Playing for the Planet: Designing Toys that Foster Sustainable Values

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ABSTRACT
The children of today are the adults of tomorrow, for this reason it is essential to educate this generation about sustainable values, such as recycling and reducing waste and energy consumption. By targeting children's main activity of playing and toys, the design of a toy that instills sustainable values is illustrated through PlayGreen, a prototype of an interactive application. We argue that this type of toy should be designed according to children's cognitive development and their learning skills, as well as conforming to a value centered design process. This paper focuses on Piaget's cognitive development theory, more specifically, the concrete operational stage processes, which occur between the ages of seven and eleven years old. Our prototype is an application focusing on the value of resource management and allows children to create new toys from household materials. This prototype was tested with 8 and 9 year old children via a Wizard of Oz method. The prototype successfully integrated a value related to sustainability and the users were able to manipulate it easily as it was adequate to their cognitive skills.

Author Keywords
Children; learning; sustainability; value development; play; user characteristics; design guidelines.

ACM Classification Keywords
H.5.m [**Information Interfaces and Presentation (e.g., HCI)**]: *Miscellaneous*.

General Terms
Human Factors; Design.

INTRODUCTION
Play is the activity that typifies childhood and is an essential part of children's healthy growth, development and learning [11]. Children spend a considerable part of their time playing with toys, and as such, toys, either for entertainment or education, have a large market; they are popular and commercially viable. Indeed, 2012 toy sales in the U.S. totaled $16.5 billion.

Toys, however, not only contribute to children's cognitive and emotional growth, but also play the crucial role of passing on cultural knowledge and values [8]. Consider, for instance, the difference between an abacus that contributes to children cognitive development, and the popular doll Barbie [2] that communicates information about social norms, albeit in a less direct way. Indeed, Barbie is a controversial example of this phenomena – researchers have argued that the emaciated depiction of the female body it presents can negatively impact young girls' notions of body image and levels of self-esteem, harmful influences which can follow them into later life [5]. Other common examples of toys that convey values include religious dolls and those that reinforce gender roles (e.g. kitchen toy sets for girls; building site toys for boys).

Indeed, researchers have argued that a large proportion of toys convey values. For example, in a 2005 survey of 125 toys, Blakemore and Centers [3] reported that 70% were rated as conveying either feminine or masculine attributes. Worryingly, they also noted that the remaining, neutral, 30% were typically those associated with developing children's physical, cognitive or artistic and expressive skills. This work highlights both the centrality of value education to the act of play, and the disconnect between this process and other developmental outcomes. We also note that while educational toys for motoric and cognitive skill development have clearly defined criteria for design (such as providing fun, keeping the child safe, offering challenge, being adaptable, ease of use and providing interaction [9] we know of no such criteria for the design of toys that aim to instill or convey values to children. This lack reflects the relative novelty of value-centric design processes. Addressing this issue, this paper proposes a value-centered design [7] framework that aims to support the of design of toys that are specifically intended to pass on values. The main goal of this is to present a design framework that brings the value-centric nature of toys to the forefront.

Our second goal is to illustrate the viability of this approach through the design a prototype toy that stimulates moral development and encourages the development of values. The focus for this exemplar is on values relating to environmental sustainability. Current toys in this space include examples such as Lego made from coffee beans or tree bark [13]. In this toy,

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designers used biodegradable materials rather than plastic. However, this sustainable Lego is only available in shades of brown and in one uniform size of brick. It is unlikely this toy would maintain the playfulness and appeal of traditional Lego with its wide variety of differently colored and shaped bricks.

To summarize, this paper makes four contributions. Firstly, it provides a theoretically grounded framework for value conveyance that encompasses both developmental theory and a value centered design process related to play. Secondly, using this process, it presents a set of values relating to sustainability gathered from the researchers, children, parents and educators. Thirdly, it describes the design of a toy using sustainability as a value and show how this can be integrated with the developmental needs of our chosen age group. We present a prototype based on the value of resource management and take into account concepts in Piaget's concrete operational stage of development. Finally we show how this prototype encourages moral development among children.

BACKGROUND

Value development

A child develops morals or values along with cognitive skills. Kohlberg [12] states that moral reasoning progresses through a series of six stages or three levels. Furthermore moral development does not occur due to maturing or socialization, rather, each stage is reached through thinking about moral issues. Socialization promotes development but this is achieved by stimulating thought through discussing problems and situations and individuals finding their views, assumptions and beliefs challenged. As they mature, children also learn to coordinate different viewpoints in cooperative activities and gradually move to subsequent stages of development [4].

Piaget's theory

Piaget proposed a number of distinct stages where the organization of intelligence or cognitive development changes throughout a child's growth [16]. Two processes Piaget called assimilation and accommodation support the transition from one stage to the next.

Table 1. Concrete operational processes defined by Piaget

Process	Description
Classification	Ability to name, identify and group sets of objects.
Seriation	Ability to sort objects in any order according to size, shape, or any other characteristic.
Conservation	Ability to see how physical properties remain constant as appearance and form change
Transitivity	Ability to follow a process and understand the relationship between successive stages
Decentering	Ability to consider multiple aspects of a problem to solve it
Reversibility	Ability to reverse operations or to take something back to their original state
Elimination Egocentrism	Ability to view things from another's perspective

Assimilation is defined as the process of an individual absorbing many forms of stimulation and information and then organizing and integrating these inputs into their existing cognitive schemas, a type of mental form or structure. Accommodation refers to the modification of cognitive schemas in order to adapt to the environment – to better explain what is observed. Piaget proposed four stages of cognitive development: sensoriomotor (0 to 24 months), preoperational (2-7 years old), concrete operational (7-11 years old) and formal operational (adolescence – adulthood). We focus on the concepts elaborated in the concrete operational stage (Table 1). Overall, in this stage, children reveal more logical, objective and deductive thinking with concrete objects, however they do not yet show abstract thinking. As the child's mind is still attached to concrete experiences, this translates to the ability to solve problems that apply only to concrete objects and not abstract concepts or hypotheses [15].

Sustainability

Environmental sustainability is an increasingly important global issue. One of the main drivers of climate change is the increase in greenhouse gas emissions, which have risen 70% between 1970 and 2004 due to human activities. Personal and individual involvement with such changes is inarguable; direct resource consumption in homes and businesses accounts for 20% percent of overall energy use in the USA [6]. Similarly, in Europe, households are reported to account for 26.7% of energy use [1]. Consequently, it is important that humans work to reduce their carbon dioxide emissions in order to reduce or mitigate the effects of climate change.

Recent research [10] has called for the whole family to be engaged in managing household consumption. However, current eco-feedback technologies, tools that provide information intended to help people manage their consumption, typically target adults rather than children or families. Consequently, existing systems do not capitalize on the social dynamics of family members (e.g. they do not harness the interactions between family members to help promote behaviors) and also miss a significant and very important part of the population: the young.

We argue that instilling values in children at a young age is particularly important as it will help to encourage sustainable behaviors at an early, formative, stage of life.

DESIGN FRAMEWORK

Value discovery

We followed the process suggested by the value centered design approach to collect values related to sustainability. [7]. The collection of values involved children as direct stakeholders and parents, educators and the research team as indirect stakeholders. The following paragraphs describe the process and steps taken to collect values for each of the parties.

Researcher Stakeholder values

We began with a brainstorming session where the ideas were generated from the following question: What is sustainability? Two designers and two Human-Computer interaction researchers participated in this session. The ideas revealed three main focus points: consequences in the long term associated with

sustainability problems, prevention efforts and supporting attitudes. The next step after the brainstorming session was organizing the concepts and ideas by creating an affinity diagram. This process allowed us to structure the ideas, translate these into values and list these values into higher-level categories. The end result indicated sustainability values for the researchers were associated with primitive emotions, feelings related to sense of duty and guilt, a number of human needs, feelings associated with kindness, knowledge about the subject and finally, a connection to the larger community.

User/Direct Stakeholder values

In order to collect the values children associated with sustainability, a session was prepared with a group of 15 children aged 8 to 9 years old. A set of pictorial scenarios depicting sustainability related behaviors was used to elicit responses and values from this group of children. The set of scenarios included seven categories of sustainable behavior, each category included four different depictions of each behavior. The seven sets were about garbage management, recycling, laundry management, food consumption, water consumption, outdoor activities and electricity consumption.

The session was split into two halves, the first where children chose which behaviors what they thought the characters in the scenarios should do. In the second one, a group discussion took place around the choices made in the first half. There were three groups of five children and a researcher, who explored the reasons and justifications the children presented for choosing each behavior. The sessions were recorded, transcribed and later analyzed by the team. Each researcher listed the values in the transcription of the sessions and later these were discussed as a team. The final result was a unified list (Table 2) of values that represented the children's views about sustainability.

Table 2. Categorization of User Values

Categories	List of values
Resources	Reduce, reuse, recycle, self-sufficient, save, efficiency, comfort versus saving, money or cost
Knowledge	Learning, knowledge about other people, specific knowledge, long-term consequences, negative consequences
Feelings	Empathy, respect, selfish, inconsiderate, polite or well-mannered, rude, guilt, careless, altruism, fun – playful, enjoyable
Community	Protection, ethics and sense of fairness, communication, preservation, share, comparison, help, awareness, accountability, children influence parents
Environment	Clean, unsanitary/unhealthy
Myself	Autonomy, personal effort, obedience to avoid punishment, initiative, being thrifty

Parent/Indirect Stakeholder values

Ten parents, three of who were primary school teachers, completed a questionnaire consisting of open-ended questions about their attitudes to sustainability (10 parents, 5 male, median age = 31, min = 22, max=50). Nine of the participants were Portuguese and one was British.

When asked to define what sustainability is, the main theme that emerged was one of protecting the environment for future generations, for example, "*…important to preserve the earth intact for future generations*" (female teacher, no age given). The second main theme from this section was the use of resources, for example "*…about making decisions on how much one really needs to consume*" (male, 31 years old). The most important aspect of sustainability for parents and educators was balance, for example: "*Humans must find a balance with the world that does not mortgage the future or past*" (male, 30 years old).

One parent stated why teaching children about sustainability is important: "*Because the children can correct themselves and their parents, so we can educate new forms of sustainable lifestyle for further generations"* (male, teacher, 41 years old). In general participants felt that the children they were in contact with were already somewhat aware of the issue of sustainability.

However, three out of the ten participants felt that the children currently knew little about sustainability. Finally we were interested in what obstacles parents/educators saw in the way of their adoption of sustainable behaviors. Two main themes were time and other people's attitudes, for example: "*Many people don't care about the use of recycling points, others use it incorrectly, throw garbage in the street. The educational issue is the main problem*" (male, teacher, 41 years old) and "*…natural resistance to new practices*" (male, 34 years old).

PROTOTYPE AND IMPLEMENTATION

Once the values were collected from all stakeholders the next phase was its systemization into a single list. For that purpose the team analyzed each set individually, and discussed it later as a group. Values were eliminated or combined and when in doubt, the research team would go back to the session transcripts or the survey data to support each elimination, replacement or integration of a particular item. The end result was a final list of 20 values common to all the stakeholders related to sustainability (see table 3). From this list of 20 we chose the management of resources value for development of a prototype. This is in part because this value emerged independently in the discussions with each of the different stakeholder groups.

The next phase was the generation of ideas that could help integrate this value into concepts that would provide children with learning tools and knowledge about concrete actions and consequences when interacting with the environment. Ultimately, the selected concept involved providing a kit with recyclable materials that children could manipulate and transform into new toys or objects. The generation of this concept was based on the fact it met the following criteria: that it was a good match to the "management of resources" value; that it was an interactive toy, game or application; that it was a system that enabled knowledge and learning about concrete environmental behaviors and their consequences and; that it was a system that could combine both digital and physical aspects. Virtual toys or toys that mix physical and virtual play are becoming more and more popular with children, therefore we decided to design a prototype that would take advantage of this popularity [17]. To help us do this, a participatory design session was conducted to understand how children would transform real recyclable materials into physical toys.

Table 3. Final list of sustainability values

Values	Description
Efficiency	Avoid waste
Communication	Interact with others and learn to share
Preservation	Protect and save the environment
Awareness	Being conscious about environmental issues
Accountability	Feel responsible for
Knowledge	Have general and specific information
Learning	Acquire skills
Costs	Learn to the difference between save, afford and worth
Respect	Think of others and of the environment
Fairness	Do the right thing
Empathy	Understand and consider others
Personal Effort	Commit and do more than required
Future generations	Being selfless, humble, protective
Thoughtful	Being considerate and polite
Creativity	Transformation and initiative
Necessity	Dependence and importance of the environment for humankind survival
Negative Consequences	Avoid punishment and unsanitary conditions
Management of resources	Reduce, reuse, recycle, balance usage and consumption
Ability to act	Feel empowered, ability to act and the children's influence on their parents
Cooperation	Sharing and cooperation between different generations

Participatory Design Session

This session had 10 participants from the same group of children who participated in the previous value brainstorming session. The session lasted 45 minutes and children were given a kit comprising recyclable materials. Specifically, each kit contained one milk carton, one yoghurt container, plastic packages and cardboard paper packages. Children were instructed to build a toy using the materials in their kit, scissors, glue and coloring pencils. The work session was recorded and transcribed. The research team analyzed the children's responses to the exercise, how they manipulated the materials and gathered the most important features to inform the design of the future toy or application.

The participants naturally collaborated when building their toy, either by providing suggestions, exchanging materials or helping others after finishing their own activity. This supports the idea that this type of toy can encourage moral development through discussion of ideas, coordination of different viewpoints and cooperation [4]. The toys built by the participants were toys they were familiar with, or made as part of their symbolic play [14, 16]. This participant shared: *"This is Maria and this is the Fast PC. This was my sister's doll she is older than me, and this is my computer"* (U2, male, 8 years old). Among the toys the children built were a computer, a moneybox, dolls that resembled the ones they had at home, a castle and a pop-up book.

When asked what they enjoyed about the activity, children mentioned the fact they could transform old materials into different objects with different purposes, with one participant suggesting that we should not throw away garbage since it can be reused to build other things, something he does sometimes at home (U8, male, 8 years old). Participants also seemed to enjoy the fact that they had to physically manipulate the materials as stated by this participant: *"I liked to make things up, this is related to the constructions I made with the Lego I have at home and I used to also use some sticks to complete the constructions"* (U8, male, 8 years old). This session led to the idea of creating an interactive sharing application where children were given a set of virtual materials they would have to transform into a toy. This concept was instantiated into a semi-functional prototype called PlayGreen (Figure 1).

VERIFICATION

The PlayGreen concept was tested through a Wizard-of-Oz technique (Figure 1). Six participants, aged 8 to 9 years old, three boys and three girls, were recruited from the previous group to participate in the play testing session. Each session was recorded, and lasted around 10 to 12 minutes.

Overall, the participants enjoyed the game and found it a fun experience. They enjoyed that they were using recycled items: "*I liked most building the toy and because I was using recyclable materials… I liked everything about the game*" (U5, male, 8 years old). In terms of how they felt about the game, they felt relaxed, amused and even good about themselves, for example: "*I felt good playing the game*" (U4, female, 8 years old). The part the children enjoyed most about the testing session was where they manipulated the materials to create new objects: *"I liked everything in the game. We could probably get more materials the more creations we completed. We could have more than just 3 materials and then we could build a lot more things. I would like that"*(U4, male, 8 years old). These responses validated the previous findings from the participatory design session.

The feature about exchanging materials and the ability to chat with their friends did not seem to attract the users attention. This might have been due to the fact that users were not given a precise task for those features. Once it was explained what those features allowed them to do, they disclosed that they would like to share their creations, stating: *"I would like to see what toys others built because I am curious... it could help me to get more materials to build things if I could exchange with them"* (U5, male, 8 years old). This is encouraging evidence that this type of toy would help children's moral development around sustainability, as discussed earlier, by sharing and collaborating with other children.

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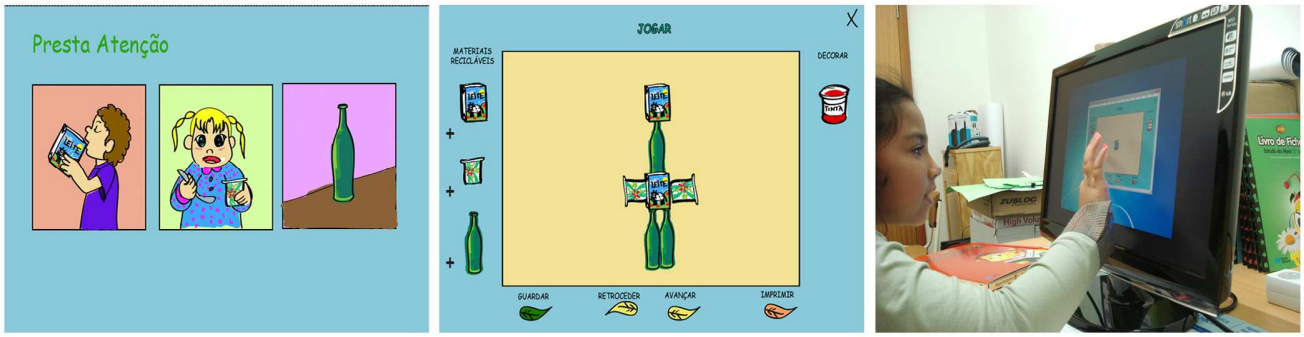

Figure 1. Scenarios depicting the materials (a), the PlayGreen prototype (b), the Wizard-of-Oz testing session (c).

Testing the concept of PlayGreen allowed the verification and observation of all of Piaget's concrete operational processes within the game context with the exception of one (conservation). When users manipulated the recyclable materials in the play section, they correctly identified the materials and used them for a different purpose, either by rotating the materials and trying different angles or by revealing an understanding of the whole construction process (classification and transitivity).

Users also transformed the materials in terms of their shape or size, and worked with those characteristics, for example, building a church by aligning the materials according to its shape and dimensions (seriation). When exploring the collection of objects created by their friends in the exchange section, users could clearly identify the final objects, and provide suggestions on what the list of objects would allow them to do (decentering, reversibility and elimination of egocentrism).

CONCLUSION AND FUTURE WORK

This paper presents four main contributions. First we presented a set of values relating to sustainability. The values were collected from children aged 7 to 10 years old, parents and educators. These values allowed for a better understanding of how children within this age range perceive environmental issues. Secondly, we provided a theoretically grounded framework for the design of toys that instill values that took into account both developmental theory and the value centered design process. Thirdly, we presented a case study that illustrated the value sensitive design method for toys that instill values. Finally, we show that the prototype developed leads to the type of communication between children that encourages moral development. Ultimately, we hope that applications similar to the one presented in this paper can enable the generation of children currently growing up to value the environment and help to preserve the world we live in for their own and future generations.

Although the domain of sustainability is attracting more and more attention in the interaction design community [10] much of the work is highly simplistic – often just illustrating or highlighting energy use. In truth, sustainability is a complex topic that sits at the center of a wide range of trade-offs (e.g. between efficiency, convenience and comfort or between short and long term rewards). This paper argues that deeper understandings of the eco-system of values that surround sustainability issues is an important prerequisite for the design of systems and artifacts that can meaningfully intervene in this space. It presents and demonstrates a value-sensitive design process intended to achieve this and describes one application prototype that emerged from these efforts. We argue that future work needs to adopt similar methods in order to effectively engage with complex, multi-layered topics such as sustainability and intend the work in this paper to serve as an example of how this can be achieved.

When designing for children, it is also essential to consider their cognitive development. Children acquire cognitive skills and understand concepts at specific ages; well-defined cognitive abilities and processes are a result of natural processes of maturation, experience and social influence [16]. In terms of design, products or services aimed towards children, in order to be accepted, need to take into account the developmental requirements and capabilities of the age range (or developmental stage) they target.

Future work could consist of conducting a long-term follow-up study to assess if the value of resource management was transferred into the household context. We would test whether what the users learned from PlayGreen, through diary studies for example, modified the child's or other household behaviors and routines.

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