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DESIGNED FOR, WITH, AND BY KIDS. INTEGRATING CHILDREN'S APPROACH INTO DESIGN TEACHING AND RESEARCH VISUALISATION

Luccarelli, Martin; Di Iorio, Mariagiovanna
Free University of Bozen-Bolzano, Italy

Abstract

This work addresses the creativity and intuitive approach of children to improve design teaching and research visualisation. Three experiments involving children as user, tester, and informant are presented. Methods and results obtained by each experiment are described herein. Parts of the results are consistent with past research. In particular, children proved to be free from certain creativity barriers observed in students. Other findings are described and discussed.

The results of the aforementioned experiences led to the development of two further experiments to target design teaching and research visualisation. The former experience involved undergraduate design students to test the disciplined improvisation teaching method. The latter involved children and researchers to test tangible representation in shared understanding. This last experience highlights certain challenges of the child's role for researchers.

Keywords: Design Education, Design learning, Creativity, Collaborative design, Visualisation

Contact:
Martin Luccarelli
Free University of Bozen-Bolzano
Faculty of Science and Technology
Italy
martin.luccarelli@unibz.it

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1 INTRODUCTION

With the increasing complexity of products, design is asking more and more for multidisciplinary minds. Designers are faced with the need of improving their knowledge in different fields, in order to understand methods and design languages spoken by the other stakeholders involved in the team. Considering the process and the resulting product with its key properties, we believe that three keywords define the successful way of thinking in terms of design. *Systematic*, *flexible*, and *simple*. Systematic thinking is intended as the ability of the designer to follow a predefined process, being able to keep track of important information such as time remaining for a given task, without loosing the overview on the whole process. Such an attitude guarantees the reduction in the number and in the severity of mistakes during the work. Flexibility guarantees to adjust and change certain aspects of the product if the chosen design path leads to nowhere or proves to be the wrong one. This aspect fosters the possibility to try different options instead of sticking with the original one chosen at the very beginning.

Simplicity is often missing in the way people think of a product and appears more than ever to be the key to solve certain design tasks (Lewis, 2012). Even if simplicity doesn't equal usability, simple designs are usually easier to use. The Consumer Electronics Association discovered that 87% of people said ease of use is the most important thing when it comes to new technologies (Tischler, 2005). According to Story et al. (1998), the third principle for Universal Design is *simple and intuitive use*, referring to a design that is "easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level". Therefore, when designing a product, it is important to subtract the obvious, and add the meaningful (Maeda, 2006). In order to be consistent with user expectations and intuition, the designer of the product should have the ability to be intuitive as well. In this regard, designers can learn something from those who are particularly skilled in using intuitivity for problem solving: the children (Hickling and Wellman, 2001). Indeed, the intuitive approach of kids can leave doors open for more creativity in the early concept phase, making children a valuable design partner (Druin, 2002; Leigh Guha et al., 2004).

This work addresses the benefits of integrating children's intuitive way of solving and designing things into design teaching and research visualisation. As stated by Druin (1999), "Children are extremely honest in their feedback and comments concerning technology, but much of what they say may be in their actions and therefore, needs to be interpreted within the context of concrete experiences". Therefore, three experiments were conducted for studying specific relationships between the intuitive approach of children and simplicity in design. The roles of the child as *user*, as *tester*, and as *informant* are presented in Section 2, 3, and 4, respectively. Based on the results of the aforementioned experiments, Section 5 targets disciplined improvisation in design teaching, while Section 6 addresses the topic of visualisation models for design researchers. The discussions and conclusions are presented in Section 7.

2 THE CHILD AS USER

This role is the first and oldest role that can be seen in the literature concerning the involvement of children in the design process. Children are asked to test a general concept that may help inform future technology developers, to better understand the process of learning that may contribute to future educational practices (Druin, 2002).

The experience presented in this section is the project *Come on Kids!* (Camuffo, 2011), which belongs to the on-going research project *EDDES* (Camuffo, 2014) since 2014. *EDDES* involves both Faculties of Design and Art and of Education of Bolzano, to develop a theoretical and operational framework for interdisciplinary collaboration between designers, pedagogues and educators. The objective of this project is to experiment, document, evaluate, and eventually to implement design's contribution to enhance creative learning and imagination with a specific focus on children's learning experience. To achieve these objectives, children are invited to a series of public events. Both formal and informal multilingual education contexts (including both museum and school settings) are considered. Design contribution addresses spaces and activities, language, process and approach, and designed objects as well. This section focuses on the use of specifically designed objects as *facilitator* (Sawyer, 2004) for creativity.

2.1 Methods used

In *Come on Kids!*, children (aged between 5 and 12) were invited at the Triennale di Milano (Triennale, 2013) and at Fondazione Querini Stampalia (Fondazione Querini Stampalia, 2013). 11 professors of the Faculty of Design and Art of Bolzano were involved in the design of drawing machines for them. The toy *Jackson P.* (Luccarelli, 2013) belongs to this collection of machines. Due to the drip painting-like drawings that can be generated by riding this toy, it was named after the abstract expressionist artist Paul Jackson Pollock. It took inspiration from a well-known low-tech toy icon designed for educational purpose: the bobby-car. This German toy is meant for kids (aged 2-4) that are learning to walk. Children sit on this vehicle as on a motorcycle and move by swinging their legs. Starting form this concept, a toy that could draw with coloured markers while moving was developed. *Jackson P'*s body is designed with beech wood with a simple open box-design to allow kids to look inside the machine. With this body feature, there is no need to turn the toy upside down for placing the coloured markers in the random positioned holes, since children can place them directly from the inside of the machine. A Large paper sheet (5 x 5 meters) was unfolded on the floor to let the children draw with the machines.

2.2 Results: facilitating creative improvisation

The improvisational performance prepared for the children was an invitation to play rather than to design or draw something specific. When children used the machine to draw, we observed their behaviour to analyse the developed educational practice.
Since children were free to improvise, we saw an active engagement with the subject of drawing through the use of the toy. Indeed, more than being attracted by the chance to draw, it appeared that the *game of drawing* thrilled them. The correlations between their chosen actions (i.e., the way they positioned the markers, the composition of the lines they created by riding the toy) and the unexpected result on the paper sheet, stimulated children's curiosity to master their design process. In addition, since children were free to interact with other children, we saw that they were able to coordinate themselves to create their ideas, Figure 1.

Figure 1. Two children interacting together with the prototype

Once children had chosen the set of colour markers, one child was pushing the machine while the other was driving it to design shapes on paper. Similar outcomes showing the ability of children to be self-coordinated were observed by Pelegrino et al. (1991), during an experiment involving classroom observations to test the improvement of problem-solving capability in mathematics through the use of specific technologies.

3 THE CHILD AS TESTER

The role as *tester* is similar to the role as *user* to some extent. However, research that focuses on children as testers is not as interested in exploring educational theories as it is in developing new technologies (Druin, 2002). Therefore, the focus is on the tested product rather than on children's behavior and response (the tester).
The experience presented in this section is the workshop *Toy Vehicles* (Luccarelli and Upmeier, 2012) that was organised at the Faculty of Design and Art of Bolzano. It involved undergraduate students enrolled in the BA Design course, children, and the VKE non-profit organisation. VKE's commitment is to organise events in the city for children, providing them toys to be used for free. Scope of this workshop was to analyse students' ability to design the right product (meeting children's requirements) under the pressure of time. In particular, we investigated possible correlations between

students' ways of thinking of the product (e.g., systematic, flexible, simple), and the resulting product properties perceived by children (e.g., functionality, usability, satisfaction). Norman (2004) has shown specific correlations between pleasure perceived by customers while using a product and the associations that a product invokes to them. Therefore, letting children choose among different options was key to study their preferences. To achieve these objectives, children were invited to try and play with the designed toys, in order to express which toy matched their expectations the best.

3.1 Methods used

The workshop lasted one week and involved 18 children (aged between 6 and 13), 7 students enrolled in the BA Design Course (aged between 20 and 26), and 2 professors. A kick-off meeting included a short discussion on the Brief, which was the design of a prototype for a toy vehicle. Students were free to choose their own concept. Only the type of wheels to be used was specified. A visit at the VKE non-profit organisation, allowed students to analyse their toys, observe children while playing as well as trying some toys themselves. In addition to the inflatable gum wheels, the provided material to build prototypes included wood, and metal bars. Moreover, old broken toys and bicycle parts were provided by VKE, and special preassembled technical components were ordered if needed by the teams.

3.2 Results: when students try (and fail) to design for kids

Similarly to the former experiment, the judging experience for the children was an invitation to play rather than to discuss on specific issues affecting the prototypes. When children used the toys, we observed their behaviour and reactions to analyse prototypes' features designed by the students.
Among the student teams, two of them used different thinking approaches to the design the same type of product (a tricycle) and, consequently, reached contrasting results when it came to customer's judgment. The first work involved Kilian and Moritz. They worked together on a sweep rowing boat concept with wheels. A bicycle-chain-system should have allowed kids to ride a tricycle by moving back and forth on a movable seat (as it happens in sweep rowing racing boats). From the very beginning, the idea appeared to be complex and difficult to be accomplished in one week's time. However, since these students were known to be very skilled in translating design ideas into engineering requirements, they were encouraged to follow their chosen path. The second example is the tricycle designed by Francesca and Sara. They wanted to fascinate kids with colour effects, by using bicycle chains to transmit movement from the rear wheels. Instead of focusing on the system to achieve the desired mechanism, they focussed on the image they had in mind, which was represented by the children's windmill, Figure 2.

Figure 2. Students' result inspired by children's windmill

When it came to testers' judgment, the windmill-tricycle caught the greatest interest among the presented prototypes (two tricycles, one portable scooter, and one four wheeled cart), while the sweep-rowing-tricycle ranked last. We observed that only 10 children (out of 18) tried the prototype made by the two boys. Instead, children kept on speeding so much with the windmill-tricycle (since the speed of the rear wheels increased the colour effects generated by the connected windmill) that it had to be repaired several times during the test. In addition, the windmill captured the attention of other kids staring at the toy while moving, leading to some children's quarrels for riding the toy. The message adopted by Francesca and Sara to call the attention of children was simple, recognisable, and hence successful. The kids understood the image and, consequently, the working principle of the machine they had built. On the other hand, the experienced Kilian and Moritz had managed to finish the construction of a toy with a high content of innovation, thanks to a systematic way of thinking. Their skills brought them enough flexibility to try several possibilities, too, being able to solve a couple of complex engineering issues in a short period of time. However, their thinking attitude had led to the design of a product that was too complicated and hence not appealing to kids.

4 THE CHILD AS INFORMANT

With the role as *informant*, children play a part in informing the design process (Scaife et al., 1997). Research that focuses on children as informant focuses on the development of new technologies as well as on better usability in design (Druin, 2002). Therefore, the relationship with adults does not only involve indirect observation (*user*) or feedback (*tester*), but also dialogue on specific design issues.
The experience presented in this section took place during the *Long Night of the Research* in Bolzano (LUNA, 2014), a public event for research dissemination. Scope of this work was to analyse the ability of children to learn specific design-engineering rules through graphic visualisation. In particular, we chose the topic of car aesthetics and proportion rules from a previous work that aimed at fostering the teamwork between designers and engineers during the early vehicle design phase (Luccarelli et al., 2014). Giving children the chance to express their own ideas on the topic was key to study their problem-solving abilities. To achieve these objectives, children were invited to draw and present their own ideas.

4.1 Methods used

The event lasted one night and involved participants aged between 5 and 15 years. Large format posters were meant to provide children with useful information for their designs. In particular, present proportion rules in conventional cars, key car packaging systems, and specific components involved in the design of electric cars were presented. Children received A4 paper sheets and colours, and were asked to choose among different drawing-tasks with six different levels of complexity, Figure 3.

Figure 3. Children drawing during the LUNA 2014 event

The first four levels were meant to verify children's ability to understand design rules, being able to translate them into their own idea. Level 1 involved the design of conventional vehicles by drawing the wheels, the body, the greenhouse, the doors, and the headlights; level 2 considered two given wheels, and children were asked to draw the correct vehicle type by analysing the ratio between wheel size and the given wheelbase; level 3 displayed a car silhouette with the missing greenhouse. Kids had to define the proper ratio between main body and greenhouse, given the wheel size and the wheelbase of the car; level 4 displayed an empty design silhouette, in which children had to position specific car packaging systems (occupants, chassis, engine, interiors and cargo) as shown on the provided posters.
The last two levels involved the design of electric cars to study children's ability to propose new ideas and mobility concepts. In level 5, specific simplified components with a given size and shape (battery pack, engine, and inverter) had to be arranged in the silhouette of a free-chosen vehicle type, considering car proportion rules; level 6 consisted of the same task of level 5, but the type of car to be designed was specified. Children could chose among a family car, sport car, city car, or an off-road vehicle.

4.2 Results: teaching design rules to creative (and free) minds

The open space layout prepared for the children was arranged with tables, colourful chairs, colour markers, and informative posters, as an invitation to draw and be creative rather than letting them feel like an exam was upon them. When children finished their drawings, we listened to their thoughts to analyse their way of approaching the problem. A total of 88 drawings were collected. 76 of them could be considered for the purpose of the analysis.

When it came to prove their ability in understanding design rules (level 1 to 4), we observed that only seven children (aged between 6 and 10) completed the task successfully. Among them only one managed to put innovative elements in his drawing (Michael, aged 9). The presented design rules were too difficult to be understood in a couple of hours. This is not surprising, considering that BA engineering students involved in an automotive design seminar needed a couple of weeks to become familiar with car design principles (Pollman and Luccarelli, 2013).

When it came to propose new mobility concepts (level 5 and 6), we saw that all explanations given by kids to explain their own design choices were connected to product function, rather than to product shape. Similar outcomes showing the focus of children on functional aspects in design were observed by Goldschmidt (1994), during an experiment involving students and children in the task of designing a house. Some children's proposal for future mobility concepts were remarkable, as they faced one specific issue affecting future car design, that is interior space optimisation. While some kids were fascinated by sport cars (10 out of 76), 21 children stated that present production cars offer little space to occupants. For them, the freedom to move in the car was the key, being able to stand up inside the vehicle if occupants are stuck in the traffic and want to stretch their legs. To solve this problem, they got inspired from their home, the most confortable environment they knew best. Their drawn cars featured a short wheelbase to facilitate car parking but were remarkably high to offer more space to the occupants. It is interesting to note that some of the latest developments for future vehicle concepts display similar features to address interior space optimisation (Rinderknecht, 2013).

5 IMPROVISATION AND DESIGN TEACHING

Previous studies have demonstrated that improvisation is key to foster creativity in different fields of education (Johnstone, 1999; Sawyer, 2004).

The scope of the design teaching experience described in this section, was to let students gain a first-hand insight into visual communication and to become familiar with book design. Considering that *reversals* are an effective method to let students learn using deconstructing procedures (Johnstone, 1999), and starting from the overturning assumption that "a book is a machine, even if we are not used to think about it" (Anceschi, 1993), this experiment puts to use the structures of *disciplined improvisation* to let design students come to the *construction of their own knowledge* (Sawyer, 2004) and to develop critical thinking.

5.1 Methods used

A workshop was organised in October 2014 at the Faculty of Design and Art of Bolzano for 60 first year BA design students (aged between 19 and 27). Students were divided into three groups of 20 each, involving each group for two weeks.

The given exercise was to design three visual books, which are typically meant for teaching children basic concepts such as primary colours, letters of the alphabet, and numbers. Therefore most of them are designed using a basic graphic language. Students were meant to learn visual language using basic forms, as they would have been learning to write again. In order to foster innovative and creative solution in the students' design concepts, they were asked to consider the book as a three-dimensional *machine* and not only as a two-dimensional graphic support. To help them keeping this approach, the focus of their task was on paper binding techniques, with four limitations. Firstly, they had to choose among three types of binding and include them as a design concept feature in their books; secondly, their books could describe one topic out of three options: movement, full/empty, balance; thirdly, only points, lines, triangles, circles, and rectangles were allowed as graphic signs to design the content; finally, no words should have been used in the books. These restrictions were meant to act as a *guiding structure* for the entire group's creativity, letting students focus on the required task and stimulating learning as a creative improvisational process (Sawyer, 2004). To present their work, students had to show to the entire group a hand-made copy of their book. There weren't any restrictions on the materials they were allowed to use to build their model.

5.2 Results: disciplined improvisation

At the end of the three workshops the students had built a total of 180 visual books, 3 for each student. We observed that only 3 books were innovative in terms of materials used, occurrence that we link to the lack of restrictions (and consequently of focus) on materials. On the contrary, most of the concepts included the consideration of the third-dimension, thanks to the highlight on binding techniques.

Among the results, Antonio managed to cope the chosen binding (spiral binding) with his visual concept of movement. He imagined a book designed to recreate a never-ending story (allowed by the circular structure of the spiral binding), in which the binding itself takes a role in the content of the book, representing a sort of paper shredder that shreds a falling ball, Figure 4.

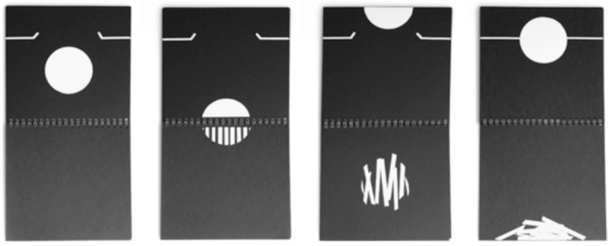

Figure 4. Student's result, focusing on the binding as design element

He imagined the binding in an unconventional and creative way and was able to describe a rather complex book-concept with simplicity, using only basic visual elements and without the need of any verbal explanation, perfectly matching the goal of the proposed exercise. His result demonstrates a new awareness and knowledge about designing books and managing basic graphic elements.

Thanks to the *guiding structure* (Sawyer, 2004) of the task that encouraged students to focus on few specific components (the binding system and an essential visual grammar), the students analysed the book (its form and features) without giving anything for granted, with a child-like non-prejudging attitude. This attitude allowed them to forget their previous idea of the book, and to include every technical and conceptual part of it into their design.

The final products proved to give the binding dignity and sense in the project, whereas paper bindings are traditionally considered as a technical element not related to the content of the book. Especially in illustrated books "There's an unspoken rule in publishing that an artist doesn't draw in the middle of two facing pages so as not to cause confusion." (Lee, 2012). Students were able to overcome this common rule and think at binding solutions as a valuable design element that interacts with the content of the book, giving it even more strength.

6 TANGIBLE REPRESENTATION AND RESEARCH VISUALISATION

Rigorous research findings have not addressed the use of media within the process of designing new products yet (Edelman and Currano, 2011). However, previous research in the field of cognitive science has demonstrated that the kind of media and the characteristics of the media with which people interact have a profound effect on how they think and consequently on the nature of their conversations (Agarwal et al., 1996; Vessey and Galletta, 1991).

This section presents an experience that started at the *Long Night of the Research 2012* in Bolzano and ended at the *27th International Electric Vehicle Symposium and Exposition* in Barcelona (Luccarelli et al., 2013). Scope of this work was to demonstrate that conceptual models with a high level of abstraction, originally designed for children, could work as successful tangible media for researchers involved in the same topic. In particular, we chose the topic of technical modularity and its subsystems: modularity in design (MID), in production (MIP), in use (MIU). Edelman and Currano (2011) have observed that, while *resolution* is a critical factor in unpacking shared models, at work *abstraction* is a key factor to foster discussion among the stakeholders involved in the team. Therefore, amplification of the topic through simplification was key to design these models. To achieve these objectives, both children and researchers were invited as *users.* The former played with the three-dimensional models, while the latter used two-dimensional graphic representations of the same models to discuss the research topic.

6.1 Methods used

The public event involving children lasted one night and involved participants aged between 5 and 15 years. The presented models were meant to sum up and visualise better the application of technical modularity in future alternative cars. Following the classes of abstraction described by Edelman and Currano (2011), we deliberately translated something familiar into something unfamiliar: *material abstraction,* the models for the exhibition were designed using a 3D-software and then milled with a CNC machine. MDF medium density fibreboard wood (MDF) was used to fabricate the bodies, a high density polymeric foam made it possible to fabricate the chassis, and beech wood was chosen for the smaller components (batteries, inverters, and engine); *formal abstraction,* to make the technological components easy recognisable to kids, all the pieces were smoothed off and painted with lively colours; *functional abstraction,* the LEGO Automatic Binding Bricks (Lego Group, 1949) inspired the design of the toys, as it appeared an appealing method to allow kids built their own vehicle compositions; *mathematical abstraction:* The models were designed with a scale of 1:20 to make it easy for little hands to grip them.

The experience in Barcelona lasted two days and involved researchers in the field of automotive design engineering. The CAD-data, used to mill the model pieces for children, was transformed in vector graphic work to create pictorial representations. Large format posters were used to display the models and to provide researchers with information related to modularity. In particular, the main differences between its subsystems: MID, MIP, and MIU.

6.2 Results: getting inspired by kids' language (to explain complex topics to adults)

The open space layout prepared for the children was arranged with tables featuring the models. Again, it was an invitation to play and build vehicles rather than letting them feel like an exam was upon them. When children played, we observed their behaviour to analyse the developed educational practice. We saw that children were able to understand the topic of the game. They were able to cope with the simple models as well as with the level of abstraction characterising them. However, the assessment proved to be less pleasant for children than hoped. Since the degree of freedom in the game was defined by a limited number of pieces, children soon got bored. A Similar problem connected to the perceived attractiveness of specific assessments was encountered by the researchers of the Vanderbilt University (Pelegrino et al., 1991). In addition, we observed that children interacted only with the models, instead of involving other children in the game. While the toy *Jackson P.* had fostered children's teamwork, these models fostered competition among them. Children were stealing pieces (e.g., wheels, or powertrain components) from other children, in order to finish their own vehicle composition, Figure 5.

Figure 5. Two children interacting with the models

At the conference, we expected the pictorial representation to work as effective *ambiguous media* for researchers, encouraging divergent conversations on the topic (Edelman and Currano, 2011). Indeed, present automotive manufactures are implementing some of the subsystems defining technical modularity, but no one has considered the whole system yet. Therefore, the model had to represent an ephemeral notion, rather than a real thing. When we observed researchers, we saw that the model worked as *hybrid media,* affording understanding and changes in relationships (Edelman and Currano, 2011) Even if the models didn't allow a physical interaction, they fostered discussion on the provisional relationships among things. Researchers involved were not referring to existing modular concepts (present attempts made by some car manufacturers covering only a part of technical modularity). Instead, they used the conceptual model to address the idea of a unified system. In particular, possible advantages that such a system would bring as well as principal barriers connected to module boundaries and customer response to MIU were discussed.

7 DISCUSSIONS AND CONCLUSIONS

Our results were consistent with past research, supporting the hypothesis that young children are stimulated in their creativity through improvisation, and that they are free from certain barriers preventing creativity in adults (our students).

From the observations of the experiment described in Section 2, it came out that the use of a product as *facilitator* was effective in encouraging creative and collaborative improvisation of learners. These results can be linked to the role of the restrictions given to first year BA design students in the experience presented in Section 5 that clearly acted as *facilitators* to reach the final objectives. In both cases, the facilitating strategy recalls the role of the teacher in Sawyer's description of disciplined improvisation as "a dynamic process involving a combination of planning and improvisation"(Sawyer, 2004). Consequently, the teacher is no longer the *sole creative force*.

The results of Section 3 and 4 are useful to address barriers to creativity. According to Davis (1999), there is a difference between *general creativeness* and *recognized creative productivity*. In this regard, design students involved in the complex prototype proved their own special-talent creativity in solving difficult engineering tasks, but lacked of a creative general approach in their way of thinking. On the contrary, the children, who had not achieved recognition for socially judged creative achievements yet (e.g., as students do when they graduate), displayed a high level of self-actualised creativity in their drawings addressing the issue of car interior space optimization. If we assume that stimulating creativity requires removing certain mental barriers, 2 of the 10 mental blocks mentioned by Van Oech (1983) are of specific interest to describe students' and children's behaviour in these two experiences. The first one is called "Don't be foolish", a cultural barrier rooted in conformity pressures that pushed the experienced design students to do what Goldschmidt (1994) calls *serious design.* The second one is called "That's not my Area", preventing a thinker from looking to other fields for ideas and inspiration. The children proved to be free from this barrier, displaying the ability to approach a topic they didn't know by taking inspiration from their home.

Other findings related to children and media were observed. In contrast to what Goldschmidt (1994) saw in her experiments with children and students, children demonstrated the ability to master the media of drawing without the need of model building to express a sophisticated system. One reason that may explain why her children and students found models more suitable than drawings to express their ideas may be the topic of their designs. They were involved in the design of space (architecture), rather than in the design of a product (vehicles).

This last consideration, involving design media, leads us to the results shown in Section 6 to discuss about the challenges of the child's role for the adult researcher or developer. The models proved to work for both researchers and children, but the latter lacked of a certain share of excitement. Children are very honest and at times severe in their assessments of technology (Druin, 2002). When we focussed on tangible shared media, we shifted our attention from the children (as we did in Section 2) to the models. By doing so, we didn't manage to develop a suitable method that could accommodate children. This again proves the importance of researchers and developers to focus on the improvisation of children in their game to encourage their creativity and, consequently, their contribution in the process.

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