How Children Represent Sustainability in the Home

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ABSTRACT
This paper describes an exploratory study about children's perspective on sustainability in the house through a drawing-telling method. Here, we describe the methodological framework used for interviewing children about issues related to sustainability using the drawing-telling technique as described by Susan Wright [26]. The participants (children from age 9 to 13) were asked to draw two houses and then describe their drawings in terms of sustainable actions and features. The results show how the participants understand sustainability and how they represent it in the context of a house. This pilot study is an initial step to investigate if there are opportunities to develop eco-visualizations (EVs) for children. The goal of this study is to inform the design of eco-visualizations for children based on their understanding of sustainability and their own visualization of their homes.

Categories and Subject Descriptors
H.5.m [**Information interfaces and presentation**]: Miscellaneous.

General Terms
Design, Theory.

Keywords
Drawing and telling method, eco-visualization, children, home, sustainability.

1. INTRODUCTION
This paper looks at how children represent sustainability in the home in order to explore if there are opportunities for designing eco-visualizations for children. Global warming, natural resource depletion, and environmental degradation are concerns that we are currently facing. In [8], DiSalvo, Sengers, and Brynjarsdottir describe different approaches within the HCI community to address these issues. One of the major themes is persuasive technology which is looking at ways to design systems "*that attempt to convince users to behave in a more sustainable way.*"

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In [19], Pierce, Odom, and Blevis suggest that HCI has a strong potential in representing information that home dwellers usually cannot see or have access to. Eco-visualizations and eco-feedback devices are one way to bring awareness to people about the amount of energy and water they use over a certain period of time. "*Eco-visualizations (EVs) are any kind of interactive device targeted at revealing energy use in order to promote sustainable behaviors or foster positive attitudes towards sustainable practices*" [19]. EVs are based on the idea that home dwellers lack awareness and understanding about how their everyday actions impact on the environment and this is one of the reasons why their behavior is not sustainable [10]. Moreover, it is believed that technology can be useful in bringing this awareness to people in their house.

While most of the literature about EVs aims at informing future design efforts with the current state of adult behavior, attitude and perspective on sustainability, there is no literature that investigates the position of children in relation to sustainability behavior and values in the home. More specifically, there is no literature that presents efforts to design EVs for children at home. Even though persuasive technologies are taking 45% of the current work and research in the HCI and sustainability field [8], there is a current discussion in the literature tackling the ethical concerns of what is a desirable sustainable behavior (desirable for whom?) and who decides how home-dwellers need to be persuaded.

This paper discusses the findings of an exploratory study conducted with n=14 child participants and how they understand and represent sustainability in their homes. There are two goals to this study: (1) using the drawing-telling technique to interview children, we investigate what children know about sustainability in their house. (2) We explore if these representations can lead to opportunities for informing or transforming EVs for children. The investigated questions are the following: Are there opportunities for designing eco-visualization for children? What representation do children have about their houses and sustainability? What can be learned from children to inform the design of future EVs?

1.1.1 Definition of Sustainability
The definition of sustainability that will be used in this paper is the one that relates to the HCI community. Tiffany Holmes, in [13] elaborates on what definition should be used for future work in EV. She starts with the 1987 Brundtland Report, where sustainable development involves: "*Meeting the needs of the present generation without compromising the ability of future generations to meet their needs.*" The author then expands this definition by adding the concerns Tony Fry puts forward. "*The philosophy of sustainability is rooted in how humans manage and maintain resources like electricity and water for future use by all cultures without compromising ecological diversity.*" [13, p.155]

The remainder of this paper is organized as follows: related works about eco-visualization, interaction design and children, environmentalism and children, and the children-parent relationship; the methodology used (drawing-telling technique); a description of the study (participants and method); a description of the findings; and finally the results' analysis, a discussion for design, the limitations of the study and the conclusion.

2. RELATED WORKS

2.1 Eco-visualization

Eco-visualizations have been studied and compared in previous research [8, 10, 11, 19, 25]. *7000 oaks and counting* by Tiffany Holmes is an example of an EV aiming at educating and curtailing power usage. Through the in depth description of the project, the author of [13] describes the area of EVs and how it can promote resource conservation by showing information that is usually hidden. In [10], Froehlich, Findlater, and Landay investigate what HCI can learn from environmental psychology and what role should HCI play in the development of eco-visualizations. The authors argue that the HCI and UbiComp communities are ready to contribute their expertise to the elaboration of future EVs.

Pierce, Odom, and Blevis [19] differentiate two general types of eco-visualization: *pragmatic visualization* and *artistic visualization*. While the first one is straightforward and aims at giving clear easily understandable data, the second one keeps a certain level of mystery. The artistic and mystical aspects of the latter type of EV are considered to be positive because they can spark a continuous interest from the public. Figure 1 presents four examples of pragmatic visualizations. *Holmes* and *Lucid Building Dashboard*® are software applications that can be accessed through a computer. They present data about the amount of energy and water that is used over time. *Wattson* and *Eco-Eye* can be positioned anywhere in the house, showing the house dwellers how much energy they are currently using. While showing this data does not necessarily imply that the dwellers will change their values to conservation oriented ones, Woodruff, Hasbrouck, and Augustin argue that the data itself is a great motivation for changing behavior [19].

Figure 2 presents three examples of artistic visualizations. Artistic visualizations rely more on curiosity, mystery, and playful engagement with the house dwellers and ludic representations of energy to encourage awareness to the energy dwellers use. [19]

2.1.1 EVs and Children

The field of EVs is still nascent but there is a gap in the literature about children and eco-visualization. Current research contains no literature on how children interact with EVs, or about how EVs are designed specifically for children, but there is research about children and information visualization. Schneider [21] and Hourcade and Perry [14] propose that children need to be prepared for the world of information we live in and explore how children from 10 to 12 years old can use information visualization tools to "*analyze datasets, interpret them and present the results of their findings*". Hourcade and Perry found that "*the children enjoyed using Gapminder and had no problems identifying trends and outliers*." *Gapminder* is a visualization tool designed for adults used to show datasets that exist over a certain period of time (usually years). This suggests that information visualization tools may be useful for children, and that it is worth examining in the field of eco-visualization.

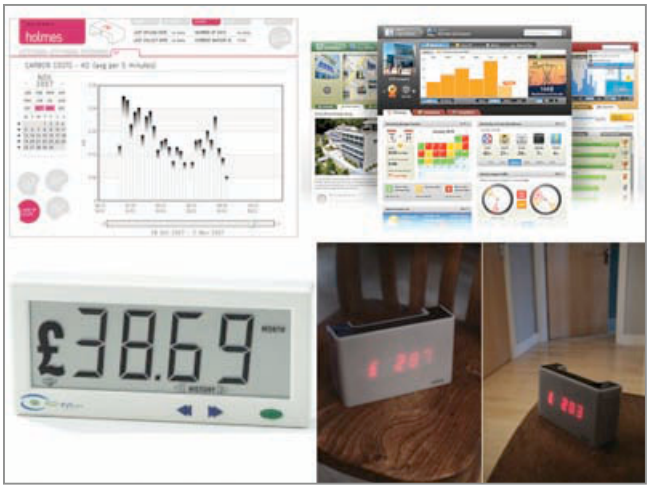

Figure 1 Four examples of pragmatic (or literal) eco-visualization. They represent the amount of energy or water used in kilowatts, liters or money value. Clockwise, starting from top left: *Holmes, Lucid Building Dashboard®, Wattson* and *Eco-eye*. (*Holmes* and *Wattson* image courtesy of DIY Kyoto, used with permission. *Lucid Building Dashboard* image courtesy of Lucid Design Group. *Eco-Eye* image courtesy of Eco-eye.com, used with permission.)

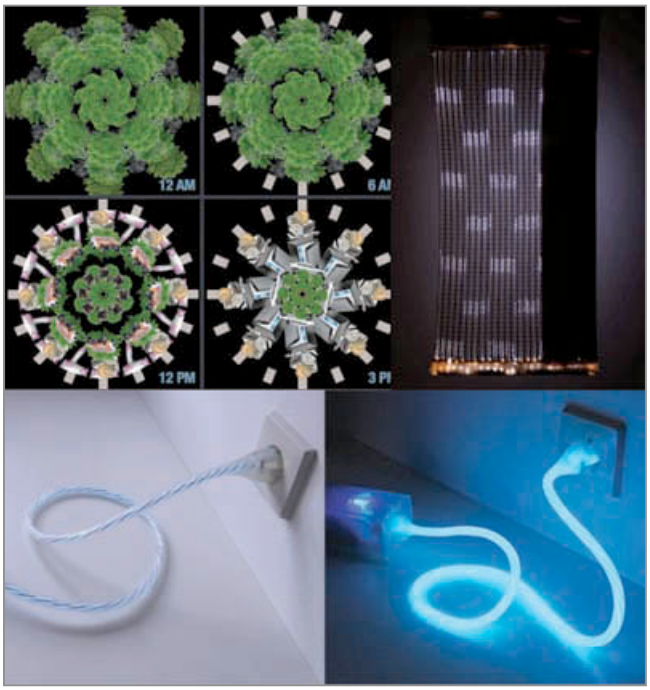

Figure 2 Three examples of artistic (or abstract) eco-visualization. Clockwise, starting from top left: *7000 oaks and Counting* (image courtesy of Tiffany Holmes, used with permission), *Energy Curtain* and *the Power Aware Cord* (images courtesy of the Interactive Institute, used with permission.)

2.2 Children and Interaction Design

On the other hand, some researchers are starting to look at how EVs can be better adapted to the user. He, Greenberg, and Huang in [11] argue that most of the current eco-visualization technologies are based on a one-size-fits-all framework. These

technologies don't take into account the different motivational stages the individuals are in, and give the same feedback to every user. Based on the trans-theoretical model described in [11], the authors describe five levels of behaviors change and demonstrate the motivational goals and recommendations for eco-feedback technologies at each level. Markopoulos, in [18], brings his attention on how children should be considered special user groups in interaction design, which have different levels of motivation, different needs, goals, abilities and knowledge. In the group of ages 8-12, children "*shift gradually from fantasy to reality*" and they start to develop their critical and analytical abilities, which are necessary when working with visualization tools. The author also presents a section about designing for children and specifies two main guidelines. The first one is to keep age-specific interaction styles and the second one is to consider the different roles children can play in the design process as proposed by Druin in [9].

Druin describes four roles children can play in the design of technology: user – the designer observes how the child uses a technology that has already been developed, tester – the child tests emerging technologies, informant – the child takes place in informing the design process before the technology is designed, and design partner – similar to informant but here the child is considered to be equal stakeholder in the design process. In this study, we are asking the children to be *informant* on our design process about the design of eco-visualizations for children through the drawing-telling technique [see section Drawing-telling Technique]. The literature about children and interaction design proposes guidelines that could be useful to the research and design of EVs for children.

2.3 Children and Environmentalism

In the current academic landscape about children and environmentalism, there is little literature about how children represent sustainability in the home, but there is a lot of discussion about environmental education. William B. Stapp first defined the concept of environmental education in 1970 [22]. Since then it has grown and continues to propose ways to bring awareness about the environment to children. "*Environmental education involves children, teachers and communities working collectively and democratically towards the resolution of environmental questions, issues, and problems. […] It is about values, attitudes, ethics, and actions. […] It is a way of thinking and a way of practice."* [6].

The literature about environmental education could be used as a starting point to design eco-feedback tools for children. However, this approach, based on theory, would keep the children out of the design process, and possibly miss on some key points that children can bring to the table. Considering the research questions we are asking (a. what do children understand about environmental sustainability and b. how do children represent homes and sustainable activities), we believe in primary research to inform this exploratory study for two reasons. (1) The field of EVs is nascent and literature about EVs for children is almost non-existent. (2) Following the guidelines proposed by Druin, we are trying to integrate children as informant to the design process through the drawing-telling technique.

2.4 Children and Parent Relationship

This research may have implicit impacts on the behavior of children's parents who would use EVs in their houses. The unidirectional influence of parents over children is very well documented and accepted [1]. However, in the 1970 and 1980, there was a change in the way researchers looked at the relationship between parents and children towards the idea that this relationship included a mutual effect on both parents and children. [1, p.15] More recently, researchers looked at the effect that children have over their parents [7, 16, 22]. Children can be a great motivation to change habits and even values. For example, in [24] Wilcox and all describe how children can influence their parents to quit smoking, particularly after children were doing a project about lung health at school. In past environmental research, it has been proved that children who learn about environmental issues can have an impact on the environmental attitudes of his or her family members. For example, a study was conducted in a Costa Rican village [16], where children learn about the environment and the parents and family's knowledge about this subject grew significantly.

As children learn about sustainability at school, they sometimes bring new ideas and actions to live more sustainably at home. They propose new ways of living, or maybe small changes to their parents and are able to occasionally to challenge them. [16]

3. METHODOLOGY

3.1 Drawing-Telling Technique

Different researchers have looked at various methods for meeting the challenges and barriers to interviewing children in qualitative research studies. Alison Clark and Peter Moss [5] developed the mosaic approach, which uses multiple channels and ways of expression to give children the best opportunities to express themselves. These data collecting techniques can be "*interviews, child conferencing, map-making, the use of cameras, story telling, drawing*" [15]. Other techniques can be added to extend this technique as long as they respect the many creative ways children can use. Susan Wright [26] combined the visual channel (what can be looked at) with the verbal channel (what is said) in the technique she calls: *drawing-telling*. In this technique, the researcher asks children to draw something in relation to a specific topic and then asks them to explain what their drawing means to them.

Amy MacDonald [17] used the drawing-telling technique in a study that aimed at understanding the children's perspective about their first day of school. This method was used to keep a focus on the lived experiences and on the perspectives of children. This research was qualitative and focused on capturing the children's stories. Carl Stafstrom in [15, p. 65] used the same technique to investigate headaches experienced by children. The goal was to collect more information about the children's headaches to include more information before a diagnosis was proposed. The author found that it was easier for children to describe their headaches through drawing for different reasons. First, children felt empowered because they had more time to reflect on what they wanted to say compared to a traditional interview. Secondly, they didn't feel as much stress when it came to talking about their drawing, as they were not talking about themselves and instead were focused on what was drawn. This also means that children tend to lie less with this technique than when only asked to talk [15]. MacDonald and Stafstrom used the drawing-telling technique for particular subjects where it was usually difficult to have children talk about their experiences and perspectives.

More closely to the design process, Hemmert et al. [12] define sketching as a "*direct and creative method for visualizing ideas that is commonly used in design process. It has advantages in being visual and concrete, without using abstract verbal descriptions*."

In [2] and [3], Barraza and Robottom present two examples of studies using children's drawings to capture representations of their construction of environmental issues. The drawings were analyzed using the content analysis method and from the different themes depicted in the drawings, five categories were constructed to gather the information. Even though they did not look at eco-feedback tools, their conclusion about the method is relevant to our study: the drawings are valuable data because they can be used to avoid linguistic barriers and "*most children enjoy drawing without showing any sign of tension. While many children dislike answering questions, drawings can be completed quickly, easily and in an enjoyable way*". [3, p. 181]

For the purpose of this study, we believed that the drawing-telling technique is appropriate to investigate children's perspective about sustainability in the sense that this concept requires a certain level of knowledge and vocabulary. We used the synthetic approach of choosing this method and investigated how we could use it for our purpose. Our idea was not to conduct a comparative study between multiple techniques and we are well aware that other ways for interviewing children exist and might be as successful. Furthermore, since one of the objectives of the study is to explore how children visually represent their homes, and sustainable houses, the drawings are precious artifacts that can inform the design of EVs for children.

4. PARTICIPANTS AND METHOD

The authors met with 14 children (7 girls and 7 boys) from age 9 to 13. The participants were all born in Canada and currently live in the Greater Vancouver Regional District. The children had various cultural backgrounds and attended different schools.

The study was conducted with four different groups of children (unisex). For each group, the activity lasted for about one hour. At the beginning, the children were told that nothing they were saying or drawing could be wrong and the interviewer tried to make them feel as comfortable as possible. The children were given an unlimited amount of time to complete the drawings and to answer orally the questions asked. All the answers to the questions were audio-recorded and transcribed. In the first phase, the participants were asked to: (i) *draw a floor plan of your house.* This first question was asked as a warm up question, before mentioning anything about sustainability in order to set the mood and introduce the children to the activity without focusing on sustainability yet. After completing the first task, the children were asked to do the following: (ii) *Using your floor plan, explain your morning/afternoon routine. Draw the path you follow during this routine*. The routine was asked for a normal school day (week day) since weekends usually have fewer routines. We wanted to keep the questions simple to avoid overwhelming the participants. During the interview, we were very open to other comments and we were sensitive to topics that were not related directly to the questions, but to our overall area of research. The floor plan helped them to keep a mental representation of their house, and made it easier for them to remember the actions. The goal of this question was to prepare the following question about sustainability. It also allowed for possible spontaneous answers about sustainability actions. The paths also showed where the children spend most of their time in the house. Following this, they were asked: (iii) *Do you know what sustainability means? Can you explain what it is?* If they could not answer, they were asked: (iv) *Do you know what being environmental friendly means? Can you explain what it is?* This question showed how the participants defined sustainability. Following this question, they were asked: (v) *Think about your morning/afternoon routine and describe what is environmental friendly about it.* They would then put a colored circle at the places where they were doing sustainable actions. This activity aimed at understanding what children can do to be sustainable in their houses and where these actions are situated. The areas and activities were then placed in a table to see if there were main themes coming out of all the participants' drawings.

The second phase of the study started with a second drawing. The guideline was: (vi) *Draw the most environmental friendly house that you can imagine*. The idea behind the second drawing was to investigate what children know about sustainability. When they were done, they were asked: (vii) *Explain what you drew, focusing particularly on the environmental friendly features*. By asking them to explain their drawing, the interviewer was able to understand the meaning of the features on the drawing. This last question was particularly pertinent because it allowed the participants to visually explore their own ideas and to clearly present their understanding of sustainability.

5. FINDINGS

The data collected for the study was a combination of drawings and recordings of the children's answers to the questions. First, all drawings were looked at to see how the houses were represented. Secondly, the drawings of the real houses were looked at in parallel with reading the transcriptions of the interviews. The transcripts were analyzed and interpreted to understand to what extent the children knew what sustainable actions entailed in their homes. Thirdly, the ideal drawings were analyzed and the transcripts of the interviews were used to better understand the meaning of the drawings. The analysis of the drawings and transcripts provided a list of key insights to consider when looking at opportunities for EVs for children. Finally, the types of sustainable actions were put in a table to group and more easily visualize in what areas children envision sustainability.

5.1 Representation of houses

Different observations could be made from the drawings children made of their real and ideal homes. The drawings could be separated in three main categories: floor plans, front view, and front view with embedded floor plans. The participants used this last category in order to display everything the children wanted to share and explain, (see Figure 3). They also used a lot of secondary views to show more detailed top plans of certain floors. Most of them were not very precise in following a specific scale for objects, room divisions and layout of the house. Finally, some

Figure 3 P5: Front view of the house with embedded floor plans.

of the participants used words and labels to describe and clarify certain features. In their ideal drawings, children represented the house as a whole, in comparison to a floor plan. This representation was their choice and we can think that it was easier for them to show what global changes should be brought to the house.

Children have their own way of representing space, particularly the space they know. They were able to use their drawings with ease to walk through their morning and afternoon routines. If they had forgotten something, and remembered it while describing the routine, they would simply, and spontaneously add the feature where it was suppose to go. For example, P6 explained how he composted and then realized that he did not draw the compost bin outside the house and added it ad hoc.

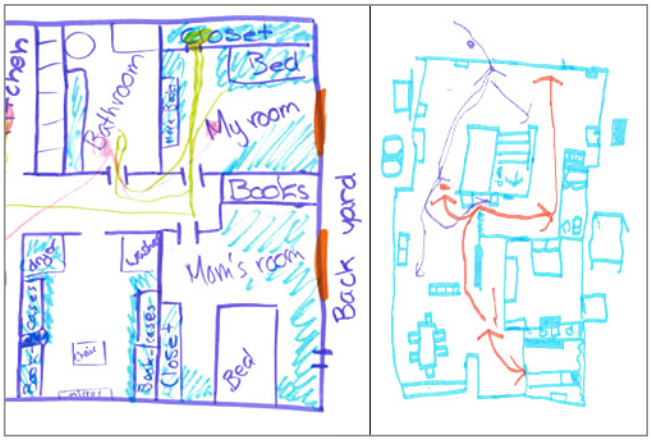

Figure 4 Left: The blue areas represent where there is clutter in the home. Right: Arrows representing movement in the home.

In figure 4, we can observe that the participants were able to use abstract visual representations and to layer them over the map of the house. Colored areas show clutter, large dots show activities and arrows show movement. One participant (P14) also added some characters (two little girls) that were living in the house. She said that they were there to show that people are living there.

This first analysis suggests that children have a sense of space and can situate sustainable actions within space. By asking more about all the features they drew, it was possible to understand more about their ideas and what their intentions were. It also showed that the participants did not draw without a reason, everything was there to fulfill a specific function.

5.2 How children define sustainability

Participants' understanding of sustainability was collected through the drawings (which will be discussed in the next two sections) and the two following questions. "*Do you know what sustainability means?*" and "*Do you know what being environmental friendly means?*" For the purpose of this study, environmental friendly will be defined the same way sustainability was. All but two participants did not know what sustainability meant. To the second question, most of the participants were able to give an answer that fits within the general definition of environmental sustainability. The answers included words such as: *make a difference, be helpful, don't harm the environment, not killing the wilderness, caring and help the environment, not polluting, recycling*, and *using renewable energy*. The answers contained also examples of sustainable behaviors such as *don't leave the tap running* and *biking or walking to school*. Even though these answers did not reflect the complete definition of environmental sustainability the way Tiffany Holmes defined it [10], they were relevant to the study's focus on environmental impacts and this implies that the participants had a basic knowledge about sustainability.

5.3 Current sustainable activities in the home

This section discusses the results found in the first drawing (a floor plan of the children's real houses). When asked to explain their routines and sustainable actions, most children were able to remember their actions and to explain what sustainable actions they are doing daily.

The lines representing the paths the participants were following through their morning and afternoon routines are indicators of valuable places in the houses where children take action. The kitchen, the washroom and their personal bedroom are places where the children were able to act (see figure 5).

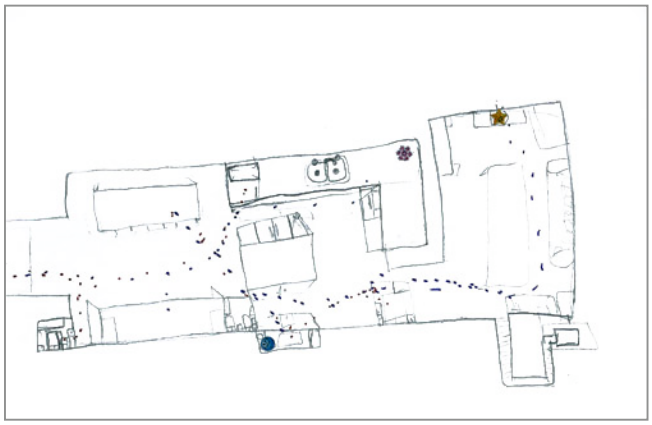

Figure 5 P3: Environmental activities represented by stickers in the bedroom and the bathroom.

Saving water was very important to the participants and nine out of fourteen mentioned that they don't leave the tap running while they brush their teeth. Some participants also mentioned (P1 and P2) that they would tell their parents to turn off the tap when they are washing their teeth or washing vegetables. P6 also explained his shower coach system. It is an hourglass that gives you a certain amount of time to take your shower. By the time it is empty, you should be done with your shower. P6 was very enthusiastic about this tool (even though he forgot to draw it, and remembered while the interviewer asked about environmental friendly actions he was taking after school). He also said that he is trying to convince his mother to use it, and that after saying she didn't need it, she agreed to try it. Some participants also said that if their parents would see them waste water, they would be very mad. We can observe that water consumption was a concern for both parents and children, and that they tried to transfer this awareness to each other.

Electricity is also a very important topic that children brought up while talking about their drawings and their routines. Using the lights only when they are necessary and turning off the television after using it was part of the habits and rules in the houses the children were living in. P14 also mentioned that her family is using compact fluorescent lamps for lighting ("*the twirly ones*", she said). In addition, waste, recycling and composting were issues that the participants brought up when describing their routines.

These results propose that if EVs were developed about water, electricity or waste, children would be able to understand the concepts they are representing. These drawings also give valuable information about where children spend time in the house and where they already accomplish sustainable actions.

5.4 Representing the ideal sustainable home

In the second drawing, the goal was two fold. The first part was to investigate to what extent the participants knew what could be done to have a more sustainable house. For example, actions that children know exist, but don't have the capabilities or the opportunities to realize. Secondly, another objective was to find original and inspiring ideas that children can have to make the house more sustainable. These ideas could eventually lead to new EV parameters or topics.

In most of the drawings, the children presented one or more alternative ways to collect energy in order to power the appliances in the house (solar, wind, or a combination of both) (see figure 6 for an example).

Figure 6 P4: House covered with solar panels to power the house. Windmill and solar powered car on the sides.

Half of the participants depicted different ways for transportation. Instead of a traditional combustion car, they drew bicycles, hybrid cars, and electric cars and said the people would also walk. Also, six participants addressed the issue of local, organic and chemical-free food.

The interiors of the houses, when represented, were not significantly different than the interiors drawn in the reality drawings. Most of the changes were either outside or in a system that could not be seen. P7 said: "*It's just a normal house, but what makes it so special is that everything is powered by wind and solar energy"* (see figure 7). This quote is interesting because it demonstrates that most of the energy and water consumption that happens in the house is invisible. This can be a great starting point for developing EVs for children that would show them how their house works *behind the scenes*.

Figure 7 P7: "*It's just a normal house*."

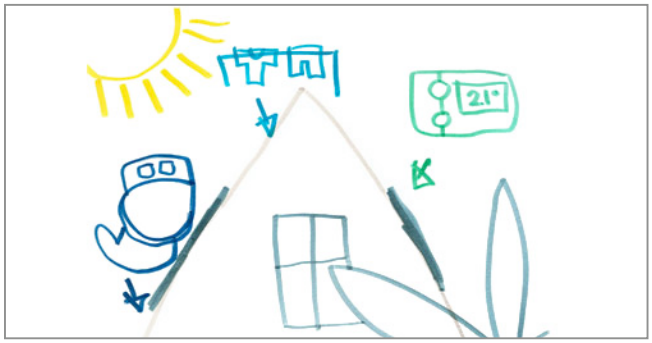

Figure 8 P11: Arrows pointing to the inside of the house.

Some participants wanted to show different parts from inside the house and used arrows to point to the particular rooms (see figure 8 for an example). P11 represented a toilet with two buttons that uses more or less water. She also drew a thermostat which you can preset using the buttons on the left. Her drawing shows yet another way to represent parts of the house that cannot be seen from the outside of the house. The features in the drawing also show that she is confident in using "widgets" to control the temperature in the house.

Children see things in a different perspective and can bring out ideas that are not obvious to designers. For example, one participant (P1) proposed: "*I made this up, I don't know if its real, but it's like this main switch button, so it's like if you want to use the electricity through the whole house, you press this button, and you flick on a light, and it'll work, and if you don't press that button, it won't turn on, so it's like to prevent from like turning on and off, and like wasting energy."* This idea suggests that children do respond to *widgets* and abstract representations. Here, the button would be one way to initiate a sustainable behavior through an electronic device.

P3 and P6 also put forward the idea of an automatic way to close the lights and water if it is going on for too long and nobody is

Figure 9 P10: The most sustainable house you can imagine: the caveman's cave.

using it. These ideas relate to the design of EVs and can help foster different and new ways to present the information about the consumption in the house.

It is worth mentioning that two participants (P8 and P10) represented the ideal eco-friendly house as a shelter with a fire, grass for bed, wool for a pillow, a sheep, and a waterfall. For them, the only way to be the most environmentally sustainable was to return to as natural a state as possible. (See figure 9)

5.5 Comparing the reality with the ideal

The environmental friendly actions and features drawn and described by the children in their two drawings differed considerably. The next tables (1 and 2) are comparative and combine all the environmental-friendly actions depending on what area they are related to. The tables serve as a starting point for the analysis. They were developed by interpreting the transcripts of the interviews and every sustainable action or feature was written down and grouped according to the area they represented. The more an area was discussed and repeated, the higher in the table it is positioned.

Table 1. Sustainable areas represented in the drawing 1: *Representation of the reality*.

Area	Description
Water	Turn off taps. Short showers.
Electricity	Don't turn on the lights. Turn the lights off. Don't always plug in the laptop. Minimize time on the Wii. Turn off the TV and computer. Use compact fluorescent lamps. Don't charge the ipod every day. Don't open the fridge too long.
Waste	Don't throw away food. Recycle paper, cans, and juice bottles. Compost.
Transportation	Walk to school.

Table 2. Sustainable areas represented in the drawing 2: *Representation on the ideal house*.

Area	Description
Water	Shower coach. The water goes off after a certain time. Chute of rainwater to power the shower. Use the water from the gutters. Use a switch for the use of warm water. Use a two buttons toilet (or low-flow). Don't wash the car too much.
Electricity	Lights go off after a certain time. No heater – all electric. Main switch button (mandatory before any other switch). Time limits on TV and computer use. Use a thermostat to control the heat. Use eco-friendly light bulbs. Use a clothesline instead of the dryer.
Energy	Solar powered. No use of energy for heating the water. Use wood instead of heating. Wind mills. Use big windows for light and heat.
Transportation	Walk to school. Bicycle. Hybrid and Electric cars.
Food	Garden to grow vegetables. Farm for animals. Don't use chemicals in the garden. Eat local food.
Waste	Reuse. Recycle. Compost.
Polluting Products	Are not allowed in the house.
Vegetation	Trees are planted. Greenhouse. Don't cut the lawn too often.
Size	Smaller house.

In the first drawing, the main areas discussed by the children were water, electricity and waste. These usually were very precise actions. In comparison, the second drawing gathers more areas of action: water, electricity and waste, and size, energy, food, vegetation, polluting products and transportation. In this case, children thought more about infrastructures and global ways the house should work. Until today, energy consumption is the main subject for EVs. The fact that the participants drew these alternative ways to have power shows that they are aware that consuming electricity is impacting on the environment and we have to find new ways to power our houses without damaging the environment.

The scale of these actions is variable and can range from the very specific (for example, the shower coach) to a very holistic vision (the type of energy used to power the house). This observation can be a starting point for different types of EVs for children.

6. DISCUSSION FOR DESIGN

This is an exploratory study to investigate if EVs can be designed for children. The results indicate that the drawing and telling technique can be a successful method to explore how children see their homes. From the findings, we discuss five points that have implications for the design of future EVs tools for children.

6.1.1 Participants' understanding of sustainability

To research children's understanding of sustainability is a substantial project and would require the use of more than one technique and more participants. In this study, our aim was not to answer this particular question in detail; but to gain a first sight in this area in order to propose directions of investigation for further work on children and eco-visualizations.

The drawings and interviews show that the participants have a very broad and holistic understanding of what being environmental friendly means. Energy and water consumption are part of their definition, but they also incorporate other dimensions like eating locally, growing a garden, alternative ways of transportation, and taking care of the wilderness. This very open understanding of sustainability can challenge the essence of eco-visualizations, which usually concentrates on very specific uses in the home (mainly water and energy consumption). Is technology the solution to behaving more sustainably? Should we keep and foster this broad understanding of the world children live in? We believe there are serious questions to ask before deciding that EVs for children are a good solution for encouraging sustainable behavior, and this should be a main research question for future work.

Putting aside these questions, some findings could clearly inform the design of EVs for children. Most of the participants had a common understanding of the current sustainable solutions such as solar panels, windmills, electric cars and water use reduction. This sets a common ground from which EVs could be designed. Finally, the means used to achieve sustainability varied from technological approach to foster behavioral change (the "main power switch") to a natural approach (living under a natural shelter with a rainfall and a fire, or living on a farm). The participants' understandings were spread between these extremes and some of them combined the two (an electric tree where you can plug in your electric car P8). These two almost contradictory approaches can spark ideas about what type of worlds can be used in the EVs for children, for example, a ship controlled with different buttons, switches, and displays or a natural setting growing plants and taking care of animals. This also relates back to the two common types of EVs described in the introduction.

Should eco-visualizations for children be more practical and utilitarian or should they be more artistic and mysterious?

6.1.2 Participants' representation of houses

The drawings are powerful data that gives us information about how children represent spaces and houses. The participants used multiple views to represent the houses and sometimes combined the different views (top and front). They also used different ways to zoom on important features (figure 8 for example), creating dynamic 2D representations of houses. This observation can be very useful while designing the visualization tools, but also in understanding where to position them in the house. Also, all the sustainable features were situated in the context of the house, emphasizing once again on the idea that the participants have a more holistic vision of what sustainability is. This can in part be explained by the nature of the activity itself, which was to draw a sustainable house, but the participants had the liberty of choosing what point of view they were drawing from and what features to draw. Finally, the drawings show that the participants understand how to layer information on a 2D drawing. Most of them used one or a combination of arrows to describe movement, labels (words) to identify rooms or objects, and colored areas to show the use or state of particular spaces in the house. They also used color (not always realistic) to differentiate different parts of the house, furniture, and sustainable features in the home. While designing new EVs, designers can use these key points to inform how they symbolize the data about the house for children – that would encourage a holistic understanding and imaginative reflection evident in our data.

6.1.3 Children-parent relationship

Since children have been found to be proactive in changing family behaviors [16], sustainable interaction design must consider the collective impacts EVs have on sustainable practices in the home. It is an opportunity for designers to take advantage of the children's knowledge about sustainability and their power to motivate certain members of the family or even the whole family. A good example of that is P6 using his shower coach and trying to convince his mother to do the same. Eco-visualization is particularly effective to show in a clear and simple way the higher concept levels of how much energy and water a house is using, for example. If the eco-visualization tools were to be designed for children, this would typically be in a family context in which an EV becomes as much a resource for collaboration and collective motivation as an individual tool for action. Specifically, EVs for children could take advantage of the particular child-parent relationship and dialogue.

6.1.4 Collaboration and sharing/copying ideas

The participants of each group (3 or 4 participants) were sitting together at one table when drawing and they were very quick in sharing ideas and concepts. They talked about how to draw their houses, comparing ways of showing multiple floors and ways to create environmental friendly houses; they also built on their friends' ideas to improve their own drawing. At one point, one participant (P5) even said: "*We are all copying each other!*" We see this collaboration and exchange of ideas as a crucial point in the design of future EVs for children and how it could inform networking and multi-user possibilities. EVs should allow children to collaborate and share strategies and results within the family and with friends in different houses through a network.

6.1.5 Age range

The range of ages (9 to 13) we dealt with is considerably broad and we were able to observe important developmental differences in the drawings and in the interviews. This was made clear because two of the groups had children who were 9-10 and the two other groups were 12-13. The participants' knowledge about environmental sustainability was not critically affected by their age, but the precision and the points of view of the drawings were influenced by the age. This observation implies that the EVs tools should consider the age of the children in the house and adapt to best fit the child's representation of space and sustainability concepts.

7. LIMITATIONS OF THE STUDY

We did not discuss the difference between the genders in this study because we have a gender bias. The two older groups were all girls and the two younger groups were all boys so the developmental differences due to age would affect the observations we make on genders.

Another fact that can be seen as a limitation to this study is that we are not actually proposing any eco-visualization tools for children. Our intent, though, is to generate a first look at the issue, try to bring to the surface some opportunities and concerns for future research and design.

8. CONCLUSION AND FUTURE WORK

By using the drawing-telling technique, it was possible to collect the child participants' understanding and representation of sustainability in their house. The findings speak to five topics: (i) participants' understand of sustainability, (ii) participants' representation of houses, (iii) children-parent relationships, (iv) collaboration and sharing/copying ideas, and (v) age range.

This study can serve future work, particularly the design of eco-visualization tools for children. The exploratory study can be seen as a first step in the direction of considering the impact children can have on their family's habits. The aim was not to understand how children interact with existing EVs, and future work should include the evaluation of existing eco-visualization tools when used by children. This would point out more precise points to change, ameliorate or de-emphasize to create eco-visualization that are more effective for children and families. Beyond the immediate concern of children's perspectives on sustainability, the implicit value of this type of study on children's view is to catch a glimpse of the ongoing understanding and future emergence of the needs and desires of sustainable actions.

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