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CHOOSE THE RIGHT MATERIAL! EXPERT AND USER INTERACTION IN PARTICIPATORY DESIGN

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1. Introduction

Nowadays to be competitive on the market it is necessary to design focusing on the user. In a wider sense, it can also mean to actively involve them, so that they can be part of the design process together with designers, in a process called "participatory design" [Muller et al. 2003]. This is a fundamental requirement: experts and users should understand each other's, using the appropriate verbal language and tools [Holman et al. 2012]. Therefore, the design should be expressed in a form that users can easily manipulate, modify and interact with it [Muller et al. 2003]. This form is often called a prototype. A prototype supports the communication between different stakeholders [Lafranièere et al. 1999] and has to be easily comprehensible to all the participants.
This research will present an experiment with three different types of low-fidelity prototypes of a web interface, made of different materials: digital, paper and plywood. We analysed their diverse level of physicality and tangibility, no matter whether the final product is tangible or not.
The aim of this paper is to assess which material users like and if designers and users are aligned in the choice of material tangibility in the different design phases.

2. Related Research

Since the probability that new ideas emerge is much greater if the team is heterogeneous [West et al. 1990], collaboration between experts and users is crucial for a successful design. Users can be involved occasionally in order to collect feedbacks or they can become part of the design team. In the latter case, we call the collaboration participatory design. Participatory design emphasizes creativity and use of different tools [Bratteteig et al. 2001]: the utilization of concrete techniques are more suitable for the collaboration with the users [Muller et al. 1993]. In fact, tangible tools allow explaining concepts visually, increase learning and memorization and allow expressing the experience's emotional point of view [Muller et al. 2013]. In addition to this, Dayton et al. [1998] states that the utilization of low fidelity materials supports and contributes to the participatory design, making tangible ideas and building artifacts. There are numerous studies that support "thinking by doing" idea and prove the benefits brought by the use of different concrete tools [Walker et al. 2002], [Statler et al. 2007], [Kristiansen et al. 2009]. Few of the researches found compare materials characterized by different tangibility's levels. The first question, which will be investigated in this research, is "*Which is the material tangibility level that users like most in the different phases of the design process?"*
In general, during the participatory design sessions, it is fundamental that experts and users can use the same tools [Bødker et al. 1991]. In fact, during the design projects low-fidelity prototypes are used from the beginning [Coughlan et al. 2007] because they incentivize the innovation level of the solution reducing the probability of failure [Leonard et al. 1997]. Usually, low-fidelity prototypes are paper based or digital mock-ups and several articles have been written to discuss the different needs met by

them [Vertelney et al. 1990]. From a designer perspective, paper is usually used during the first phases and digital during the last ones. How about users? It is very important for users and designers to be aligned in the choice of materials to utilize throughout the process, because both have to be able to interact with the materials offered. There are many studies about the different possible kind of prototypes, their utilization in the different phases of the design process, their negative and positive aspects, ... but to our knowledge, no research has been done comparing the experts and users' point of views on the tangibility of the material to use in the different phases of the design process. The second question, which will be investigated from this research, is *"Are users and designers aligned in the choice of tangibility of the material in the different design phases?"*

3. The experiment

The emotional involvement influences human-interface interaction from a physical, aesthetic and usability point of view [Biolchini et al. 2009]. In the prototyping activity, previous research already dealt with aesthetics (i.e. rough vs final prototype) and usability (i.e. wireframes vs working websites) while the physical choice of the material to use is still to be investigated. In this research, we expressed the physical factor as the prototype different levels of tangibility obtained with diverse materials, which are digital, paper and plywood. They have been reported from the less tangible one to the most tangible one. We chose the first two because they are the most used materials in the web design process, while the last one was chosen because it is as easy to find as the other two. The plywood is a crude material that responds well to the needs of the early stage design process and is a very common material in other design processes (e.g. architecture). Hence, we conducted the experiment through the variation of only one factor according the principles of the control experiment methodology. In this way, behaviours and phenomena have been studied focusing mostly on descriptive goals and on the direct observation of the testers while they were going to accomplish specific design activities or choices of the experiment.
At the beginning, we considered all possible touch points between designers and users, during the participatory design process. Brainstorming, building and testing are the phases in which the end-users can cooperate with experts. Then, every phase has been investigated in detail considering that the experiment is on a web-interface design. Then for each of these sub-topics, we identified the key need to which the chosen prototype should respond. The experiment followed a semi-structured interview; each question was referred to one specific sub-topic (see Table 1).
Concerning the second question we tested at the same way both users and designers in order to be able to compare their answers and to get at least two points of view for each question.

Table 1. Needs and questions for each design phase and sub-topic

PHASE	SUB-TOPIC	NEED	QUESTION
Brainstorming	Idea generation	To increase creativity	*Which material would you use to take note of ideas and to make quick sketches?*
	Idea selection	To visualize the concept	*Which material would you use for selecting some of the ideas emerged in the previous step?*
Building	Develop Screenshots	To make it tangible	*Which material would you use to make tangible the selected ideas and start to develop them?*
	Navigation Process	To show the interaction	*Individuate the navigation process to search for an internship inside a company. Where are you able to better individuate and follow it?*
	Web Page's Structure	To create new shapes, change elements' position	*Which material would you use to organize and move the different elements and buttons inside the page?*
	Graphic	To choose font and colours	*Which material would you use to change or choose new colours and/or font?*

Testing	At early stage	To follow the concepts	*Thanks to which material can you get better product ideas?*
	At later stage	To perform specific tasks	*Which material do you use to build pop-ups?*

4. Methodology

4.1 Experimental methodology

Participants. The goal was to interview two different groups of people. We called the first one end users and the second one experts, meaning people that work daily on web interfaces design. We recruited 25 "end users". The end users (aged 20-30) have different education backgrounds, in order to try to have a sample significantly independent from other variables. None of them has had previous experiences in website development. Furthermore, we recruited 18 "experts", which were web designers (28%), user experience designers (22%), developers (22%), requirement analysts (22%) and web merchandisers (6%). We chose these kind of experts because they cover key-roles during the human-interface interaction design process.

Apparatus. The wooden versions of the prototype and the ones made of paper had the size of an I-pad and in particular, the paper versions were photocopied. There were also several pieces of wood of different sizes, some coloured post-it notes, colour markers, pencils and rubbers. The digital versions of the prototype were displayed on a 12.1" HD laptop screen.

Setting. The experiments were conducted in informal and quiet places, such as university classrooms, libraries and the participants' own places or offices. All prototypes have been displayed in three rows to be well visible in front of the tester. In the first row, there was the laptop that showed the video prototype; in the second one, there were the paper prototypes with some colours makers, pencil, rubber and post-it and in the third one, there were the wood ones, with some colours makers and several small pieces of plywood. We replicated the same setting for every test.

Procedure. The testers were interviewed singularly. The participants were presented the three different materials, and showed the built interfaces as examples of possible uses. It has been explicitly asked the testers not to focus on the product rather on the differences they perceived between the artefacts, because of their different materials. After these preliminary informations, the core interview started following a specific procedure inside of the semi-structured interview (see Table 2). For each question, the participants were asked to specify which of the three materials they would have used and why, to modify the product with the material they had chosen and to give some feedbacks after having tried it. We recorded and transcribed all participants' comments.

Table 2. It shows the experiment's procedure that participants had to follow for every question

REQUIRED ACTION	TYPICAL QUESTION	SCOPE
1. Choose: the prototype to use in the specific case.	*Which material would you use for...?*	Understand opinions and motivations of the participants
2. Make: the specific interaction with the chosen prototype.	*Do it, please. / Explain it, please.*	Test holding, feeling, manipulating and touching of the materials for the specific tasks.
3. Comment: about the interaction with the prototype.	*It has been easy? / Did you like to use it for this scope?/ What did you like it? / After having tried it, would you want to change your answer? / ...*	Analyse and get other additional feedbacks through the participants' reflections after use.

In order to get the real motivations to the answers, "Why?" questions were repeatedly asked. They were encouraged to think aloud, even when they touched and used the prototypes. The testers

generally gave more than one reasons. Answers, in which the participants wanted to use more materials at the same time, were accepted and they had just to specify for which specific scope they would have used one or the other.
Ethnographic notes were taken as well notes about their interactions with the materials. The observations were direct and testers were aware of this. Their additional comments and opinions have been recorded and then transcribed. Then all data have been clustered as explained in the following section.

4.2 Prototyping methodology

For the experiment, we designed the same low-fidelity prototype with three different appearances. In order to keep constant the aesthetic and usability factors, they showed exactly the same website interfaces. These prototypes had the same sizes of an I-pad and they look different only because they are made of different materials: plywood, paper and digital (see Figure 2). What differs is the human interaction according to the type of material. For the first one we used plywood and we draw on it by using colour markers. Every button is a small piece of plywood, which was attached at the base with adhesive tape, so that they could be easily removed. For the second one, we hand drew on the paper with a pencil and colour markers. We built the third one by using Cacoo, a free online software (http://www.cacoo.com).

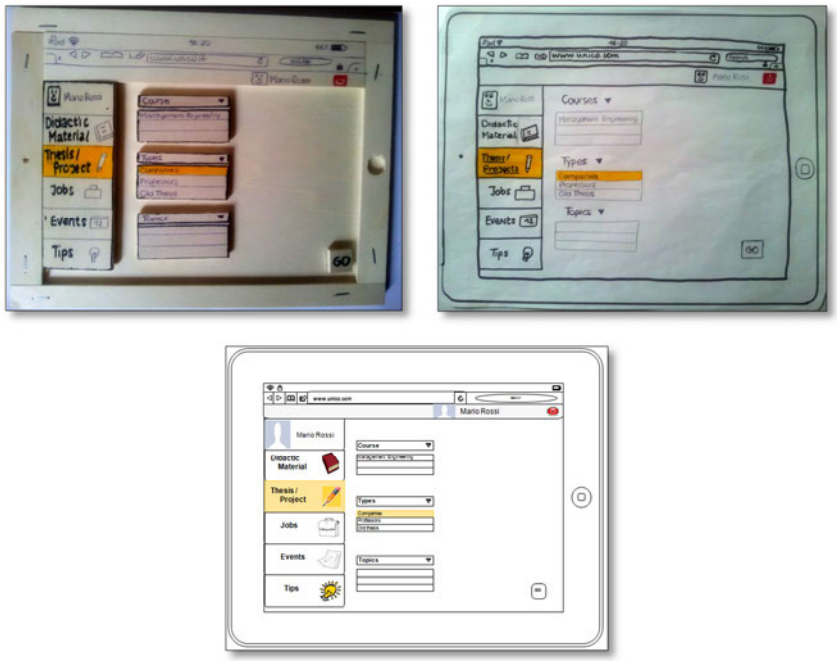

Figure 1. Examples of three prototypes. The first is the one wooden made, the second is the one paper made and, the third is the digital version

4.3 Analysis methodology

The analysis methodology used is qualitative, so it was focused on disclosing and collecting experiences, comments, behaviours and thoughts of the participants. This involved listening to the testers and collecting their observations.
All the recorded data have been transcribed and comments have been added about testers' behaviours and attitudes, in order to get a better and more complete understanding of the single interviews. They have been divided in two groups, according to the group of the tester: "end users" or "experts". Afterwards, we analysed each question and interpret the answers, with an independent coding procedure, in order to find common patterns based on two levels. The first one was related to the type of material the tester would have used in that specific case, while the second one was about both the

different motivations and the feedbacks given after its utilization. Finally, for each question the percentage of the answers and motivations has been calculated. This allowed understanding which were the recurrent opinions of the participants for each topic, by considering the two groups separately. After that, the answers given by the users and the experts have been compared.

5. Results

It is necessary to consider the results from the two points of view investigated in this study, the one of the users and the one of the experts. The percentages of the results are in Table 3. The empty slots represent the cases in which the percentages were not meaningful. Percentages in bold, instead, highlight that in those situations experts and users' choices are aligned.

Table 3. End-Users Experts alignment matrix

	Participants					
	END-USERS			EXPERTS		
Materials / Phases	*Wood*	*Paper*	*Video*	*Wood*	*Paper*	*Video*
BRAINSTORMING						
Idea Generation	-	**80%**	-	-	**89%**	-
Idea Selection	40%	-	44%	67%	17%	17%
BUILDING						
Develop Screenshots	**36%**	-	**64%**	**44%**	-	**56%**
Navigation Process	28%	-	72%	-	-	78%
Web Page's Structure	**72%**	-	-	**78%**	-	-
Choose Font & Colors	-	-	**88%**	-	-	**100%**
TESTING						
At early stages	40%	-	52%	28%	28%	44%
At later stages	-	-	**84%**	-	-	**100%**

Ideas' generation. For generating ideas 80% of the end users preferred the paper, because they consider it easier (47%) and faster (35%) to use, and above all, 52% said it is the most immediate material as you can write your thoughts directly on it. 89% of the experts usually work using paper, because it allows to a group of people to co-work writing and erasing sketches easily.

Ideas' selection. In this step people already know what they are going to do and they are more focused on selecting among some options. The answers mainly differ in two categories. Some end users (40%) would use wood since they considered it immediate to use and it enable you to think and move the blocks simultaneously. They said that wood is a creative material and it encourages creativity and collaboration, but it has to be easily writable and erasable and there shall be many pieces of different sizes available, in order to not be limited by the material itself. If these requirements are met, then you can quickly build your ideas in different ways and immediately see the results. End-users think that with this material the work becomes more enjoyable. Then, there is another group of end users (44%), which use the computer every day or have IT knowledge and so know several programs and feel really self-confident in using these tools, they said they would start to use the digital already from this phase because this helps them to better order their ideas. A not homogeneous answer emerged from the experts. The wood has been preferred by 67% of the designers, they think it is a very good prototype for co-working with users during the convergence phase for different reasons. It is enough abstract to

focus on structure and macro-functions and not on the details. In addition, according to their own experiences, they realised that the use of such tools, which allow both users and designers to feel self-confident, facilitates a more open dialogue and a better interaction between different actors. In fact, when you are using your hands to build something, you are able to explain your thoughts in additional ways. It stimulates users' curiosity, arising a major number of questions that could come out. All this is true if participants have already an idea of what are going to do. Therefore, the experts give credit to the materials' tangibility.

Develop screenshots. To develop the first rough screenshots, 64% of the end users preferred the video prototype; it helps them to organize ideas and evaluate their strong and weak points. However, 36% of the end users would like to have something more tangible in their hands, such as a wooden I-pad or a real one. At the early stages of the design process, the wood is considered good, because everyone can try to modify it. 44% of the experts preferred wood for this phase; in fact, it helps to not focus on details and to co-work: more people can touch and build the prototypes at the same time. It gives to the entire team the same possibilities to act, even to those people without IT knowledge the plywood could be a good mean to build in phisycal word what the experts successively will transform in the digital world. The video has been preferred by 56% of experts in order to keep the prototype close as much as possible to the final solution. In general, all the interviewed experts said that it is a hard question, since it is not possible to generalize. In this case, the choice of level of tangibility is strictly dependent on the kind of end-users: from their capacity to not focus only on the details, their IT or artistic skills and their age.

Navigation process. The video has been preferred to analyze the navigation process by 72% of the end users because they could clearly follow the sequence of "clicks" and the pages flipping, as it happened in the reality. It reflects what people expect to see. On the other hand, 28% of end users preferred wood: thanks to its 3D component the contents and the buttons stand out much more and this helps concentration. The video has been preferred by 78% of the experts since they think this is the material that better simulates the real interaction while the other proposed options are not suitable.

Web Page's Structure. The wood was preferred by 72% of end users to study the web page structure and so for changing the position of the menu and other elements, because it is the most effective material: the thoughts and the actions are directly linked. It is faster and immediate, the changes are immediately visible and no particular hand drawing or IT skills are required. They can also better assess the spaces of the page. Even 78% of the experts preferred the use of wood for this step: it is immediate, simple, and perfect in order to actively involve a group of people. Furthermore, it may be useful to choose between two options (A or B testing), because designers do not need to build, many versions and users can really understand which one they prefer and direct easily modify it.

Choose Font & Colours. In this phase it is necessary to take into account graphic and details such as font and colours, the video is considered a better solution by 88% of end users since it is the material used to display the final solution. In addition to this, the range of choice is wider, the changes are immediately visible, it is faster to use and it is possible to get a lot of ideas or suggestions by looking at software options. All experts (100%) agreed with end users, these details have to be studied on the same mean of the final solution.

At early testing stages. If the project is in the early stages, 40% of the end users preferred to see the wood prototype, something tangible. In this way, the subject of discussion looks more real and this allows a better focus on the concepts. 52% of the end users preferred the video prototype; since they think to understand better the product if they see it on real mean. Even for this question experts had many difficulty, in fact 90% of them stated it strictly depends on the kind of end user, because some of them could not take seriously prototype wooden made and instead it could be necessary for other people in order to help them to focus on the macro functions and not on the details. For these reasons, the data collected about this section are heterogeneous: 28% considers the wood a useful mean, because the users could easily interact by keeping it on their hands. Since until now they never came up to use it, 44% preferred video that they always used without having any difficulty and instead only 28% chose paper in order to collect the first impressions about the product itself.

At later testing stages. When the process advances, digital is considered the best mean for 84% of end users, because it is the most immediate and credible tool. End users can better understand the almost

definitive product and in this way, the number of logical steps is minimised. All experts agreed with the end users about the use of digital in this phase, because thanks to the existing software it is the faster mean to modify and also because step by step the interaction has to be always more truthful and this affects also what the users have on their hands.
In many occasions, data gained from observations contradicted what people declared. The main point was that few participants pay attention to the digital prototype. They just had a quick look at the first screenshot but then they did not flip the other pages. When they had to draw a comparison between the three different materials, they just kept looking at the wood and paper artefacts and it was necessary to remind them to look also at the video. They nodded but they did not do it. The opposite happened with the wood: the majority of end-users started to touch and play with it since the beginning. During the first part of the interview, 53% of end-users have shown an interest in it, but at the same time, they were reluctant to use it, and just after some time they started to consider the wood in a different way and asked to change some of the answers they had given, which often were incoherent. In fact, at the beginning of the interview some end-users said that they would never use the wood, because they considered it unprofessional, but when they were asked: "Which material would you like to use to modify the interface?" they chose the wood and in the end, they changed their mind about it. At the same time, end-users who had instinctively chosen wood, once they have tried it, they recognised that it was not the most suitable material for every situation. Many end-users were enthusiastic and amused, they said they felt like children playing and they said that this mean would make them less tired after many work hours. However, as some experts suggested, it should be presented in a different way in order to be efficient: small magnetic blocks of different standard sizes could represent the grid columns used by developers to divide the work page. This would solve the problem of not having all the necessary pieces for size and shape. Writing and correcting shall be easy to do on the pieces. In general, also the experts appreciated the wood. Firstly, during the design phase it helps to abstract concepts. Secondly, it may be very useful when presenting products to users or customers because it is considered a really powerful mean of communication and collaboration and it stimulates creativity. In addition to this, it is well seen because if it is easily erasable it could limit the hard utilization of paper that usually happens during the early stages.
For what concerns the acquisition of information through iconography, because of mental preconceptions, the participants were able to associate the images to the respective information on the video screen, but they were not able to do the same with the other two prototypes, even if the icons were exactly the same. These graphic elements are well appreciated in the video screen since they mainly immerse the participants in the context. The testers in fact said to clearly notice the images on the video screen because they are exactly as they are used to see, instead on the wood the images stand out thanks to the 3D component of the pieces of wood, in fact each one of them is seen as a possible button. Finally since the paper is flat, only the elements particularly well-drawn or coloured stand out.

6. Discussion

To answer to the first question, it is possible to declare that the plywood, the most tangible material tested, involves participants much more than the other two materials. It catches the users' attention, it makes them curious and more active, and they immediately start to touch, modify and play with it. They involuntarily start "thinking by doing" showing positive emotions. In addition, it promotes the team-building phenomena, the creation of a common language and knowledge. In addition, the characteristics that the plywood should show clearly arise from the research: it has to be easily writable and erasable and there shall be many pieces of different standard sizes in order not to be limited by the material itself. In addition, these small blocks could represent the grid columns used by developers to divide the work page. In order to answer to these requirements the new wooden made prototype version has been proposed: it has been painted with writable paint and the small chunk cut as sub-multiple of the grid columns above mentioned (see Figure 3). This new solution solves the questions about the reuse and the modularity of the small blocks. As the solution introduces initially, the prototype has to be dimensioned as a real i-pad and chunks are attachable by scotch tape and writable by coloured pencils and pens.

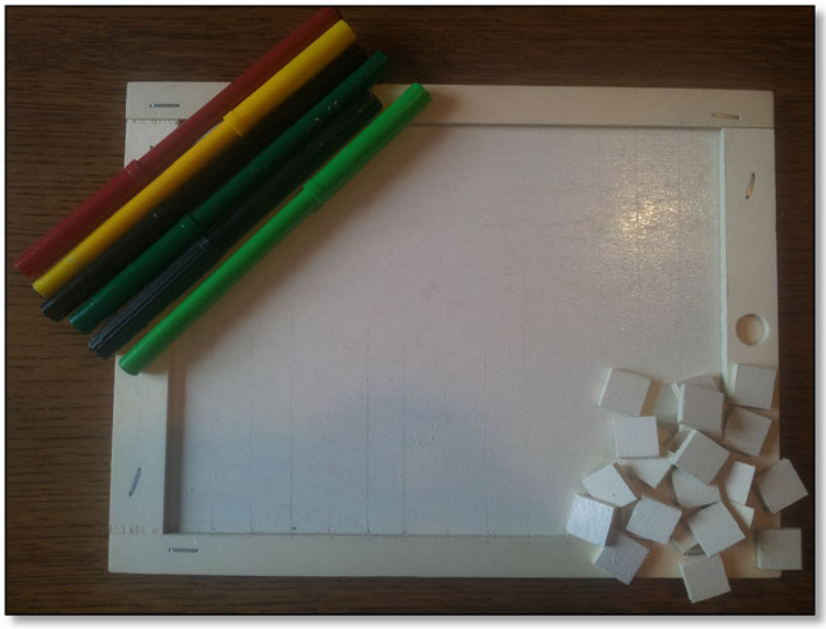

Figure 2. The new version of the wooden made prototype

Table 4 summarizes the findings, about the second research question, underlining the suggested tangibility level associated to each phase. For the idea generation, experts and users agree about the paper's use. Vertlney et al. [1990] and Osterwalder et al. [2010] confirm this by discussing about the use of post-it and whiteboards for noting ideas or drawing sketches. For the idea selection, users, depending on their IT skills level, choose to use the video or the wood. The experts, instead, prefer the use of wood. Researches about this specific topic have not been found, but all the studies about the visual thinking [Osterwalder et al. 2010], the simple tools that encourages creativity [Gabrysiak et al. 2007] and participation since they do not require any particular skills [Safelin et al 2003], [Shulz et al. 2011] give credit to the wood utilization. Since experts and users' choices are not perfectly aligned, this suggests to expert to evaluate which is the material that better fits to the specific user. To develop screenshots, experts and users agree about the use of video, because it allows evaluating the idea on the mean of the final solution. They are equally agree about the use of wood this would make it possible the realization of the "design-by-doing" process. Tudor et al. [1993], the researches about the constructionism and the Lego Serious Play confirm this finding. To study the navigation process, experts and users agree about the video's use. This do not confirm Tudor et al.'s studies [1993], who proposes wood for this activity. To structure web pages, experts and users are aligned in the choice of using plywood. Statler [2007], discussing about the Lego Serious Play, confirms this by recognizing the possibility to build complex systems through using simple materials. To choose fonts and colours, experts and users prefer to use the video. Biolchini et al. [2009] confirms this hypothesis stating that only with a high-fidelity prototype it is possible to get feedbacks about visual elements. To test concepts and macro functions, users are divided between those who prefer the video, saying that it is the most immediate mean since it is that one of the final solution, and those who prefer the paper, affirming that the video's use would not be coherent with this initial phase. From the experts' point of view, there is no a real answer: the material that they would choose, is that one which could fit with the users. Researches about this specific topic have not been found. It suggests to experts to try to know the users before choosing the tangibility level to propose. For testing the final solution, experts and users agree to use the video. There are many studies that confirm this hypothesis (such as [Vertlney et al. 1990]): this is the last step so it is necessary to test every functionality and detail in the most real possible way.

In conclusion, these findings hold if: 1) the team is not virtual, so it can physically share tools and experience different tangibility levels; 2) the project is highly innovative, so that the creativity, the contact with the users and utilization of different prototypes are of fundamental importance.

Table 4. Levels of material tangibility suggested for each phase

Phase	Level of tangibility
BRAINSTORMING	
Idea Generation	**Medium**
Idea Selection	**High**
BUILDING	
Develop Screenshot	**High / Low**
Process Navigation	**Low**
Web Page's Structure	**High**
Choose Font & Colors	**Low**
TESTING	
At early stages	**High**
At later stages	**Low**

7. Conclusions

This research investigated on the web interface participatory design process, in particular on brainstorming, building and testing phases. The aim was to understand which material tangibility level, expressed differently in the three presented prototypes, users like most in the different design phases and if users and designers were aligned in this choice. For this reason, both points of view have been investigated trough a control experiment, in which qualitative data about actions, behaviours and comments have been gathered. From our analysis, mostly observations' data, we could assert that plywood is the mean which users like most.

People were attracted and intrigued from the wooden prototype since the beginning and during the experiment, their curiosity increased. It allows to abstract the main functions and to encourage the creativity. It can be used to discuss and work in team, many people can touch it at the same time, and it helps the creation of a common language and knowledge. It seems that the high level of tangibility produces users' emotional attachment.

Experts and end users are aligned in the choice of tangibility's level for almost all activities analysed except for those of idea selection and testing at early stages. For these phases and for the developing screenshot one, the choice of material tangibility's level depends on the kind of end user. Informatics and artistic skills, cultural background and age are important variables to be considered. In fact, table 4 shows the general guidelines to follow during the choice of the material tangibility level to propose to the end users. However, it is important that experts try to know the end users before offering them a certain material.

This study is a first attempt to understand how to support communication between designers and end-users in participatory design and has many limitations. In any case, providing some guidelines on choosing the right mean to make communication tangible is, in our perspective, at the core of design, since design is a conversation.

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