Moura, H.; Cardador, D.; Vega, K.; Ugulino, W.; Barbato, M.; Fuks, H. **Co-designing Collaborative Museums using Ethnography and Co-creation Workshops**. Proceedings of VIII Simpósio Brasileiro de Sistemas Colaborativos (SBSC 2011), pp. 152-159. Paraty, RJ: ACM, 2011. ISBN 978-85-7669-254-6.

Disponível em: http://groupware.les.inf.puc-rio.br/work.jsf?p1=8432

Co-designing Collaborative Museums using Ethnography and Co-creation Workshops

Heloisa Moura
Pontifical Catholic University of Rio de Janeiro (PUC-Rio)
Informatics Department
Av Marques de São Vicente, 225, Gávea, Rio de Janeiro RJ, Brazil
+55 21 3527 1500 ext 4553
moura@id.iit.edu

Débora Cardador
Pontifical Catholic University of Rio de Janeiro (PUC-Rio)
Informatics Department
Av Marques de São Vicente, 225, Gávea, Rio de Janeiro RJ, Brazil
+55 21 3527 1500 ext 4553
dcosta@inf.puc-rio.br

Katia Vega
Pontifical Catholic University of Rio de Janeiro (PUC-Rio)
Informatics Department
Av Marques de São Vicente, 225, Gávea, Rio de Janeiro RJ, Brazil
+55 21 3527 1500 ext 4553
kvega@inf.puc-rio.br

Wallace Ugulino
Pontifical Catholic University of Rio de Janeiro (PUC-Rio)
Informatics Department
Av Marques de São Vicente, 225, Gávea, Rio de Janeiro RJ, Brazil
+55 21 3527 1500 ext 4553
wugulino@inf.puc-rio.br

Marcos Barbato
Be! Interactive
Av Ataulfo de Paiva, nº 341, room 407
Leblon, Rio de Janeiro, RJ, Brazil
+55 21 2529-2101
barbato@be-interactive.com.br

Hugo Fuks
Pontifical Catholic University of Rio de Janeiro (PUC-Rio)
Informatics Department
Av Marques de São Vicente, 225, Gávea, Rio de Janeiro RJ, Brazil
+55 21 3527 1500 ext 4553
hugo@inf.puc-rio.br

ABSTRACT
The paper presents a human centered approach to co-design of groupware and socialware for collaborative museums, using ethnography, co-creation workshops and Blank Model Prototyping. It discusses the concepts and processes of human centered design, participatory design, ethnography, concept generation and iterative prototyping - pointing their value to the support of group systems design, in comparison to other approaches. It also gives an overview of the state of the art of museums around the world. Next, it describes a case study conducted in a Brazilian Planetarium and Science Museum, highlighting details of the context, process and results. The intent was to implement a system for collaborative museums that supports an integrated user experience before, during and after the visit – through groupware, socialware and cross reality technologies – for continuous engagement, co-construction of knowledge, intergenerational interaction, multimodality, sharing of ideas, and emergence of mentorship networks.

Categories and Subject Descriptors
J.5 [**Computer Applications**]: Architecture

General Terms
Documentation, Design, Experimentation, Human Factors

Keywords
Ethnography, co-creation, blank model prototyping

1. INTRODUCTION
A few centuries after the emergence of the first modern museums, they are still considered essential to the public sphere. Museums, by definition, are institutions dedicated to the acquisition, preservation, study and interpretation of the tangible and intangible inheritance of humanity and its environment, focused on the dissemination of information, exhibition, entertainment, and, more recently, informal education. In the past, museums used to display cold and static collections inside glass boxes, representing different historical moments.

Today, in contrast, the public has a growing thirst for immersive experiences, drama, adventure, fun and engagement. And in response, current museums need to be transformed into something capable of capturing attention and imagination, and stimulating collaboration amongst visitors inside and outside their spaces. In this context, groupware, or group support systems, and socialware, or systems that support social interaction, together with cross reality tools and technologies, amongst others, can play a growing role in transforming the static, 'don't touch the exhibit' museums into lively and sensorial collaborative spaces.

Designing truly engaging museum exhibits – those that are culturally relevant and where visitors get a real feeling of immersion and excitement, and even interact socially with strangers – however, is a challenge. Human-centered design offers a path towards this goal, starting with the contextual understanding of the people that actually visit, work and interact with the particular museum at hand. Through a process of co-creation, it moves from ethnographic research to design criteria, and to relevant concepts that can respond to the identified problems and opportunities. Next, it prototypes these ideas iteratively, while interacting with the very people that will use the solutions, in order to continuously learn from them throughout the development phase. As a consequence, meaningful solutions can emerge.

This paper starts with the discussion of the concepts and processes of human centered and participatory design, and explores some of the methods that can support co-creation of cross reality groupware and socialware, pointing their value, strengths and limitations. Next, it examines the state of the art of museums that are focused on collaboration. Finally, to bring the discussion into

context, it presents the case study of a Brazilian Planetarium and Science Museum, exemplifying the use of selected methods to co-create ideas that can transform the current space, exhibits, artifacts, interfaces and services into something collaborative, exciting and stimulating, and integrate the user experience before, during and after the visit. Such as described in the words of a ten years old boy who joined one of the workshops, "I want to come here [at the Planetarium] and feel that I am the astronaut, travelling through space, exploring the planets, stars and black holes".

2. HUMAN CENTERED AND PARTICIPATORY DESIGN METHODOLOGIES AND METHODS

Design methodologies refer to systems of methods, tools, principles and processes of the design discipline, as well as their application. Dorst [1] proposes that design methodology "includes the development of formal models of design activities, from which methods, techniques and computer tools can be derived" (p.8), and described in theoretical, empirical and practical terms.

The human-centered design methodology, or HCD, places human needs, skills, creativity and potentialities at the center of the activities of technological systems [2, 3]. According to Gasson [4], such tradition arose as a reaction to the perceptions of traditional approaches towards technology design – which see people simply as users of technology, focusing only on the specific interaction, rather than questioning what, how, when, where and why technology may be of service in supporting human activities. And which, by focusing only on use and usability of technology, excludes both the context of use and the richness of human beings and their lives. As Bjorn-Andersen [5] affirms, human beings are "much more than eye and finger movements" (p. 387).

The user-centered design term, or UCD, in contrast, as defined by the software development and design communities, refers to an approach whose principles include early and continuous focus on users throughout an iterative design process [6]. John Karat [7] suggests that it is a process that sets users or user information as a generative source of design ideas or as the criteria by which a design is evaluated. And according to Vredenburg et al. [8] user-centered design can be described as an overall development process where users are taken into account, including their active involvement for a clear understanding of task requirements, which combines a multidisciplinary approach, and iterative design and evaluation.

Melican [9] affirms that although the term 'user centered' is widely used, it is far from an ideal descriptor. And Bruce Hanington [10] highlights the importance of using the term 'human', instead of 'user', since it better ties design to human needs and concerns. Another criticism to UCD is that it fails to promote human interests because of a goal-directed focus on the closure of predetermined technical problems [4, 11]. Bødker and Nielsen [12] agree that relational aspects in UCD are largely overlooked in the literature, and use this criticism to facilitate a discussion on how discourse, activities and materials can give shape to user involvement in design activities. The referred authors, at Vision Lab, continuously draw experiments for devising innovations and creative solutions with users, using the workshop format. And by doing that, they combine user-centered design with the participatory approach.

The Participatory Design research methodology, also known as PD, corresponds to a set of theories, practices, and studies related to end users as full participants in activities, leading to software and hardware computer products and computer-based activities [13, 14]. The field is wide and diverse, drawing knowledge from numerous traditions, without leading to a single theory or paradigm of study or approach to practice [15]. According to Nardi and Engestrom [16], PD is a way to understand knowledge by doing; focused on the tacit and often invisible ways that people perform everyday activities and how these activities might be shaped productively. Crabtree [17] highlights that in treating users as the experts within their own context of activity, PD is characteristically concerned with creating situations and environments in which users and designers can formulate appropriate designs together. However, missing in this approach is an in-depth analysis of current work practices – a problem that has led to the adoption of the ethnographic method and its techniques.

Regarding the processes, methods and techniques used by each of these different design approaches [18], there is no agreement on how to conduct studies for gaining understanding of human activities and needs, or on how to analyze and synthesize data for guiding the creative process of design, or how to generate human-centered solutions based on such research material.

Ethnography, for instance, is becoming an increasingly widespread tool for conducting user research from the point of view of either HCD, UCD or PD traditions. Originally developed in the field of Anthropology, it can be seen as a set of methods for data collection focused on understanding human beings in their natural settings or in the context of everyday activities [19, 20].

Melican [9], however, highlights that ethnographic methods may also be of limited value in confronting the transformational implications of introducing new technologies – due to their concern with the analysis and description of the current situation and practice – and in supporting the process of envisioning entirely new systems.

Suchman [21], nevertheless, points out that imagining future solutions requires that current solutions can be articulated. On that regard, Zeisel [22] proposes a way to resolve this seeming paradox by locating and studying those settings, users and problems that are representative of future ones, and generalizing from them to the probable contexts and users. As Dourish [23] notes on the value of ethnography: it provides reflection on, insight into, and a broad understanding of the organization of social settings, bringing analytic and inspirational aspects to the design process.

For the purposes of the present research, a human-centered approach to design is taken, understood as a process of design informed by human needs and business objectives, using participatory design methods: to draw the continuous involvement of relevant participants from research to development and implementation; and to co-create solutions that are human-driven and contextually meaningful, and that, at the same time, can add value to real people and be sustainable – socially, economically, environmentally and institutionally [24].

3. COLLABORATIVE MUSEUMS AND TECHNOLOGIES

Museums, as educational and recreational organizations, have adopted a visitor centered approach, no longer focusing on collections and information, but on enhancing people's museum experience and understanding of exhibitions. Supported by increasingly sophisticated technologies, they offer visitors a range of experiences, including: visual and sensory interactions, learning, recreation, sociability, celebratory and enchanting encounters, or a distinctive combination of exposures [25].

It is noticeable, on the one hand, that substantial effort has been applied to designing and developing new museum exhibits and systems in order to facilitate engagement and collaboration, and to enhance learning opportunities of groups of visitors, since they normally attend in social clusters – such as family, friend, or school tour groups [26]. On the other hand, research on the dynamics of collaboration [27, 28] and on technologies that support groups and social interaction have helped to lighten this challenge.

On regards to collaborative museum experiences, they enable visitors to feel like a curious group of explorers, who, by interacting socially and collaborating with others, discovers wonders through the exhibits. That has been the case with several science museums, where interacting with other visitors is often included.

Dirk vom Lehn, Christian Heath and Jon Hindmarsh [29] highlight what they consider to be the three most relevant issues that should be acknowledged throughout the design process when developing collaborative museums exhibits: 1) social interaction is fundamental to visitors' experience of exhibits and exhibitions; 2) visitors need opportunities for sustained interaction both in direct relation to exhibits and around them; and 3) visitors also need spaces for single participation within exhibits, as well as resources to help them individually examine and make sense of exhibits that are designed for groups of people or multi-parties. On that regard, the authors suggest to offer resources for participants so that they are able to creatively shape and configure the experiences of others. They also emphasize the need to create exhibits that accommodate both group and individual needs and modes of interaction.

New tools and technologies have played an important role in creating the conditions for collaboration to occur in museums, and enabling the development of exhibits and systems that facilitate interactivity. Examples are groupware and socialware – or systems that support groups [30, 31] and social interaction [32, 33]. Because people normally examine and make sense of exhibits through social interaction, socialware [34] have been used to support during-the-visit intragroup communication and allow clusters of visitors to share experiences and information.

Together with systems that promote an interplay of physical, Augmented [35, 36] and virtual reality [37] technologies, known as cross reality or mixed presence tools and technologies [38, 39], these have shown interesting results in museums.

Mixed Presence Groupware, MPG, or software that connects collocated and distributed collaborators, and their disparate displays, through a common shared virtual space [40, 41], is another similar example that has been explored in order to allow multiple people to work together over a shared exhibit space. And games, simulations, and mobile devices are a few of the other technologies that have been used to engage visitors in museum exhibitions and encourage interaction and collaboration.

Examples of collaborative exhibits using these technologies include: the Boston Museum of Sciences game, called Mystery at the Museum [42], where students and parents are brought in as a team of experts to try to solve a fictitious crime at the museum space. This groupware [40] allows players to gather clues as they visit the museum and collaborate by both communicating and exchanging clues with teammates using location aware pocket computers. Another system focused on collaboration amongst children and parents is the Lunar Surface Navigation System [43]. This MPG [40, 41] connects co-located collaborators with a combination of tabletop Augmented Reality and virtual environment. Children play the role of the astronauts and parents act as the mission commanders who give instructions on exploration activities based on real lunar exploration episodes reported by NASA.

4. BRAZILIAN PLANETARIUM AND SCIENCE MUSEUM CASE STUDY

In order to bring the discussion into context and exemplify the use of a human-centered participatory approach for the design of collaborative museums, supported by cross reality group technologies, the case of a Brazilian Planetarium and Science Museum is presented. Amongst the Brazilian museums, the Planetarium and Science Museum at hand is a public institution situated at a cosmopolitan city. Its vision is to act as a culture and entertainment institution, with the mission to divulge astronomy – which is absent in the Brazilian K12 curricula – as well as to promote other related science fields, through the use of avant-garde technologies and an innovative environment. And amongst its challenges are included: to become financially independent from the government – who currently covers 60% of its expenditures; to renew the space and exhibits in order to support discovery and interactivity for a diverse public in terms of age, education, socioeconomic status and interests; and to maximize its physical capacity.

In order to collaborate with the Brazilian Planetarium and Science Museum in this effort, the Groupware@Les research group of Computer Science Department of the Pontifical Catholic University of Rio de Janeiro, proposed a project to co-design – together with children, teenagers, teachers, designers, computer scientists, and astronomers, amongst others – and transform the museum spaces, exhibits, artifacts, interfaces and services, so that visitors are able to use cross reality systems and enabling group and socialware to: explore collaborative exhibits; interact multimodally [44]; immerse in collective play; co-construct knowledge and share ideas about astronomy and other related sciences; and participate in mentorship networks together with other visitors and museum staff. The present article focuses on reporting this participatory process.

4.1 Research Framing

In the present research, ethnographic, co-creation and prototyping methods were used to identify guiding criteria for the

development of groupware for collaborative museums. The macro-process is shown on Figure 1, using Business Process Modeling Notation (BPMN) [45].

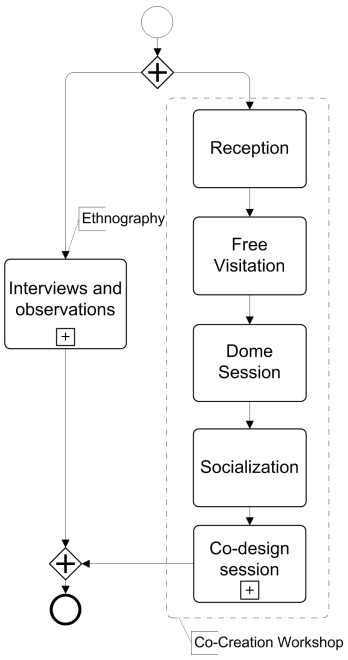

Figure 1. Research macro-process in BPM notation.

4.2 Ethnographic Study

The ethnographic research [20] started with the study of the Brazilian Planetarium and Science Museum staff, including astronomers, market and administration personnel, architects, visitor guides and support workers, amongst others. And it was followed by the study of different types of visitor profiles, helping to identify: patterns of behaviors, relevant narratives, and differences in point of view, interests, motivations and needs. Included in its research protocol were in-depth contextual interviews and shadowing observations, documented through video, photographs and field notes. Figure 3 (next page) illustrates this process.

From the interviews and observations, relevant narratives and patterns of behaviors were highlighted, leading to recurrent themes, findings or insights, and design criteria through a structured bottom-up process of analysis and synthesis [9], based on Grounded Theory [46], as shown on Figure 2. Some of the emergent design criteria, for instance, were to: activate imagination before visit; provide tour options according to profile; and make the museum experience tangible.

Narrative 15: "*Once you come to the dome session, you never forget it* [...] *You feel immersed in the sky projection. It is impressive* [...]"

Narrative 19: "*What I like most is the environment. One dives into the experience* [...] *It's an immersive space*."

Narrative 20: "*If someone's bedroom was shaped like a dome and had a super lamp that could project the stars, then he wouldn't need to come to the museum. Otherwise, this place is uncomparable.*"

Narrative 22: "*The dome projection can't be compared with traditional movie projection*"

Finding 3: Immersive experiences stir emotions (which must be addressed).

Figure 2. Selected narratives from the ethnographic study.

4.3 Co-creation workshop

The co-creation workshop [13, 14] gathered a group of participants, whose profiles were selected based on significant behavioral and demographic polarities, pointed by the findings of the ethnographic study – such as kid vs. adult, museum personnel vs. visitor, first time vs. recurrent visitor, individual vs. group, in-depth vs. little knowledge about astronomy, early vs. late technology adopter, and so forth. A few details of the participants profile are shown on Table 1.

Table 1. Co-design workshop participants

Pseudonym	Age	Occupation	Scholarity	
Mario	47	Retired	K12 (9th year)	
Ana Carla	34	Architect and urbanist	MSc Student	
Brian	34	Astronomer	Undergraduation (complete)	
Fabio	40	Internet Media Director	Undergraduation (incomplete)	
Johnny	19	Student	High School (complete)	
Thierry	9	Student	K12 (4th year)	
Breno	31	Student	PhD Student	
Thaiala	14	Student	High School (10th year)	Average = 16 y.o. variation amplitude = 22
Leonard	10	Student	K12 (5th year)	
Lucia	14	Student	K12 (9th year)	
Alicia	49	Pedagogue	Post-graduation (MBA)	
Hector	52	Professor	PhD degree	
Vinny	28	High School Teacher	Undergraduation (complete)	
Boratto	41	Marketing Director	Undergraduation (complete)	

Minimum age: 9 years old. Maximum age: 52 years old. Variation amplitude: 43

Such variety of profiles was a purposeful choice, since it is considered a condition for the co-creation of groupware solutions that can appeal to various visitor and worker profiles, and that can fit the contextual dynamics of the museum.

The activity started with the presentation of the workshop schedule (process represented on Figure 1), and distribution of a journal, where each participant was requested to write about daily routine, entertainment history, extreme cultural experiences, sources of information, past visits to the museum, and view of its future.

After filling in the journals, the participants were organized in pairs, where each one read and analyzed what the other one wrote, and, then, presented the findings to the entire group. During the presentation: the participants profiles were represented on poster size graphs; their relevant narratives were documented on a white board; and the emerging guiding criteria were synthesized to the

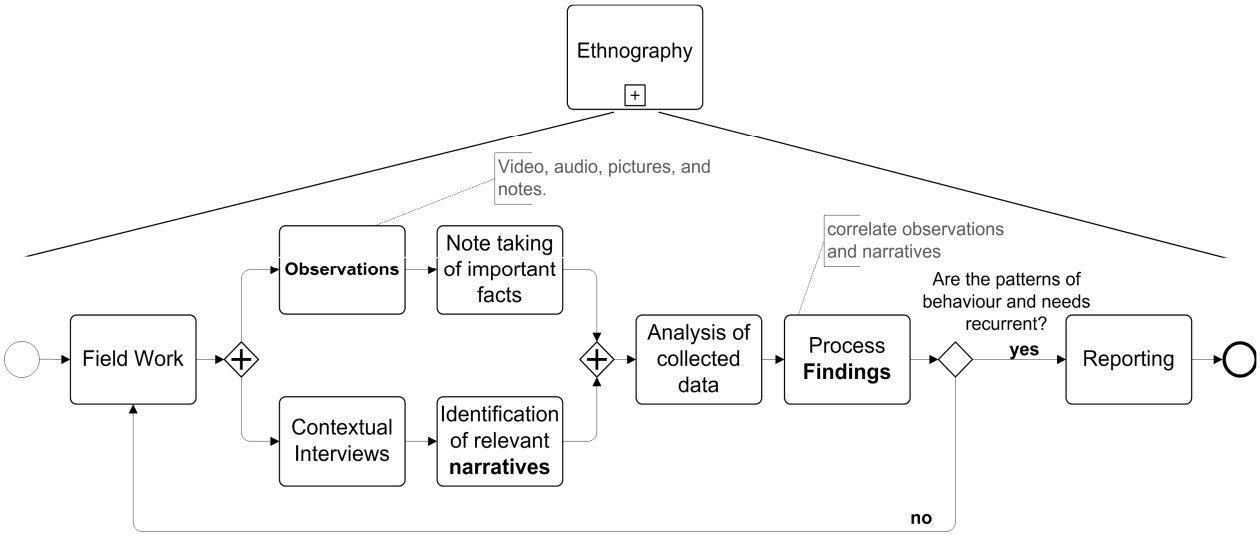

Figure 3. Process details of the ethnographic study

whole group. Next, these criteria were discussed with the participants, leading to refinement and addition of new ones.

Based on the reviewed criteria, a brainstorming session was initiated, where each sentence guided the ideation of innumerous solutions by the participants. The ideas were written down on note size papers by each one and handed to the moderator, who read them aloud. In response, the other participants wrote down complementary ideas or new concepts inspired by them. During the co-design workshop, 14 participants generated 81 relevant ideas in 20 minutes.

Some examples were: a museum-school portal, 2nd Life Planetarium, online check-in, tour guide totem, iPad navigator, Augmented Reality space mission, planet hunt collaborative game, space wiki, visitor foot prints, and outside exhibits.

After the ideation session, the generated concepts were grouped according to the guiding criteria. Figure 4 illustrates some of them in cloud format, where the font size of each word or expression represents the number of ideas that were created in relation to it.

As a result of the analysis of the ideas produced during the workshop, a ranking of the most significant criteria, according to the participants' point of view, was produced. The top ones were: 'Create an immersive experience', with 26 ideas generated in relation to it, and 'Provide interactivity', with 18 related ideas.

In addition, the concepts were classified according to subjacent theme, illustrated as a cloud of themes on Figure 5. Included amongst the ones considered most relevant to the participants were: 'Museum Itineraries' – with 13 related ideas; 'Dome Session Activities'– with 10; and 'Astronomy Games' – with 9. The theme 'Collaborative Exhibits' was spontaneously mentioned by the participants in 6 ideas, and 'Interactive Technologies' was mentioned in 7 ideas. Following the brainstorming, prototyping sessions took place to develop the concepts further.

Figure 5. Recurrent themes based on idea classification

4.4 Prototyping session

Following the co-design workshop, selected participants were invited for prototyping sessions, including architects, computer scientists and designers, since the method used [45], known as Blank Model Prototyping, requires the participation of potential users, or design and technology professionals. Blank Model Prototyping is a rapid role-playing technique that uses readily available art and craft materials to construct rough physical representations of a technological concept, according to a predetermined scenario. The goal of the prototyping session was to collect potential user impressions and detailed ideas about a new technological solution, either hardware or software, for creating a collaborative museum.

Figure 4. Guiding criteria on cloud based format, according to the number of related ideas gathered in the brainstorming

Previous to the session, the settings, team, recording equipment and supplies were prepared according to a plan. Also the 81 ideas and the criteria list of the co-design workshop were arranged in the form of cards and poster, respectively. Figure 6 shows the activities that were planned and then executed.

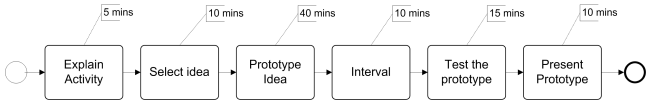

Figure 6. Activities of the prototyping session.

The prototyping session started with an explanation of the schedule and presentation of the materials (Figure 7a). Participants were asked to read the idea cards and the guiding criteria poster in order to select one concept or get inspiration for creating a new one (Figure 7b). After that, they were instructed to design the prototype, in order to evolve the original concept and rationale, converge on a solution, develop guidelines and propose design specifications [47]. During one of the sessions, as shown on Figure 7c, participants prototyped a trip to different planet environments, which could be shared by different social networks through pictures and short movies. They designed maps of the exhibit rooms, and interfaces for interacting in the rooms, like identification cards with QR codes for social network sharing, 3D glasses for the simulation trip and touch screens for selecting the planets (Figure 8). The participants then tested their prototype, reflected upon the test result and re-designed the solution accordingly. Finally, the session was concluded with a discussion and presentation of the prototype, using the designed objects as a support for dramatizing a scenario that presented the simulation rooms, as shown on Figure 7d.

Some of the lessons learned were: a) it is not enough to include computer scientists, designers and random users in the Blank Prototyping sessions – a thoughtful selection must be made to guarantee the constant presence of the point of view of extreme users and museum personnel, for instance, so that the solution will keep on track and meet the needs of the institution regarding, for example infrastructure and maintenance, and interest to visitors of different profiles; b) group composition within co-creation workshops should be carefully selected based on complementary profiles, so that each can have an equal voice; c) workshop participants need prior time to be immersed in the ethnography findings to make optimal use of the material; and d) developing twin prototypes in the physical and virtual worlds lead to different but complimentary findings about collaboration, such as behavioral and motivational.

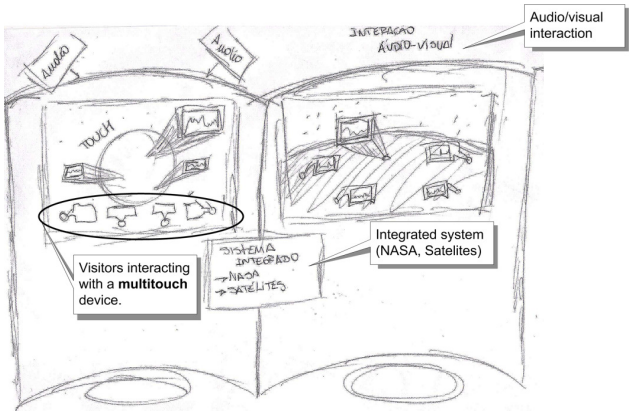

Figure 8. A multitouch device representation

5. CONCLUSION

The use of ethnography, co-creation workshops and prototyping – taking a human centered and participatory approach to design – has allowed the fast generation of numerous meaningful ideas and prototypes to support mixed presence collaboration and social interaction in the context of a Brazilian Planetarium and Science Museum. Involving researchers, children, teenagers, teachers, designers, architects, marketing specialists, computer scientists, and astronomers, amongst others, and through an iterative process of research, prototyping, testing and refinement, several collaborative solutions for museum – such as the exhibit simulating a trip to different planet environments that are shared by different social networks – are currently being developed.

The ethnographic research with museum personnel and visitors shed light regarding some of their behaviors, expectations, motivations, aspirations and needs. This study led to the identification of patterns and profile polarities that informed the organization of the co-creation workshop, from which emerged guiding design criteria and numerous concepts to the identified opportunity space for collaboration and social interaction within and outside the museum space. Through an iterative prototyping and testing process, ideas have evolved into increasingly tangible and detailed solutions.

The selected methods aided the challenge of involving people of different profiles around the task of creating and making something tangible together, focused on the collaborative human experience, but without forgetting the business objectives of the museum.

Figure 7. Activities made by participants during the prototyping session.

6. ACKNOWLEDGMENTS

Wallace Ugulino (grant 142916/2010-2), Katia Cánepa (grant 140859/2010-1), and Débora Cardador (grant 141520/2010-8), are recipients of individual grants awarded by the National Research Council (CNPq). Hugo Fuks is the recipient of individual grants awarded by the CNPq and the Rio de Janeiro State Research Council (FAPERJ) Project entitled ‘‘Cientista do Nosso Estado.” And Heloisa Moura is the recipient of individual grant awarded by FAPERJ.

7. REFERENCES

[1] Dorst, K. (1997) Describing Design: A Comparison of Paradigms, Self-published Doctoral Dissertation, Delft University of Technology, Delft, Holland.

[2] Gill, K. (1991) Summary of Human-Centered Systems Research in Europe, Part 1, Systemist, the Journal of the UK Systems Society, 13(1), pp.7-27.

[3] Scarbrough, H. & Corbett, J. (1991) Technology and Organization: Power Meaning and Design, Routledge, United Kingdom.

[4] Gasson, S. (2003) Human-Centered vs. User-Centered Approaches to Information System Design, Journal of Information Technology Theory and Application, JITTA, 5(2), pp. 29-46.

[5] Bjorn-Andersen, N. (1988) Are Human Factors Human? The Computer Journal, 31(5), pp. 386-390.

[6] Preece, J. (1993) A Guide to Usability: Human factors in computing. Addison Wesley, The Open University.

[7] Karat, J. (1996) User Centered Design: Quality or Quackery’ Interactions, 3(4), p.20, July-August.

[8] Vredenburg, K., Mao, J., Smith, P., Carey, T. (2002) A Survey of User-Centered Design Practice, Proceedings of the SIGCHI conference on Human factors in computing systems: Changing our world, changing ourselves. Minneapolis, Minnesota, USA. ACM Press, New York, NY, USA. pp. 471-478.

[9] Melican, J. (2000) Describing User-Centered Designing: How Design Teams Apply User Research Data in Creative Problem Solving, Doctoral Dissertation, Institute of Design-Illinois Institute of Technology, Chicago.

[10] Hanington, B. (2003) Methods in the Making: A Perspective on the State of Human Research in Design. Design Issues, 19(4), pp. 9-18.

[11] Dourish, P. and Button, G. (1998) On "Technomethodology": Foundational Relationships between Ethnomethodology and System Design. Human-Computer Interaction, 13(4), 395-432.

[12] Bødker, M. and Nielsen, J. (2008) Vision labs: Seeing UCD as a Relational Practice. In Proceedings of OZCHI, December 5-8, Cairns, Australia.

[13] Muller, M. and Kuhn, S. (Eds.) (1993). Special issue on participatory design. Communications of the ACM, 36(6), June.

[14] Schuler, D. & Namioka, A. (Eds.) (1993). Participatory design: Principles and practices. Hillsdale, NJ: Lawrence Erlbaum Associates.

[15] Slater, J. (1998). Professional misinterpretation: What is participatory design? In Proceedings of PDC 98. Seattle: CPSR.

[16] Nardi, B. & Engestrom, Y. (1999) A Web on the Wind: The Structure of Invisible Work, In: B. Nardi and Y. Engeström (Guest Editors). Computer Supported Cooperative Work, 8(1-2), Special Issue.

[17] Crabtree, A. (1998) Ethnography in participatory design, Proceedings of the 1998 Participatory Design Conference, pp. 93-105, Seattle: Computer Professionals Social Responsibility.

[18] Newman, W. & Lamming, M. (1995). Interactive Systems Design. Harlow: Addison-Wesley.

[19] Blomberg, J.; Giacomi, J.; Mosher, A. & Swenton-Wall, P. (1993). Ethnographic Field Methods and Their Relation to Design. Participatory Design : Principles and Practices. Edited by Douglas Schuler, Aki Namioka. Hillsdale, N.J.: L. Erlbaum Associates. pp 123-155.

[20] Hammersley, M. & Atkinson, P. (1995) Ethnography: Principles in Practice. London, Routledge.

[21] Suchman, L. (1987) Plans and Situated Actions: The Problem of Human-Machine Communication, Cambridge: Cambridge University Press.

[22] Zeisel, J. (1984) Inquiry by Design: Tools for Environment-Behavior Research, p. 37, Cambridge University Press, Cambridge, UK.

[23] Dourish, P. (2006): Implications for Design. In: Proceedings of the ACM Conference on Human Factors in Computing Systems, CHI 2006, April 22 – 28, Montreal, Quebec, Canada, ACM Press, pp. 541-550.

[24] UNDESA UN Department of Economic and Social Affairs (2001) Indicators of Sustainable Development: Guidelines and Methodologies. United Nations, New York.

[25] Anderson, G. (Ed.) (2004). Reinventing the Museum: Historical and Contemporary Perspectives on the Paradigm Shift. Walnut Creek, CA, Altamira Press.

[26] Lyons, L. (2009). Designing Opportunistic User Interfaces to Support a Collaborative Museum Exhibit. In Proceedings of the 8th International Conference on Computer Supported Collaborative Learning, Rhodes, Greece, June 8- 13, 2009, (pp. 375-384).

[27] Dillenbourg, P. (1999) What do you mean by ‘Collaborative Learning’? Collaborative Learning: Cognitive and Computational Approaches. Oxford: Elsevier Science.

[28] Fuks, H., Raposo, A., Gerosa, M., Pimentel, M. & Lucena, C. (2007) The 3C Collaboration Model. In: The Encyclopedia of E-Collaboration, Ned Kock (Org.), pp. 637-644.

[29] Vom Lehn, D., Heath, C. and J. Hindmarsh, (2005). Re-thinking Interactivity. Rethinking Technologies in Museums. Limerick, Ireland.

[30] Coleman, D. & Shapiro, R. (1992). Defining Groupware. Special Advertising Section to Network World, June 22, 1992.

[31] Stahl, G. (2005) Groups, group cognition & groupware. Paper presented at the International Workshop on Groupware CRIWG 2005, Recife, Brazil.

[32] Tomek, I.; Giles, R.; Zhang, H. & Di, L. (2007) Groupware and Socialware: Overview and perspectives. In Proceedings of the 13th ANZSYS Conference - Auckland, New Zealand, 2nd-5th December, 2007, pp.1-12.

[33] Tomek, I. & Giles, R. (2008) Collaboration in the age of Augmented Reality. In 14th International Conference on

Concurrent Enterprising, K.-D. Thoben, K. S. Pawar, & R. Gonçalves, eds., 23-25 June 2008, Lisbon, Portugal.

[34] Hattori, F.; Ohguro, T.; Yokoo, M.; Matsubara, S. & Yoshida S. (1999) Socialware: Multiagent Systems for Supporting Network Communities. Communications of the ACM, 42(3), pp. 55-61.

[35] Cawood, S. & Fiala, M. (2008) Augmented Reality: A Practical Guide. Raleigh: Pragmatic Bookshelf.

[36] Freedman, R. & Steed, A. (2006) Interactive Modeling and Tracking for Mixed and Augmented Reality. VRST'06, November 1–3, 2006, Limassol, Cyprus.

[37] Wexelblat, A. (1993) The Reality of Cooperation: Virtual Reality and CSCW. In Virtual Reality: Applications and Explorations. Edited by A. Wexelblat. Boston: Academic Publishers.

[38] Lifton, J. (2007) Dual Reality: An Emerging Medium. Ph.D. Dissertation, M.I.T., Department of Media Arts and Sciences.

[39] Coutrix, C. & Nigay, L. (2006) Mixed Reality: A model of Mixed Interaction. AVI'06, May 23–26, 2006, Venezia, Italy.

[40] Tang, A.; Neustaedter, C. & Greenberg, S. (2006) VideoArms: Embodiments for Mixed Presence Groupware. In N. Bryan-Kinns, A. Blanford, P. Curzon and L. Nigay (Eds.) People and Computers XX – Engage. Proceedings of HCI 2006. Springer, September.

[41] Tang, A.; Neustaedter, C. & Greenberg, S. (2004) Embodiments for Mixed Presence Groupware. Research Report 2004-769-34, Department of Computer Science, University of Calgary, Calgary, Alberta, Canada.

[42] Cabrera, J., Frutos, H., Stoica, A., Avouris, N., Dimitriadis, Y., Fiotakis, G. & Liveri, K. (2005). Mystery in the museum: collaborative learning activities using handheld devices. Proceedings of the 7th International Conference on Human Computer Interaction with Mobile Devices & Services, Salzburg, Austria, September 19 - 22, vol. 111. ACM Press, New York, pp. 315-318.

[43] Asai, K., Sugimoto, Y., Billinghurst, M. (2010) Exhibition of lunar surface navigation system facilitating collaboration between children and parents in science museum. In Proceedings of of the 9th ACM SIGGRAPH Conference on Virtual-Reality Continuum and its Applications in Industry, Seoul, South Korea, December 12-13, 2010, pp. 119-124.

[44] Moura, H. (2008) Bringing Multimodality and Affordances to Design of Technology Enhanced Learning Environments, Doctoral Dissertation, Institute of Design-Illinois Institute of Technology, Chicago.

[45] OMG Object Management Group (2008) Business Process Model and Notation (BPMN), Version 1.2.

[46] Glaser, B. & Strauss, A. (1967). The Discovery of Grounded Theory: Strategies for Qualitative Research. New York: Aldine Publishing Company.

[47] Mander, R. & Michael A. (1994) Blank Models: A Method for Early User Participation. Interact: American Center for Design Journal 8(1), 38-45