääriäinen, accepted). The DATEMATS *Experimental wood-based materials workshop* reported here was an opportunity to try out how the Chemarts' approach could be introduced in a short-term workshop. The workshop applied principles of collaborative learning, which is common today

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in design and engineering education. It is a student-centred teaching strategy in which students of different levels of ability or background work in small teams, and all team members participate in completing the assigned task (Emam et al. 2019). The tendency is for design education to move towards the reality of design practice, in which projects are almost exclusively collaborative endeavours, often requiring multidisciplinary and interdisciplinary expertise (see Valtonen and Nikkinen 2022). Transformation towards a sustainable future starts by working and reflecting with people from various backgrounds, ideas, and working styles (Valtonen and Nikkinen 2022). In this workshop, the teams were heterogeneous: the students had diverse backgrounds and experiences, and aimed to simulate a real-life design situation (see Emam et al. 2019).

In this chapter, we focus on materials and material knowledge as part of the workshop. The emerging circular economy and eco-design have led to an urgency to study and develop material-related education for designers. The knowledge involved in the new materials and technologies within science and engineering is vast and ever increasing (Ferraro and Pasold 2020). An educated understanding of the potential of new materials and technologies is essential. Future designers need skills that cut across disciplines to help learn how to develop and use materials to embrace multiple properties, including aesthetic, technical, functional, and sustainable features (see Haslinger and Bang 2015, 27).

In our very brief literature review, we discuss the characteristics of collaborative design ideation and the materiality in the design. After this, we provide an overview of the workshop and projects of five international student teams. Subsequent sections discuss the case study of one team's process in more detail. Our aim has been to understand how working hands-on with materials enables the emergence of insights into the collaborative idea-generation process. The team's process was video recorded and analysed qualitatively. The team's process is reported here in chronological order, and we explain nine critical events and the related material facilitation of the idea generation in the recorded episodes.

Finally in the conclusion, we reflect on the outcomes. The results of this analysis highlight how the team used typical design representations and practices to communicate their ideas, to create new knowledge, and store it. External sources of inspiration and information were used most in the idea-framing phase and the representation created by the team themselves increased in the latest phases of the process. Sketching activity played a surprisingly small role in idea generation. However, the role of the self-made material was vital. It worked as a source of inspiration in a joint material practice, i.e., material sketching that helped draw the final idea and concept together.

We conclude that this type of short workshop is most suitable for senior students who already master the design process quite well. It works as an inspiring introduction to making and using experimental cellulose materials in the design process.

2 Collaborative Design Ideation

Collaborative design is an activity driven by communicative practices and representations for mediating ideas (Artman et al. 2005). A central aspect of successful collaboration is sharing the evolving representations as well as negotiating, elaborating, accepting, or abandoning ideas (Lahti et al. 2016). We focus on a collaborative ideation process, which started by framing the given task. *Framing* refers to 'the creation of a standpoint from which a problem can be successfully tackled' (Dorst 2011, 525). Framing the situation starts with gathering information and inspiration to generate ideas, moves on to choosing a promising idea(s) then refining and developing the idea, and finally ends with the design concept.

Idea generation is the interaction between previous experiences and new external influences (Laamanen and Seitamaa-Hakkarainen 2014). Different practices such as information gathering, collecting sources of inspiration, and sketching (Goldschmidt 2003; Keller et al. 2006) or techniques such as mind-mapping or brainstorming help map out the possibilities for the current design task. In a collaborative setting, the design team aims for a shared understanding of the data that have been gathered, and acts on that data through organization, externalization, pruning, and interpretation (Kolko 2010). At the same time, the idea space narrows and constraints are created (Kolko 2010; Laamanen 2016). Selecting an initial *key idea* suitable for further development and refinement is essential. *Key* refers to a certain openness in an initial idea to avoid committing too early. It constrains the process and inspires new ideas when developed further in an explorative process (Laamanen 2016; Lawson 2006). The iterative process continues in idea development. The idea is defined and refined through a range of decision-making and problem-solving, requiring experimental practices and information-gathering activities that are sometimes repeated multiple times (Mace and Ward 2002). Idea refinement can include the adaptation of an idea or set of ideas via conceptual combination (i.e., combining aspects of multiple ideas) or elaboration (i.e., extending the development of a particular feature) (Watts et al. 2019). The idea is tested and refined by materializations such as quick sketch models. A physical model enables one or more aspects of a product to be demonstrated (Hess and Summers 2013). It is a valuable tool for communicating in a team, as well as sometimes a tool for exploring new ideas (Jacucci and Wagner 2007). A finalized idea, i.e., a product concept includes a detailed description of the form, behaviour, and features of a product, its specifications, and justification of the current situation. However, in this context, the resulting concepts are at a very experimental level.

3 Materiality in Design

Material or representation is often needed to mediate the activity in product design. Some sort of representation, such as a sketch, document, material, diagram, or prototype is typically involved in communicating one's thoughts to others, be this a team member or a client. These different types of graphical, verbal, and physical representations are generated and transformed from the ideation to the finalization phase (Laamanen 2016).

For product designers and engineers, material knowledge is essential, because the work is mostly based on hands-on practice (Haslinger and Bang 2015). General knowledge of the materials relates to, for example, the selection available, their technical properties, their sustainability, their experiential qualities, their cost, and how they can be processed. This type of knowledge can be gained at least partly from different information sources (see Härkki et al. 2016, 2). However, when working with emerging materials or in scientific material research, the design approach differs from conventional product design processes. Through material exploration and experimentation, designers and engineers gain an understanding of the materials' properties and behaviours even at the beginning of the material development process. New insights support not only product development, but also ideating completely new applications (Härkäsalmi 2017).

Playing around with materials, samples, and prototypes, and studying their qualities reveal associations on many levels, extending thinking and helping decision-making (Kosonen and Mäkelä 2012). Sensorial attributes are links between the physical composition of the material and the associations created from it (Haslinger and Bang 2015). Sensory experiences such as seeing, touching, smelling, gesturing, heaving, and moving convey 'informational cues' from objects (Jacucci and Wagner 2007).

Kirsch (2010) labels the interactive process of projecting structure and materializing it as the most fundamental process of thought. However, this is a two-way street: materiality also affects and shapes our mental functioning (Wertch 1991). Therefore, previous experiences of materials and the related embodied knowledge enable us to imagine feel and other properties even from images, before the physical making phase (Groth and Mäkelä 2016).

These imaginary explorations and visions are especially important for designers when making material choices. The better the repertoire of design and material knowledge, the more solutions can be seen and expressed (Alesina and Lupton 2010). Designers typically make material choices based on existing materials. However, Haslinger and Bang (2015, 30) observed that if the selection process is only based on existing materials, this restricts participants and products, and only properties already known to the participants are articulated.

4 Overview of the Workshop of Experimental Wood-Based Materials and Student Projects

4.1 Workshop Description

The DATEMATS workshop was held at Aalto University, Finland. Its content was based on the joint DATEMATS workshop structure, following the framework of '*understanding, experimenting and applying*' (Parisi and Ferraro 2020, 153–169). However, the schedule and the programme were adapted to enhance the specific needs of experimental wood-based materials. Altogether 19 students from four different universities and from the fields of design and engineering participated. All of them were already in their third, fourth, or fifth year of studies. The design process was carried out in five teams of three to four students. The company challenge for the workshop was given by Honext, a young Spanish company that focuses on sustainability and the utilization of cellulosic waste streams. Honext asked the students to develop *innovative interior applications for cellulose waste panels.* Four other companies gave presentations during the week to broaden the students' understanding of the potential of wood-based materials.

4.2 Learning Environment

Chemarts courses are usually held in a specific learning environment that is designed for hands-on material experimentation and is a combination of a designer's studio or kitchen and a chemistry laboratory, equipped with tools and materials from both realms. It is an open space located in a large, high-ceilinged hall, which contains a variety of laboratory equipment and prototyping machinery. In this case, the student teams had their own home bases—long and steady laboratory tables where the main 'cooking' activities took place. The students moved around fetching ingredients, weighing them at separate workstations, or carrying the prepared 'cookings' to the oven at the other end of the large hall. Three of the teams shared this environment, so the space was filled with talk and, now and then, strong whirring noises from the blenders. The tutor went around to check the students' progress, helping them, sharing knowledge, demonstrating, and sometimes shouting advice to everyone together. The first part of the workshop, understanding, involved predefined experiments and students were given laboratory guides that summarized instructions for laboratory work and recipes for the four assigned tasks. In addition, students could use all the resources available, for example, material samples on the walls and shelves, recipes for additional experiments, and the Chemarts Cookbook (Kääriäinen et al. 2020). The raw materials and ingredients had their own distinct sensory elements such as structure and smell, which influenced the making experience and also left traces for the final experiments.

DATEMATS Workshop at Aalto University 24.-28.1.2022

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
Everyday 8.15-8.50 Breakfast at restaurant Maukas				
VÄRE Q101	*Abio*	*VÄRE Q101*	*Abio*	*Abio*
9.00-9.20 Welcome	9.00-9.15 Preparations	9.00-9.15 Joint Discussion	9.00-9.15 Preparations	9.00-12.30 Finalizing prototypes, concepts and presentations
9.20-9.40 ICS Wereables EM&Ts - Venere Ferraro	9.15-9.45 Pill talk! VTT - Anastasia Ivanova	9.15-9.45 Pill talk! Stora Enso Evellina Juuri	9.15-9.45 Pill talk! Uusipuu - Virpi Korhonen	
9.40-10.00 Advanced Growing EM&Ts - Anke Pasold	9.45-12.30 Laboratory work	9.45-10.15 Pill Talk! Nordic Bioproducts Group - Dario Forneris & Ville Nyman	9.45-12.30 Laboratory work	
10.00-10.10 Break		10.15-10.30 Break		
10.10-11.00 HONEXT Company and Challenge - Claudia Carrasco		10.30-12.30 Idea development with experts		
11.00-11.10 Break				
11.10-11.30 Nanomaterials EM&Ts - Robert Thompson Casas				
11.30-12.30 Experimental Wood-based Material EM&Ts - Tapani Vuorinen				
Everyday 12.30-13.30 Lunch at restaurant Maukas				
Abio	*Abio*	*Abio*	*Abio*	*VÄRE Q101*
13.30-14.30 Familiarizing laboratories and safety measurements	13.30-17.00 Laboratory work	13.30-17.00 Laboratory work	13.30-17.00 Preparing final presentation	13.30-17.00 Project presentations and comments from experts and company
14.30-16.00 Laboratory work				
VÄRE Kipsari Lobby				
16.00-17.00 Datemats Exhibition Visit				

Fig. 1 Workshop schedule

The workshop consisted of four distinctive social settings (see the workshop schedule in Fig. 1): (1) the experts' and organizations' presentations, (2) making and designing in small teams, (3) discussions with experts and tutors, and (4) students' presentations. The making activities included cooking various materials, making the final prototype, designing digital models, and preparing the presentation. Students could also perform two more experiments. The making took place in a laboratory space and the designing (ideation process and finalizing the concept) was mostly done in a classroom. Tutoring was ongoing in the laboratories and classrooms, and the presentations were held in a regular classroom setting.

5 Summary of Student Projects

The Honext product—interior panels made of cellulose waste—was not available for prototyping, but the company representative described the technical and visual properties of their product to complete the information available on their website. Four out of five teams decided to include material development in their concept. One team created the concept of a functional, aesthetic divider with integrated carbon foam that would work as an air filtration system (see Fig. 2); another explored a flexible mobile fitting room combining rigid and flexible materials (see Fig. 3); the third used textile waste for visual effects (see Fig. 4), and the fourth created the concept of a recyclable retail window display system made of Honext panels and fungal materials (see Fig. 5). The fifth team focused on innovating a new functional retail use for the panels, using only material experimentation to communicate their assembly idea (see Fig. 6).

(For a deeper understanding see appendix with all the projects).

The Honext company representative gave the team constructive and insightful feedback. She asked questions about, for example, the aesthetic and technical aspects of the proposed concepts, and pondered their applicability, use, recyclability, and future scenarios. In general, Honext considered the student ideas good, some of them even promising and worthy of more detailed testing and development. All the student project posters are presented as an appendix.

Almost all the students answered the feedback questionnaire ($N = 17$). Overall, their feedback was very good. The students considered all the content (pill talks, expert talks) interesting and well explained, and felt that the didactic resources were used appropriately, and the materials were easy to understand. In addition to the DATEMATS Inspirational cards for EM&T integration and Toolkits as well as the Chemarts Cookbook was mentioned as useful. The framework of ‘understanding, exploring, applying’ received good reviews. The answers to the open questions revealed that online talks were considered somewhat challenging, and that the time reserved for the workshop was slightly too short. Over half of the students (58%) reported that they had worked overtime. The answers to the open questions revealed that the briefing (too short) and materials (lack of samples) given by the Honext aroused mixed thoughts and they received varying ratings, although good overall. The involvement, discussions, and feedback of the company were considered good. Experimental hands-on work with materials was experienced as highly inspiring, useful, enjoyable, and even the best part of the workshop. According to the students, the workshop supported idea generation by enabling them to concretely understand the properties of the materials and by facilitating collaboration. The multidisciplinary, international teams were appraised positively. However, the students wished they had been better introduced to the other students and that they had had more leisure activities (which were sadly not possible due to COVID-19) and information about Finland.

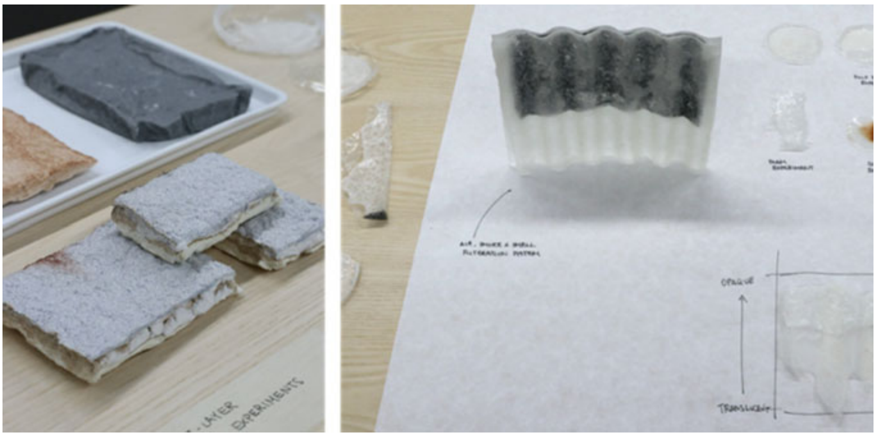

Fig. 2 Material experiments and small divider prototype with air filtration system

Fig. 3 Material experiments of cellulose leather, small prototype, and mobile fitting room concept

Fig. 4 Material experiments with textile waste and ideas for wall applications

Some students experienced the amount of information as challenging to take in, but overall learning rated it as good.

We conclude that the method seems to support new thinking in idea generation and concept creation. A five-day workshop is very short for diving deeply into wood-based material development, and real-life applications easily remain

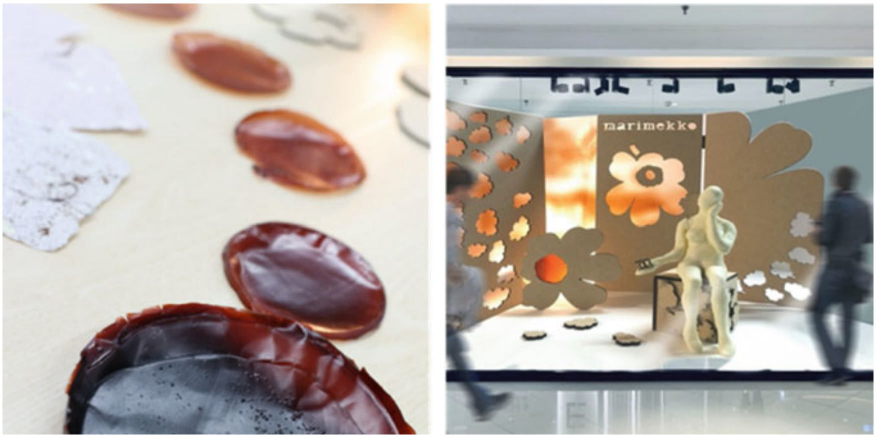

Fig. 5 Material experiments and concept of recyclable retail display consisting of wood-based panels and pre-grown fungal materials

Fig. 6 Material experiments for modular interior designs for retail

distant. However, the tutors found the systematic implementation of the DATEMATS framework of 'understanding, exploring, applying' useful for developing future experimental material courses.

6 Materiality in One Team's Process

To better understand the students' ideation processes, we decided to follow and analyse the work of one of the teams. The aim was to examine *how materiality (different representations and materials) enabled the emergence of insights into the* *collaborative idea-generation process*. In the analysis, we traced *critical events*. We identified how materials advanced critical events, which in turn advanced the design process.

7 Method

7.1 Participants

The team was selected so that none of the members had any previous experience with Chemarts' courses. The selected team included Zoe, a sustainable fashion design BA student and Jade, who had a bachelor's degree in product design and was studying design and engineering at BA level. Michael was studying mechanical engineering and design engineering as a double BA degree and Elena was continuing her chemical engineering studies at MA level (names have been changed). The students did not know each other beforehand and represented four different nationalities.

7.2 Data Collection and Data Analysis Methods

We used video recording as a data collecting method. This allowed us to capture real-time, naturally occurring data. By video recording we could follow the activities of the student team in distinct social settings. We recorded most of the students' processes (including making and designing in small teams and discussions with experts and tutors). This produced 12 hours and 30 minutes of video material from a single camera. However, we presumed that the students advanced their ideas outside the recorded sessions. Therefore, in order to 'catch up' with the process, a researcher also asked the team to summarize their activities and reflect on their learning at the end of the day and sometimes between working sessions.

The students followed the workshop schedule and therefore, as expected, the video-recorded data included episodes of (1) carrying out the assigned tasks, (2) the students' own experiments with materials, (3) framing the design task, (4) ideating with materials, (5) refining the idea and finalizing the concept, (6) making and presenting a prototype.

The analysis consisted of typical qualitative content analysis practices (Krippendorf 2013) with the help of ATLAS/ti software. Qualitative content analysis was utilized in a generic manner, rather than making a detailed analysis of communication, i.e., interaction analysis (Katila and Raudaskoski 2020).

Powell et al. (2003, 416) define a critical event (based on the research literature), as a construct that represents a contrasting change from students' previous understanding. We identified nine critical events, and according to their occurrence, we were able to narrow them down to Episodes 2, 3, 4, and 5 for deeper analysis.

Table 1 Summary of critical events

Critical event	Time	Episode
1. Choosing own material experiments (decision)	Tuesday AM 08:00–15:17.	2
2. Discarding window idea (decision)	Wednesday AM 01:10:22–01:10:32	3
3. Cellulose leather (demonstration)	Wednesday PM 05:04–07:46	4
4. Problem is found (Eureka! moment)	Wednesday PM 09:51–11:07	4
5. Context is found (Eureka! moment)	Wednesday PM 35:39–35:49	4
6. The idea for the structure (Eureka! moment)	Wednesday PM 1:03:41–1:05:36	4
7. First prototype (demonstration)	Wednesday PM 1:09:06–1:17:45	4
8. Shimmering wood panel pattern (proposal)	Thursday AM, 01:12–06:50	5
9. Final structure (decision)	Thursday AM 27:45–31:06	5

Table 1 presents a summary of the critical events and the date and time when they emerged as well as some related episodes. Three of the events were decisions (1, 2, and 9), one of them was a proposal (8), two were demonstrations with material (3 and 7), and three of them were Eureka! moments (4, 5, and 6).

We found that one of the critical events qualitatively changed the process trajectory. This so-called watershed critical event (see Powell et al. 2003), here Critical event 4, connected sequences of critical events in Episode 4 (Ideating with materials), marked by an orange hue in Table 1. These sequences created the most intensive phase of the process during which the idea was found and formulated. Next, we describe the whole ideation process and the critical events.

8 Results

8.1 Towards Framing the Given Design Task

The first critical event defined the materials the team had for use in the rest of the process. On the same morning (Tuesday), the team had finished the assigned material experiments. On the same afternoon, the team gathered around their workstations in the laboratory and browsed the Chemarts Cookbook (Kääriäinen et al. 2020) together. The discussion revolved around the images they saw in the book, and which materials seemed interesting. They carefully examined the photographs and discussed the assumed features of these materials (see Fig. 7). The focus of the discussion was on cellulose leather. They had decided to also make transparent material, but this was only mentioned in passing during the rest of the process.

During this event, they created tentative visions for the use of the chosen materials; three of the students pondered the possibility of layering them in Honext panels. Thereby, from the beginning, the brief and the interests and requirements of the client were borne in mind, although they had only seen images of the Honext panels and received a verbal description of its features.

The discussion during this first critical event illustrates how the students applied material thinking before having the actual material in their hands (see Groth and

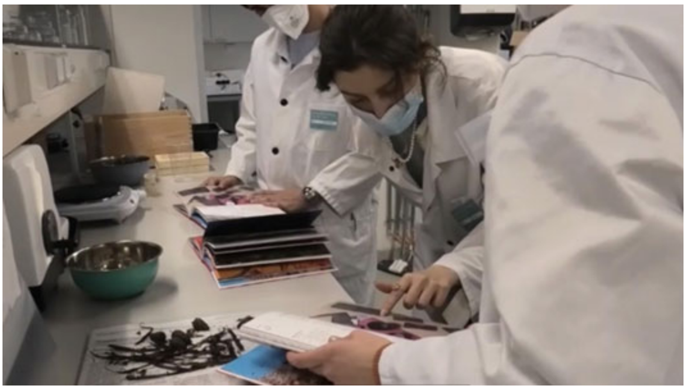

Fig. 7 Examining detail in the photograph of cellulose leather

Fig. 8 Two framing sessions: Tuesday afternoon in the lab and Wednesday morning in the classroom with consortium experts

Mäkelä 2016). It can be assumed that the students' previous knowledge of the leather type of materials and the product images gave them ideas on how to use it in this design task.

After choosing the materials (cellulose leather and transparent material), the students started making them, spending about half an hour cooking samples in pairs. However, as there was a delay between making the material and the finished product, they spent the rest of the day framing the design task and idea space with impartial information. For some reason they did not ask the tutors for material samples (cellulose leather or transparent material).

Three of the students were in attendance when they began the very typical design practices—searching for images of already existing products, sources of inspiration, and information and discussing them, while sitting together in the lab (see Fig. 8). They browsed internet sources and images, but also utilized the DATEMATS Material Integration cards.

Moving between ideas from the cards and other sources, the students collected the potential contexts and product proposals into a document (see Fig. 9). This document, containing ideas of 'what could be', was the first concrete example of a shared object in this collaborative process. The team continued working on it the next morning (Wednesday) and communicated their notes to Elena who had been absent the previous evening.

A second critical event occurred on Wednesday morning. It had already been agreed that the idea of a screen divider for privacy had potential. Also, a fitting room idea with a signalling function emerged. However, Elena introduced her proposal of a window application, which could harvest solar energy. Her chemical engineering background enabled her to create this idea from an a Material Integration Card. The group spent some time finding out how it could work. They searched for information on the internet and Jade made some sketches in order to understand the function. She did not share the sketches with the team, they seemed to be more like thinking tools for Jade. The discussion went in turns of elaborating and evaluating the screen idea and window idea. Discussion of the window idea highlighted that it was quite complicated for the team in terms of the new information required. The available materials did

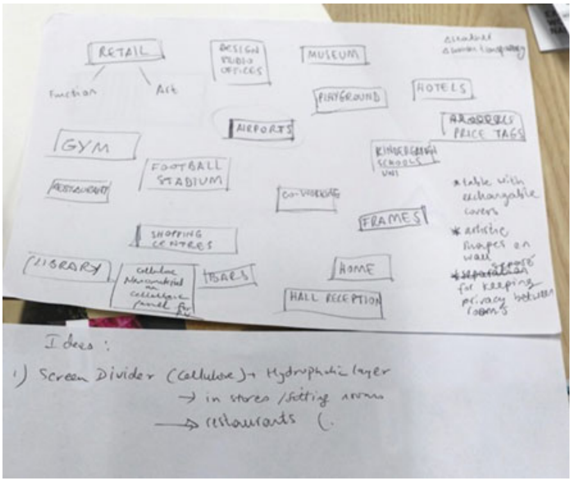

Fig. 9 First shared document created during the process

not sufficiently help the discussion. There were also gaps in communication, partly because of the students' different educational backgrounds. In the end, a discussion with one of the experts made them discard the idea as too difficult for such a short workshop. After this decision, they narrowed down the key idea to be developed further as the screen divider.

8.2 *Ideating with Materials*

On Wednesday afternoon, qualitative change in the process took place. The students took all their samples to the classroom in order to continue framing the task, but now with the help of materials (see Fig. 10).

Fig. 10 Material samples made by Team 4: cellulose leather (left) and transparent material sample (top right). The team also made paper samples

Fig. 11 Critical event 3: cellulose leather demonstration, proposing flexible spiral fitting room

The afternoon contained a sequence of five critical events during which the key idea developed into the final idea (see Table 1). The first of the sequence of events (Critical event 3) was Zoe's demonstration using a cellulose leather sample. Zoe and Michael took cellulose leather samples in their hands, right at the beginning of their meeting, turning and folding them, making sense of their material properties. Direct experiences with materials naturally lead to associations (see Haslinger and Bang 2015). Materials suggest ways in which they could be used, their behaviour and properties suggest different types of structure, surface, and connection (Alesina and Lupton 2010). Their flexible nature triggered Zoe to propose a cylinder—a spiral fitting room space in which the door could be bendable (see Fig. 11). This was critical, because Jade reacted to it by suggesting that the flexible material (leather) could be covered with strips or pieces of Honext panel so that the form could be bendable and at the same time rigid. Some minutes later, Michael proposed combining several screen dividers, so it could be used as a movable fitting room. These proposals paved the way for the later pivotal events.

Critical event 4, i.e., the watershed event, emerged when Jade started thinking about a crowded shop. This was a clear Eureka! moment. The transcript below highlights how they found the design problem. From this point onwards, it was possible to evaluate the features of earlier solution proposals at the same time as the problem.

Jade: Haa, I'm thinking, you know when like, for example Primark, which is, I mean it's like filled with lots of people and sometimes you don't even want to go to the fitting room

Elena: OH MY GOOD, YEAAAH! (claps her hands together)

Jade: Because you just want to try instead of…

Elena: Are you thinking what I am thinking?!

All: Laughing
Jade: I was just thinking about the purpose, because sometimes
Elena: It ..a.. a mobile, mobile
Zoe: Fitting rooms
Elena: Fitting rooms exactly
Zoe: Laughs
Jade: Yea I don't know if it is possible to do, even, not just Primark…
Elena: Anywhere yeah!!
Jade: ..But places where you just want to try something, like you don't really want to try in front of everyone, but you don't want to go to the fitting room. I don't know if it's like good idea
Elena: Mobile fitting room could be a great concept
Jade: Probably it could be with…
Elena: It could be box of four panels and you work with whatever, motion sensing idea and yea, same idea but
Zoe: On wheels
Elena: Yea
Jade: I don't know
Zoe: I feel that's new
Elena: Yea (0:11:07)

After this event, the team discussed the form, as well as a suitable context for the fitting room. Jade challenged the regular box shape, and they pondered variations. Zoe took the leather spiral fitting room idea up again, because it enabled flexibility and gave the fitting room a social aspect. Jade elaborated on this, and they both made some sketches. Their discussion highlighted the material aspects they had to imagine, such as the anticipated behaviour of the new cellulose leather on a large scale, as well as the nature of the Honext panel they had not concretely seen. Below, Fig. 12 presents the examples that were developed from the spiral idea and imagined combinations of the rigid panel part and cellulose leather as the flexible part.

When discussing the context, the students evaluated where the sustainable fitting room idea would be feasible, and how it would support the user experience. The

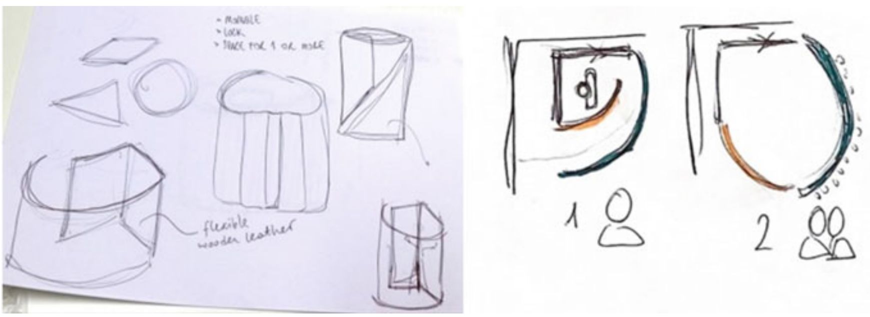

Fig. 12 Sketches of fitting room ideas

Fig. 13 Critical event 6. Michael demonstrated the idea of the structure and the others participated

vintage market context emerged as a new proposal by Jade when the consortium expert entered their discussion. The students discussed this context for twenty minutes and accepted it as the most suitable, making this Critical event 5. The expert made two important remarks that acted as enabling constraints later in the process: (1) she reminded them that the structure needed to be rational, for example, from a logistics point of view; and (2) she suggested that instead of thinking ‘rigid and flexible’ they could think of the whole thing as flexible, but with supporting structure.

After this, the team again pondered the form and structure for a while, and Jade suggested that they use the earlier mentioned layered structure panel (strips or any other form) on leather. Further elaborating this idea, Michael proposed a structure, in Critical event 6, that would combine the many necessary solution requirements (movability, adaptability, supporting structure, social aspect, rational form) that they had set during the process. This highlights not only elaboration but also the use of conceptual combination, i.e., idea refining by combining aspects of multiple ideas (Watts et al. 2019). His suggestion for the structure was based on one large cellulose leather piece to which the panel pieces would be attached, leather enabling flexibility between them. Thereby, the very initial, intuitive idea of layering, already taken up in the first critical event, also became part of this proposal.

Michael started demonstrating the idea with paper and cellulose leather samples. Jade and Zoe wanted to grasp the idea and joined in, trying out the structure (see Fig. 13). It was a moment of shared material discussion and ‘sketching’, during which they could feel the idea in their hands to be able to make an initial estimation of its material and spatial functionality. This type of activity continued when they made the first sketch model in Critical event 7 (see Fig. 14).

The sketch model helped them try out the proposed structure and how it would function in different compositions (see Fig. 14). It also became an important shared object, a tool to finalize the idea. Although it was made from paper, it became the first materialization of their idea of combining two types of material.

As a three-dimensional object, the sketch model enabled turning, folding, and adding new things such as a mirror and a rack (see Fig. 15). Thereby, this sketch model became an evolving object and finally a storage vessel for the knowledge produced during the ideation phase, as well as an important tool for the next phases.

Fig. 14 Critical event 7. Trying out modifications in the sketch model

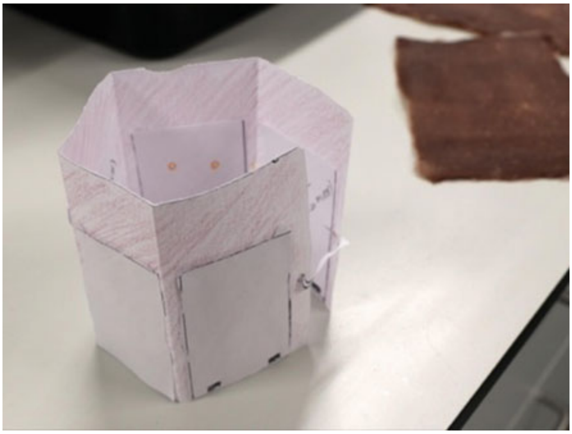

Fig. 15 Sketch model

8.3 Refining the Idea and Finalizing the Concept

On Thursday morning, Critical events 8 and 9, the last two, finalized the team's idea and concept. In Critical event 8, Jade proposed applying a 'Shimmering Wood' pattern (structural colour produced from nanocellulose) to cover the panels. She suggested that they discard the idea of signalling (which would have needed electricity or batteries) and instead integrate a nanocellulose-based shimmer for a unique look. The group had seen an example of 'Shimmering Wood' on the Material Integration cards but had not fully understood the idea. Jade had learned more when discussing it with her roommate. She had found a video of the material, which now also helped the others team members grasp the idea. The suggestion was accepted, and in the end, they decided to use 'Shimmering Wood' as laser cut patterns which could be customized for each customer.

The decision concerning the final structure was the last critical event, number 9. The movability of the fitting room had been a requirement that the team had pondered along the way. At this point, the team decided to add wheels, and Michael suggested

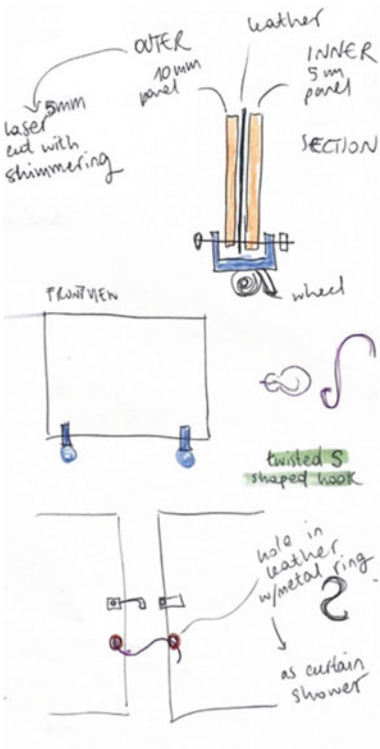

Fig. 16 Sketches containing details of the final structure of the fitting room idea

a specific construct that would also provide some structural support. This discussion was enhanced by examples from the internet, but the most important aspect was the drawings that Jade and Michael made to explain the final structure. The sketches in Fig. 16 contain details agreed on in the finalizing phase, complementing the sketch model (see Fig. 16).

9 Conclusions

In this chapter, we have described the five-day *Experimental wood-based materials workshop* held at Aalto University in the Chemarts learning environment. The workshop structure followed the DATEMATS framework of *'understanding, experimenting and applying'*, adapted for experimental wood-based materials. Five international and multidisciplinary student teams worked on a design challenge involving interior panels produced from cellulose waste. We reported one team's ideation process and related materiality in more detail. During the workshop, the team carried out the core elements of the design process. This resulted in the creation of an artefact that solved an identified design problem and met the given design brief. It was an open-ended design process in which the problem was defined in the middle of the process.

Cross (1997) characterized the emergence of an idea in collaborative design as a gradual process of building creative bridges between a problem and a solution rather than making an immediate, significant creative leap. This was also highlighted in this study. Nine critical events in the students' collaborative process illustrated how the ideas were built gradually and iteratively from the first initial insights.

The team spent most of the workshop developing their idea together. Thus, the team members, as well as other peers, were themselves important sources of information. Despite some communication challenges, the team was able to elaborate on each other's ideas, which ensured the emergence of the critical events. However, the consortium's expert guidance also had an important influence.

The team used typical design representations and practices to communicate their ideas and to create new knowledge as well as store it. External sources of inspiration and information were used mostly in the framing phase. Towards the end, the team naturally created more of their own representations and the use of shared representations increased. In the team's process, the shared representations were the document of collected ideas, sketches, and the sketch model. However, the drawn sketches played a surprisingly small role in the idea generation in the sense of shared objects among the team. The sketches were mostly shared in pairs, first when the flexible round form ideas of the fitting room were generated and second when the technical structure of the fitting room was developed. The DATEMATS Material integration cards for EM&T's integration served the team quite well. However, it became obvious that the students could not understand all the examples thoroughly enough and did not have time to explore them in more depth. Due to these restrictions, the team chose realistic ideas instead of pursuing more speculative visions.

The results highlight that understanding the material or the material's imagined features is an important part of the process, even when not concretely present. This became evident as the team worked with impartial knowledge of the materials. They had no real panel material at all, and the cellulose leather samples were not ready until the middle of the workshop. These samples were vital. They worked as a source of inspiration, and flexibility triggering important insights. Joint material practice emerged in a material demonstration and followed in the form of the small-scale sketch model of a mobile fitting room. The material samples and the first sketch model were central for communicating the materiality of the concept idea to the peers, tutors, and the company.

We conclude that this type of short workshop is most suitable for senior students who already master the design process quite well. Although it cannot provide an exploratory process of developing one's own recipes and materials (see Laamanen and Kääriäinen, accepted) it could work as an introduction to making and using experimental cellulose materials in the design process. According to the feedback collected, the students greatly enjoyed the making part; it was new to them. They said that they had not known, for example, that colour can be derived from plants. The use of self-made material and the goal of integrating several technologies of course brought new perspectives to the design process. It was a challenge that differed from normally encountered problems and whose outcomes were not predictable, even for the teachers. These types of tasks often simulate a sense of inquiry and curiosity in the learner (Garner and Evans 2015, 73), hopefully leaving an impactful trace in the memory and an interest to continue working in the field of developing sustainable materials.

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