Co-Design Strategies with Children in Full-Body Interaction

for Situated Non-Formal Learning Experiences

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Für Noah. Kinder erinnern uns daran was glücklich sein wirklich ausmacht.

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Abstract

This dissertation focuses on better achieving co-design of Full-Body interactive learning experiences with children and experts (teachers, museum curators, pedagogues, etc.). Hence, on the one hand, it has studies how to better design Full-Body Interaction for children in public spaces and, on the other, how to achieve a better involvement of co-designers during the design process to have their voice and vision in the final experiences. The study focuses specifically on learning experiences for public space. These non-formal learning contexts (such as museums, cultural heritage sites and theatres) are characterized by the relation of people's behaviour in shared experiences and their interactions with socio-cultural contents that are meaningful for society. Previous research has pointed towards the benefits of the specific properties of Full-Body Interaction for shared experience in public spaces. However, methods to design with and for the body in this research area are still unexplored. To address this challenge, this thesis presents the design and analysis of three Full-Body interactive experiences. The main goal is to research techniques that promote children's embodied awareness and focus on their expertise in movement, playfulness and socialization.

This thesis proposes a set of *Embodied Design Thinking* qualities to understand the benefits and limitations of design techniques for Full-Body Interaction with children. On the other hand, the findings of this research lead to the definition of a preliminary Full-Body Interaction co-design method *(FUBImethod).* This method entails a set of clearly defined steps to help interaction designers in guiding intergenerational teams with children to understand and foster the role of the body in a Full-Body Interaction experience. This method summarizes the main outcomes of this research and represents a guideline for design and evaluation strategies in this research context.

Resum

Aquesta tesi es centra en aconseguir un millor codisseny entre nens i experts (professors, conservadors de museus, pedagogs, etc.) per al desenvolupament d'entorns d'aprenentatge basats en la interacció de cos sencer. D'una banda, s'ha estudiat com millorar el disseny d'interacció de cos sencer en instal·lacions interactives a espais públics per a nens. D'altra, s'ha analitzat com obtenir una millor participació dels codissenyadors durant el procés de disseny, amb la finalitat d'incloure la seva veu i la seva visió en les experiències interactives. Amb aquest propòsit, la tesis es basa concretament en experiències interactives en entorns d'aprenentatge no formal (com ara museus, patrimonis culturals i teatres), els quals es caracteritzen per la seva estreta relació amb el comportament humà durant l'experiència compartida, així com amb les seves accions i actituds envers els continguts socioculturals, els quals són de vital importancia per a la societat. Diversos investigadors han suggerit el potencial de la interacció de cos sencer per a donar suport a l'experiència compartida a espais públics. No obstant, els mètodes per dissenyar amb i per al cos en aquesta àrea de recerca encara no han sigut explorats. Per abordar aquest repte, aquesta tesi presenta el disseny i anàlisi de tres experiències interactives de cos sencer, on l'objectiu principal és investigar tècniques que promoguin una consciència corporizada *(embodied awareness)* en els nens, i que es centrin en la seva experiència amb el moviment, el joc i la socialització.

En aquest context, aquesta tesi proposa un conjunt de qualitats del procés creatiu corporitzat *(Embodied Design Thinking)* per tal d'entendre els avantatges i limitacions d'utilitzar tècniques de disseny d'interacció de cos sencer amb nens. D'altra banda, els resultats d'aquesta recerca condueixen a la definició d'un mètode de codisseny preliminar d'interacció de cos sencer (Full-Body Interaction, *FUBImethod).* Aquest mètode comporta un conjunt de passos clarament definits per ajudar als dissenyadors d'interacció a guiar els equips intergeneracionals de nens i nenes, i així entendre i fomentar el paper del cos en una experiència d'interacció amb cos sencer. Aquest mètode resumeix els resultats principals d'aquesta investigació i representa una pauta per a les estratègies de disseny i avaluació en aquest context de recerca.

SUMMARY

1 INTRODUCTION

The concept of learning with and through the body is gaining increasing attention in the Human-Computer Interaction (HCI) community and, specifically, in educational contexts for children. According to a review reported by Yarosh et al. (2011), 20 % of publications of the International Interaction Design and Children conference between 2000 and 2009 that address learning were grounded on the embodied cognition framework. In addition, a systematic review of the field showed a growing tendency in the development of learning environments based on Full-Body Interaction during the last decade (Malinverni and Pares, 2014). The concept of Full-Body Interaction describes how the relation of the user's body moving in space with the computer-controlled system generates meaning in the experience. Within this novel research field, many Full-Body interactive experiences have been developed for non-formal learning contexts in public spaces.

Zukin (1998) has described the notion of public spaces as a "spatial metaphor" for locations that represent social identity. Under this description count social spaces such as museums, archaeological sites, theatres and other cultural institutions. Full-Body interactive experiences have been gaining popularity in these contexts, in part due to their advantage of often being non-invasive and needing short preparation times (Kourakis et al., 2012; Pares et al., 2005). Interactive interfaces and installations in public spaces frequently demand a fast processing of visitors per hour. Thus, they have only a few seconds to attract visitors' attention and frame engagement (Fosh et al., 2013). These short learning curves stress the importance to provide experiences for visitors which allow quickly grasping the content and educational goals behind them.

However, researchers have highlighted the limitations of a technology-driven perspective on Full-Body Interaction. On the one hand, the underlying theoretical framework of this medium is poorly understood (Antle, 2013). On the other hand, there is a need for additional reflections on the epistemological framework in which this research should be situated (Harrison et al., 2011). This demand encompasses the consideration of a wider range of aspects that are involved in the meaning-making process in public spaces. First, learning is considered a body-anchored experience (Bonini, 2008; Svanæs, 2013) and embedded in action (Varela, 1996). These claims are derived from a theoretical framework related to embodied cognition and experiential learning, which suggests that knowledge unfolds through movement (Freiler, 2008; Glenberg, 2010; Goldin-Meadow, 2011) and experiences in the world (Dewey, 1968; Kolb et al., 2001; Piaget, 1955). Second, people rarely visit public spaces on their own. Instead, families and friends in small groups or school classes enjoy shared learning experiences together. Often their motivation is driven by the desire to get involved with educational contents in different ways than they could at home. Among other benefits, experiences in public spaces allow visitors to collaboratively explore, share and compare reflections upon educational contents. Lastly, the visitor experience is strongly shaped by situated aspects of the location such as embedded socio-cultural values, person-environment interactions and physical qualities (Marshall and Hornecker, 2013).

These features are particularly potential for educational experiences for children. Research has highlighted how children naturally use their bodies as instruments to explore and understand the world (Ackermann, 2007; Resnick, 2002; Zuckerman and Resnick, 2005). In this context, site-specific experiences have demonstrated to help children discover multiple layers of meaning and promote different ways of thinking (Langer, 2000). Furthermore, scholars stress the benefits of social interaction for children to obtain better results when doing tasks in collaboration compared to doing them alone (Doise et al., 1975).

Several researchers have questioned the methodological appropriateness of the techniques and methods employed to design for embodied learning. The risks of applying criteria that conflict with the roots of embodiment have been highlighted (Harrison et al., 2011). Antle (2013) highlights the current tendency for positivists research methods that ignore the variability in children's cognitive development, behaviours and the contextual variables that influence the situated use of interactive products for children. Further reflections stress the need to move beyond the evaluation of only cognitive aspects in order to encompass the wider range of human resources included in meaning-making processes (Jewitt, 2013). Malinverni and Pares (2014) point towards a lack of user involvement in the early stages of the design process and a general scarcity of embodied design techniques for children. In summary, these limitations point towards a general need for research efforts on novel approaches for methodologies for Full-Body Interaction design in educational contexts.

1.1 Research Framework: Motivation and Goals

In this PhD thesis, I focus on researching co-design strategies with children in Full-Body Interaction for non-formal learning contexts. As a general context for this research, I decided to conduct several case studies related to the concept of public spaces. For this dissertation, our research group defined this concept from a perspective which particularly focuses on the social aspects of public spaces, i.e. its nature to engage with a wide range of participants from the elder to the youngest. In this sense, using the term "public" we do not concern contemporary debates related to open-access policies of privately owned public spaces. Instead, the term describes the relation of people's behaviour in shared physical spaces and their interactions with socio-cultural contents that are meaningful for the society (Zukin, 1998). Zukin's pragmatic approach to this concept is also reflected in Certeau's (1988) definition of space. He suggested that the feel of spaces is shaped by the practices that take place within them. Karoff (2015) described the concept of space "as enacted through the body". In that regard, in this dissertation the notion of public space entails people's social and bodily interactions and use of physical space that is available to them. Physical spaces described by this concept often deal with non-formal learning contexts and are owned by cultural institutions such as museums, cultural heritage sites, science centres, theatres, libraries, among others.

The decision to focus on public spaces was motivated by the fact that the properties of Full-Body Interaction open a broad potential for this context. On the other hand, it allowed me to reflect upon qualities of research methodologies in the design of Full-Body Interaction. For instance, as described above, the effects of meaning-making processes in multi-user and site-specific settings have a strong influence on the user experience but design techniques to think of these features are still unexplored. On the other hand, the focus on public spaces provided a context in which I could specifically engage children in playful environments and shared meaning-making experiences.

This PhD thesis has been carried out within the research project *Evaluation-Driven Design* funded by the Spanish Ministry of Economy and Competitiveness (Grant TIN2014-60599-P) for three years (2015 to 2017). During this research, our research group has explored, analysed and defined design and evaluation methods in several Full-Body Interaction Learning Environments (FUBILEs). The aim of this dissertation is to contribute to the research field of HCI by generating novel knowledge on co-design strategies for Full-Body interactive experiences for intergenerational teams designing for and working with children for non-formal learning contexts. My research has been inspired by research on embodied design methods that incorporate somatic practices as techniques to stimulate users' awareness towards their own body (Loke et al., 2013b; Schiphorst, 2011). For the exploration of design techniques for children, I adopt a phenomenological perspective on play that regards space as a bodily and social practice (Karoff, 2015). Furthermore, I was interested in researching the synergies that arise between design partners during projects driven by the design of learning technologies. Therefore, I explored different ways of involving children in the Full-Body Interaction design. I also researched possibilities that could provide design teams with strategies that engage children as partners and build on their specific expertise, skills and capacities (Iversen and Dindler, 2013). Finally, I included a multimodality approach that focused on how children expressed meaning through multiple resources (Kress, 2010) during the use of different design techniques. This method helped me to better understand and interpret the outcomes of the design sessions.

Within this research, I focus on the sub-goals as follows:

- Provide a comprehensive overview of current design practices and identify research gaps in Full-Body Interaction in public spaces.

- Research the specific features of educational experiences based on Full-Body Interaction in public spaces.

- Research design methods that facilitate the design for and with the body.

- Empower children by focusing on their expertise and skills that they can bring into Full-Body Interaction design.

- Develop a set of design strategies to enhance children's embodied experience with Full-Body Interaction interfaces for non-formal learning contexts.

- Understand the potential of these design strategies to elicit children's contributions and involve them in the design.

- Define a set of guidelines and “good practices” for intergenerational design teams working with children that address the identified shortcomings in current design approaches for Full-Body Interaction.

1.2 Methods

This dissertation is positioned within the ‘third paradigm of HCI’ (Harrison et al., 2007) that entails a phenomenological perspective on interaction design. Its central focus is the understanding of meaning construction as the outcome of users’ situated knowledge and collaborative practices. Focusing on these principles allowed me to consider several viewpoints and generate multiple understanding of a design context and social relationships within a project. Furthermore, this paradigm particularly focuses on the underlying role of embodiment. It involves the design for complex real-world practice driven by physical activity, social interaction and the awareness on socio-cultural aspects. In alignment with the interdisciplinary nature of this paradigm, my research has been informed by multiple theoretical lenses stemming from fields such as cognitive science, phenomenology, psychology, pedagogy, computer science and design (Chapter 2). In this context, I consider theory as a heuristic instrument to intervene in empirical practice. Therefore, I used several frameworks that provided me with reflective lenses on the results of the studies employed in my work. For instance, I employed Lentini and Decortis’s (2010) five dimensions of experience in physical space (Section 5.1) to evaluate the requirements of the design for a VH experience. In Section 5.6, I used Skovbjerg’s et al. (2016) views on childhood to research the differences between designer’s assumptions on children’s role in the design process.

The overall framework for this thesis is based on a Research-Through-Design (RtD) (Zimmerman et al., 2007) approach combining theory, design and empirical studies. Zimmerman, Stolterman, and Forlizzi (2010) defined RtD as a research approach that employs methods and processes from practice as a legitimate method of inquiry. In contrast to the ruling positivist paradigm of experimental research methodology that has been especially dominant in HCI, rooted in psychological research in the 1960s, RtD builds on using experimental and exploratory design practice to develop questions that could not be asked in controlled laboratory settings (Stolterman, 2008). In relation to this thesis, I have designed, implemented and evaluated several Full-Body interactive experiences in iterative design processes with children, interaction designers, educational and topic experts (Chapter 4 and 5). Through practice-based work such as design and prototype development, I generate knowledge and experiences that are difficult to obtain by other means. The projects have been directed towards a view that considers design as a multi-voiced, communicative and situated process (Harrison et al., 2007) and a common vision that is shaped through continuous and ambiguous social interactions between the participants (Iversen, 2005). On the other hand, RtD describes a designedly inquiry that offers a different lens of doing research and alternative ways of understanding the design process. In this sense, it allows a shift towards a critical focus and stimulates reflective practice on the design. Building on this perspective, I employed in my studies value-based approaches to HCI such as Participatory Design (Muller and Druin, 2010) and Critical Discourse Analysis (van Dijk, 1993).

The exploration and development of co-design strategies (particularly in Chapter 4) were inspired by research efforts in related fields that include somatic practices in the design of movement-based interaction (Loke et al., 2013b; Schiphorst, 2011). These embodied design techniques helped participants to reflect upon their own behaviour and explore self-awareness of inner-body states related to movements. They suggest that knowledge is constructed through the lived body-experience (Svanæs, 2013). For this research, I employed somatic practices as warm-up activities to awaken user's felt-experiences and provide bridges between traditional design thinking methods and Full-Body Interaction design. I also incorporated somatic practices in concrete techniques aimed to allow designers experience and bodystorm their ideas for this medium.

Furthermore, to obtain a holistic understanding of stakeholders' contributions in these design processes, I used Multimodal Analysis (Jewitt, 2013; Kress, 2010) for the evaluation of the outcomes of the empirical studies. Multimodality is an interdisciplinary approach, derived from socio-semiotics, that aims to understand how people communicate and represent meaning in different forms (Price and Jewitt, 2013). This approach has been particularly relevant to the interpretation of children's contributions in Participatory Design (Malinverni et al., 2016a; Van Mechelen et al., 2016). Previous work has highlighted children's difficulties in expressing their ideas verbally (Kontra et al., 2012). Multimodal Analysis offers the design team a perspective that goes beyond the limits of verbal language by considering several multimodal resources to express meaning and opens an additional window into the understanding of children's minds.

The primary focus on qualitative research methods in my work, allowed me to perform an in-depth analysis of selected issues without being constrained by predetermined evaluation categories (Patton, 1990). To make our findings more solid that resulted from the data analysis, I followed the concept of two triangulation methods proposed by Patton (1990): (1) comparing multiple qualitative data sources (within methods) by using observation data from in-situ interaction, interviews and open-ended questionnaires and non-verbal outcomes (e.g. drawings, low-tech prototypes); (2) multiple perspectives from multiple observers (across different analysts of qualitative data).

As a researcher, I have taken part in all parts of this work and have overseen the organization and coordination of the empirical studies and design workshops. I have also been the link when orchestrating stakeholders' relationships and combining methods from several disciplines and traditions. Hence, this work emphasizes the importance of including multiple competencies as well as the participation of involved parts throughout the whole design process, from field studies to design and prototype implementation and evaluation.

1.3 Contributions

My main goal has been to explore and define design methods that allow designers to engage children in the design of Full-Body Interaction and to develop interactive experiences that take full advantage of the potential of this medium in non-formal learning contexts. To reach this goal, I have conducted several case studies in which I specifically focused on children's roles in the design process and their expertise as users of Full-Body interactive experiences. These efforts have led to the following contributions that are described in a chronological order within the dissertation:

- I have defined a set of *Embodied Design Thinking* qualities to understand the benefits and limitations of design techniques for Full-Body Interaction with children (Section 4.1). Therefore, I have conducted an exploratory study within the *EcoSystem* project to research the benefits of playful embodied design techniques to define concrete interaction design ideas. Based on children's contributions, I evaluated their potential as design techniques and proposed initial guidelines for their use with them.

- I have developed new approaches for co-design techniques aimed to promote children's embodied awareness and help them to translate this knowledge into concrete design ideas. (Section 4.3). Therefore, I conducted co-design workshops together with children of the local theatre school *Plàudite – Espai d'Arts Escèniques*. The result was the development of an interactive storytelling experience based on Full-Body Interaction. Through this prototype, I evaluated the potential of these co-design techniques using our *Embodied Design Thinking* qualities framework and reflected upon the necessary features of somatic practices in Full-Body Interaction design with children.

- I have designed a Virtual Heritage experience for primary school children based on an emerging AR projective interaction paradigm, called World-as-Support (Chapter 5). The goal of this project was to complement the educational experience of the existing guided visit of the Spanish bomb shelter *Refugi 307*. I first analysed the requirements for this project through a contextual inquiry study of the guided visit and consecutive co-design workshops in school with a total of 40 children. I validated then two design iterations of the system through experimental evaluation with a total of 52 children. Our results showed that the educational experience offered opportunities to enhance students' understanding of the historical context. Specifically, it fostered students' comprehension of socio-cultural values related to the Spanish Civil war such as human dignity, solidarity and pluralism.

- I have proposed recommendations on how to handle a common agreement of emerging values and project goals between design partners (Chapter 5.6). This contribution is based on a critical retroperspective analysis of designers' assumptions and influences of children's roles in the design of a Virtual Heritage experience. For this project was carried out in collaboration with curators and educators from the Barcelona History Museum (MUHBA). The used framework was inspired by discussions during the workshop titled "Being Explicit about Underlying Values, Assumptions and Views when Designing for Children" that I attended at the International Conference on Interaction Design and Children in 2016 (Skovbjerg et al., 2016).

- I defined a co-design method to structure and guide the design of interactive experiences in Full-Body Interaction (FUBImethod). The aim of the method is to take advantage of the expertise that children can bring into the design of Full-Body Interaction. To illustrate the employment of this method, I described one representative co-design technique for each design stage (Chapter 6). Finally, I analysed the benefits of the FUBImethod for designers in related research fields. This contribution is also an outcome of discussion during my research stay at Aarhus University and, specifically, the collaboration with my hosting supervisor Prof. Dr. Ole Sejer Iversen.

- I have published eight conference papers and three journal articles related to this thesis. In the next section, I present a list of publications. Their order is structured in their relation to each thesis's chapter.

1.4 Dissertation Outline

The PhD thesis is structured as follows. In Chapter 2, I provide the State of the Art and a review of topics related to this thesis. In Chapter 3, I present previous work on embodied design methods in HCI and outline the challenges in Full-Body Interaction design to justify the need for novel research method approaches in this field.

In Chapter 4, I present our research efforts in exploring co-design techniques aimed to promote embodied awareness in children and translate this knowledge into design ideas. The following publications were published in relation to the results of this chapter:

Laura Malinverni, Marie-Monique Schaper and Narcis Pares. (2016). An evaluation-driven design approach to develop learning environments based on full-body interaction. *Educational Technology Research and Development. 64(6): 1337-1360.*

Marie-Monique Schaper and Narcis Pares. (2016). Making sense of Body and Space through Full-Body Interaction Design: A case study. *In Proceedings of the 15th International Conference on Interaction Design and Children* (IDC '16). ACM, New York, NY, USA, 613-618.

Marie-Monique Schaper, Laura Malinverni, and Narcis Pares. (2015). Sketching through the body: child-generated gestures in Full-Body Interaction Design. *In Proceedings of the 14th International Conference on Interaction Design and Children* (IDC '15). ACM, New York, NY, USA, 255-258.

Marie-Monique Schaper, Laura Malinverni, and Narcis Pares. (2014). Participatory design methods to define educational goals for full-body interaction. *In Proceedings of the 11th Conference on Advances in Computer Entertainment Technology* (ACE '14). ACM, New York, NY, USA, Article 50.

Laura Malinverni, Marie-Monique Schaper and Narcis Pares. (Accepted). Multimodal Methodological Approach for Participatory Design of Full-Body Interaction Learning Environments. *Qualitative Research.*

Marie-Monique Schaper and Narcis Pares. (To submit). Co-Design Techniques for and with Children to promote Embodied Awareness in Full-Body Interaction. *Co-Design Studies.*

Marie-Monique Schaper, Laura Malinverni and Narcis Pares. (To submit). Embodied Design Thinking Qualities: A framework to analyse design techniques in Full-Body Interaction for the child experience. *International Journal of Child-Computer Interaction.*

In Chapter 5, I extended this knowledge to the design of non-formal learning contexts. Specifically, our team designed a Virtual Heritage experience for a Spanish bomb shelter aimed to complement the guided visit for primary school children. Within this case study, I also explored the potential of an emerging projective AR interaction paradigm called World-as-Support (WaS). The design procedure was published in the following publications:

Marie-Monique Schaper, Maria Santos, Laura Malinverni, Juan Zerbini Berro and Narcis Pares. (2018). Learning about the past through situatedness, embodied exploration and digital augmentation of cultural heritage sites. *International Journal of Human-Computer Studies.*114: 36-50.

Marie-Monique Schaper, Maria Santos, and Narcis Pares. (2018). Orchestrating experts' assumptions and children's values in the design of Virtual Heritage experiences. *International Journal of Child-Computer Interaction.* 17: 5-15.

Laura Malinverni, Cristina Valero, Marie-Monique Schaper, and Narcis Pares. (2018). A Conceptual Framework to Compare two Paradigms of Augmented and Mixed Reality Experiences. *In Proceedings of the 17th International Conference on Interaction Design and Children* (IDC '18). ACM, New York, NY, USA, 7-18.

Marie-Monique Schaper, Maria Santos, Laura Malinverni and Narcis Pares. (2017). Co-Designing Virtual Heritage Experiences for Archaeological Sites based on the novel AR Paradigm World-as-Support. *ACM Celebration of Women in Computing, WomENcourage Conference 2017.*

Maria Santos, Marie-Monique Schaper, and Narcis Pares. 2017. Moving through the past: design and evaluation of a full-body interaction learning environment for a public space. In *Proceedings of the XVIII International Conference on Human Computer Interaction* (Interacción'17). ACM, New York, NY, USA, Article 54, 3 pages.

Marie-Monique Schaper, Maria Santos, Laura Malinverni and Narcis Pares. (2017). Towards the Design of a Virtual Heritage Experience based on the World-as-Support Interaction Paradigm. *In Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems (CHI EA '17).* ACM, New York, NY, USA, 2034-2041.

Laura Malinverni, Julian Maya, Marie-Monique Schaper and Narcis Pares. (2017). The World-as-Support: Embodied Exploration, Understanding and Meaning-Making of the Augmented World. *In Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17).* ACM, New York, NY, USA, 5132-5144.

Marie-Monique Schaper and Narcis Pares. (To submit). Designing for socio-cultural values in Virtual Heritage. *ACM Transactions on Computer-Human Interaction.*

Marie-Monique Schaper and Narcis Pares. (To submit). Retroperspective evaluation and critical analysis of the design process of interactive experiences for children. *Interaction Design and Architectures Journal.*

In Chapter 6, I formalized our results in the definition of a structured co-design method which I called FUBImethod. The goal of the method is to engage children and intergenerational teams in the design of Full-Body Interaction. The protocol of the method is reported in this publication:

Marie-Monique Schaper, Ole Iversen, Laura Malinverni, Narcis Pares. (Under Review). FUBImethod: Co-Design Strategies to engage Children within Intergenerational Teams in Full-Body Interaction. *International Journal of Human-Computer Studies.*

Finally, in Chapter 7, I draw my conclusions for this thesis and offer suggestions for future studies.

2 RESEARCH CONTEXT

In this chapter, I present and analyse previous work related to the design of Full-Body interactive experiences. In Section 2.1, I contrast different theories of embodiment and explain how they have been applied in HCI. In Section 2.2, I describe the core aspects in child development theories that are relevant to the design of embodied learning technologies. Both sections give a brief overview for situating the goals and requirements of the work that I present in this thesis. Subsequently, I explain in Section 2.3 how these theories have been considered in the design of Full-Body interactive experiences in public spaces. Therefore, I highlight core features that this medium offers to support non-formal learning experiences. The goal of this review is to contextualize the research area in which the projects presented in this thesis have been realized. I close the State of the Art chapter by outlining the current limitations and challenges in Full-Body Interaction design.

In relation to this chapter, it is important to describe our understanding of the differences between the terms *Embodied Interaction* and *Full-Body Interaction.* From our perspective, Full-Body Interaction is considered part of the field Embodied Interaction. Dourish (2001) defined Embodied Interaction as "the creation, manipulation, and sharing of meaning through engaged interaction with artifacts." He particularly focused on how tangible and social interaction are connected and form the foundation to understand the notion of embodied interaction. In addition to this definition, Dourish (2006) proposed a different perspective that recognizes both 'space and place' as products of embodied social practice and as a means to understand and structure action. In this sense, research on Full-Body Interaction builds on these concepts. However, instead of considering only tangible user interaction, Full-Body Interaction is concerned with how technology enables certain forms of whole body movement and physical actions in space to acquire meaning. Other scholars have referred to this concept also as

Whole Body Interaction (Connell et al., 2013; Holland et al., 2011; Price et al., 2015). This term describes the same interaction concept

2.1 Human-Computer Interaction and Embodiment

Embodiment was described by Dourish (2001) as an approach to understand human-artefact interaction by considering its contextual, situated, corporeal and social nature. In philosophy, Merleau-Ponty (1962) referred to the concept of embodiment to the human being as a "lived body" situated in and influenced by the physical world. These perspectives contrast with the traditional view of human cognition, which claims that thinking is abstract information processing (Newell and Simon, 1976). Theories of embodiment focus on how our bodies and active experiences shape what we perceive, feel and think (Marshall and Hornecker, 2013). This theoretical account has been drawn from two main branches: phenomenology and embodied cognition.

2.1.1 The phenomenological perspective

In the early stages of HCI research, many theoretical models e.g. in artificial intelligence and cognitive psychology were grounded on cognitivism. This approach treats mental processes and physical interaction as separate domains. This strict separation between body and mind has its roots in fundamental principles of Western culture. Descartes formulated in this context the theory of Cartesian mind-body dualism in which he defined the human as an immaterial mind having a physical body (Figure 1). According to him, a human being can be considered a self-conscious entity whose body is controlled, comparable to a machine, by natural laws (Svanæs, 2013).

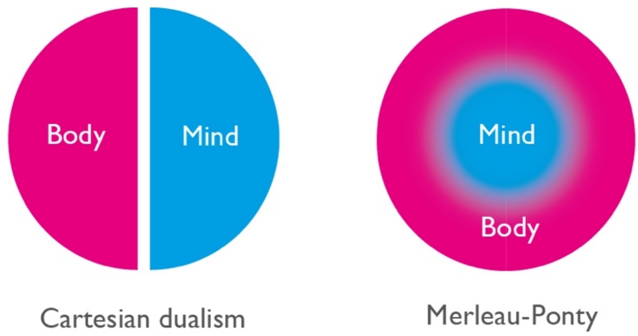

Figure 1. Two models of mind-body perception

Winograd and Flores (1987) presented an alternative to the cognitivist approach that has been a significant influence for current HCI research. Drawing from phenomenology (Dreyfus, 1991; Heidegger, 1927), Winograd and Flores proposed an understanding of interaction with technology that is inherently historical, material and social (Marshall and Hornecker, 2013). According to this view, knowledge unfolds from intelligent actions grounded in a complex history of skilful bodily experiences (Dreyfus, 1991) and the state of being-in-the-world within a particular context (Heidegger, 1927).

Suchman (1987) presented another influential perspective, arguing against the cognitivist conception of mind. This view was adopted from ethnomethodological orientation (Bittner and Garfinkel, 1967; Sacks et al., 1974) and phenomenology (Schütz, 1970) empathizing on the everyday practical engagement of social interactions. Building on this perspective, behaviour can be seen as *situated action*, i.e. interaction with the contingencies of the physical and social environment.

Dourish (2001) presented embodiment as a foundational concept for HCI by drawing upon and expanding the phenomenological perspectives of this previous work. He argued that nowadays our primary experience of computation is not anymore limited to "a single user sitting at desks and interacting with conventionallydesigned computers employing screens, keyboards and mice for interaction" (Dourish, 2004). Instead, there has been an evolution and integration of computer technology within the world in which we live and work. He explained that phenomenologically, the use of multi-sensory artefacts embedded in digital technology are more adequate when they are placed in particular cultural contexts or environments than mere desktop computers. Dourish's theoretical account paved the way for research that has explored new forms of embodiment in technology such as digital manipulatives (Zuckerman and Resnick, 2005), tangible (Hornecker and Buur, 2006), mobile (Oulasvirta et al., 2005), ubiquitous (Chalmers and Galani, 2004) and Full-Body Interaction (Pares et al., 2005), among others.

Novel perspectives particularly focus on the body and its felt experience. Moen (2005) discussed the kinaesthetic interaction experience from the phenomenological perspective of Merleau-Ponty's concept of the lived body. Larsssen et al., (2007), reflected upon the role of the body played by the kinaesthetic sense in Human-Computer Interaction. Loke (2008) used Laban movement analysis and phenomenological views to research design for moving bodies in interactive, immersive environments. Antle et al., (2013) presented the role played by embodied metaphors in augmented spaces. Svanæs (2013) focused on the user experience and its relation to phenomenology.

2.1.2 The embodied cognition perspective

Another strand of work that has rejected aspects of the dualistic perspective of thinking and interaction is based on theories of embodied cognition. There is currently no unified view on the core concepts of the embodied cognition approach. Some approaches reject the Cartesian cognitive science completely, and others retain some parts of it, such as symbolic representations or some aspects of functionalism (Marshall and Hornecker, 2013). Gibson (1979) presented an ecological approach to visual perception. He stated that cognitive processes and action are inseparable and, building on this theory, he described how the human body affects human understanding mediated through bodily perceptions. Niedenthal and Barsalou (2005) claimed that knowledge is "embodied", i.e. grounded in bodily states and in the brain's modality-specific systems. Furthermore, Barsalou (2008) suggested in his grounded cognition approach hat the same neural patterns are involved when we are physically enacting and then mentally recalling a particular movement. Gallese's mirror neuron theory (2005) extended this idea claiming that this even occurs when we observe the same action performed by others. According to Gallese, mirror neurons are directly involved in the cognitive processes of communicative action, in imitation, in basic forms of mind reading, and experiences of empathy. Lakoff and Johnson (1980) proposed the Embodied Metaphor Theory that suggested how abstract concepts and conceptual metaphors in language are based on image schemas. The authors explained that mental structures are formed through sensorimotor interaction with the world to guide our action.

Drawing from this work, Wilson (2002) identified six core claims of embodied cognition: (1) *cognition is situated:* it takes place in a real-world environment and inherently involves perception and action; (2) *cognition is time-pressured:* it functions under the pressures of having to interact in real time with a dynamic environment; (3) *we off-load cognitive work onto the environment:* cognitive workload is alleviated by holding or manipulating information in external structures; (4) *the environment is part of the cognitive system:* the information flow between mind and world is so dense and continuous that the mind alone is not a meaningful unit of analysis; (5) *cognition is for action*: the function of the mind is to guide action, i.e. cognition should be understood in terms of its contribution to behaviour; (6) *off-line cognition is body-based*: even when decoupled from the environment, mechanisms evolved for interaction with it play a role in cognition; sensorimotor systems are involved in processing even in the absence of task-relevant perceptual input. Wilson argued that the first three and the fifth of these claims were not sufficiently solid and needed further evaluation to understand their application contexts.

Furthermore, she questioned the truth of the fourth claim. She agreed on the fact that behaviour and cognitive processes are influenced by external forces in the world. However, she disagreed on the scientific judgement that included the environment in the boundaries of a cognitive system. Finally, she pointed out that particularly the last view had received little attention in the literature on embodied cognition. She highlighted the potential of cognitive activities based on sensorimotor functions to stimulate the memory, mental imagery and cognitive processes such as reasoning and problem-solving.

Theories grounded on the phenomenology and embodied cognition perspectives have found application in the design of learning technology in the HCI community and, specifically, in educational contexts for children. Design strategies of these technologies are also derived from developmental psychology and media-studies literature that provide evidence for the importance of understanding the role of embodiment in the development of children's cognitive skills. In the next sections, I review relevant literature in child development theories and outline how children can benefit from activities based on embodied learning in public spaces.

2.2 Pedagogical perspective on embodied learning

The focus on embodiment both broadens and changes the possibilities of designing for children's technologies. Novel design approaches in this field need to provide ways that are better tuned to children's developing abilities (Antle, 2009). Therefore, designers must consider three core aspects in child development theories that offer, in conjunction, a holistic view of how embodied learning unfolds and can be supported.

Children make meaning through action: Several scholars have developed theories around this claim. Piaget suggested that people construct their knowledge from active experiences requiring both physical and mental actions (Piaget, 1955). Dewey (1968) and Kolb

(1984) described a process by which hands-on opportunities in an active learning environment drive knowledge. Bruner (1962) claimed that human cognition is not exclusively conceived as an in-mind process, i.e. that knowledge begins with enaction. In summary, these theories point towards the fact that children use their bodies as instruments for learning in real-world contexts by exploring their environment through sensorimotor experiences, gestures and movement (Ackermann, 2004; Goldin-Meadow, 2011; Kontra et al., 2012).

Children learn through socialization: Vygotsky (1980) argued for the fundamental role of social interactions in the development of cognition. Based on this theoretical perspective, scholars have shown that children obtain better results when doing tasks in collaboration compared to doing them alone (Doise et al., 1975). Moreover, collaborative learning facilitates critical thinking (Nelson, 1994), allows a longer retention of the concepts and promotes positive attitudes towards the learning materials (Kreijns et al., 2003).

Children use the physical space to perceive the world: According to Certeau's (1988) definition of space, users produce and transform space through practice. The emotional experience that people live in the world is determined by the relationships to the space they are in, the people and material objects around them. In this context, the Reggio Emilia approach points towards the influence of spatial arrangements in learning (Gandini, 1998), considering the physical environment and its components as a "third teacher". According to this approach, a classroom should be equipped with varied facilities and materials to foster spontaneous learning, individual study, and collaborative activities.

In the previous two sections, I have described the research context of this thesis in relation to the different perspectives on learning theories that inform Full-Body Interaction research and the design for educational experiences. This theoretical perspective constitutes the foundation of my work and helps me to make interaction design choices for projects presented in Chapter 4 and 5. I particularly focus on the phenomenological perspective of the body-anchored experience in learning.

2.3 Designing for Full-Body Interaction in public spaces

Research on embodied learning technologies has tried to understand and support the ways in which the body, spatiality, and socialization have an impact on children's cognitive development. Within the embodied interaction concept, Full-Body Interaction has become a growing field of research and design. Full-Body Interaction is understood as a concept that takes advantage of users' motion and body capabilities to interact and construct meaning in physical and virtual space. From a theoretical perspective, Full-Body Interaction has the potential to support learning (Revelle, 2013). Research in this field is grounded on the hypothesis that involving users at different levels (e.g. sensorimotor, cognitive and affective) and the performance of specific gestures during the interactive experience may facilitate the construction of knowledge (Freiler, 2008; Glenberg, 2010; Goldin-Meadow, 2011). At the same time, conceptual changes can be shaped by the specific physical characteristics of the environment (Hornecker, 2006; Márquez Segura et al., 2016), socio-cultural influences (Hornecker et al., 2014) and the living experience of others' actions in the world (Ackermann, 2004).

Digital technologies can provide relevant support for learners to engage with educational contents. During this decade, several Full-Body interactive experiences have been developed for public spaces addressing different aspects of learning. Increasingly, novel design approaches for Full-Body Interaction (Malinverni and Pares, 2014) are inspired by Papert's "learning by doing" approach (Papert, 1980), understood as the fundamental role of hands-on activities and active experiences in the learning process. This field has also been informed by research on digital manipulatives (Zuckerman and Resnick, 2007, 2005) that have explored the potential of sensory interaction with tangible objects to promote learning of abstract concepts. Designers in Full-Body Interaction employ these notions by using interactive and augmented material to construct knowledge around artefacts and, through this, facilitate the understanding of abstract concepts or phenomena. In embodied interaction, this approach links to the idea of 'external scaffolding' (Antle, 2009), i.e. providing opportunities to manipulate and restructure the spatial configuration of elements in an interactive environment to create meaning around a general concept. For instance, in the installation *Connected Worlds*, developed for the New York Hall of Science (Design IO LLC, 2018), children learned about sustainability through the performance of local actions that had an impact on the global environment. They worked with a fixed amount of water in the system and had to collaborate to manage and distribute the water across the different environments. Clouds returned water from the environments to the waterfall which released water to the floor when it rained (Figure 2).

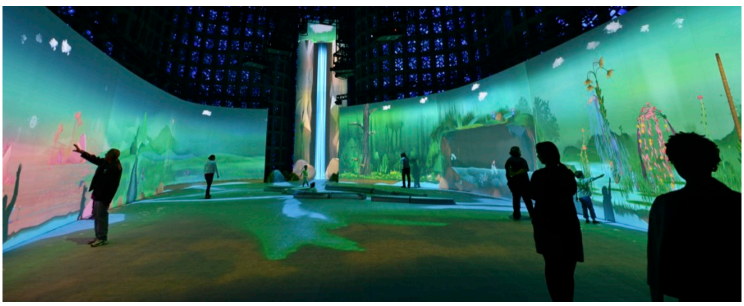

Figure 2: The installation Connected Worlds is a large immersive interactive ecosystem. Image reproduced from Design IO LLC, 2018.

The installation *Connected Worlds* is representative for an emerging trend in public spaces. Museums increasingly include collaborative experiences and hands-on group activities in their exhibitions (Allen and Gutwill, 2004). As previously described, from a pedagogical perspective, social interactions play a crucial role in child development. Research in the design of Full-Body Interaction has shown that collaborative learning experiences may increase children's comprehension of scientific concepts (Carreras and Pares, 2009; Karadimitriou and Roussou, 2011; Lindgren and Moshell, 2011), reflection upon abstract data (Roberts et al., 2014), supports the construction of a positive social space (Malinverni and Pares, 2015; Scaife and Rogers, 1998) and provides opportunities as intervention tool for the stimulation of social initiation (Mora-Guiard et al., 2016). Rogers et al. (2004) pointed towards the benefits to enhance children's collaborative behaviour through sharing interactive devices and objects within a virtual interface. In addition, even in the case of single-user environments scholars have stressed their opportunities for fostering social interaction by attracting other visitors as the audience (Mora-Guiard and Pares, 2014; Pietroni and Adami, 2014; Tscholl et al., 2013). Dalsgaard and Hansen (2008) stressed that participating in an interactive experience in public space implies the involvement of both the performer and spectator, i.e. other people are aware of the performance experienced by someone else and the performer is aware of being observed. In this sense, collaborative environments allow visitors to shift from the individual interaction to a shared learning experience highlighting their beneficial properties for educational experiences in public spaces.

Collaborative activities in Full-Body interactive experiences have also shown to promote abilities related to the notion of perspective-taking (Kourakis et al., 2012; Rogers et al., 2004; Roussos et al., 1999). This idea refers to "how people drift in and out of their own viewpoint" (Ackermann, 1996) and how this helps them to build up a better understanding towards specific topics and phenomena. In other words, perspective-taking (Ackermann, 1996) involves "both differentiation and coordination of viewpoints", e.g. to transmit another person's point of view and foster values related to empathy. In Full-Body Interaction design, this idea has been explored using metaphorical concepts to transmit abstract meanings. This research branch is based on Lakoff's and Johnson's (1980) idea of "embodied schemas", according to which the understanding of certain metaphorical concepts may be grounded in embodied experiences. For instance, in the project *MEteor* (Tscholl et al., 2013) children's movements controlled the trajectory and physical properties (i.e, velocity, position or angle) of an asteroid (Figure 3). The interface offered users the opportunity to observe and to experience the realistic effects on celestial objects since they were provided with the sense of being the asteroid themselves.

Figure 3: Museum installation MEteor. Image reproduced from Tscholl et al., 2013.

Lyons et al. (2012) used physical exercises as a metaphor for the notion of effort. In the interactive experience, the users had to race each other on bikes while they were immersed as polar bears in the virtual Arctic Ocean. The resistance of the bikes changed according to the differences of sea ice cover between 1970 and 2010. Antle et al. (2013) created a Full-Body interactive experience based on a springboard system. The application enabled the users to explore images and personally rate those related to the issue of social justice. The mechanism of the rating was carried out by balancing or unbalancing the board. The museum installation *NanoZoom* (Mora-Guiard and Pares, 2014) used the notion of the body as a referent to mediate the concepts of scale and proportion. This idea was based on the claim that the Roman architect Vitruvius made, which stated that "man was the measure of all objects" and which was later picked up by Leonardo da Vinci and represented in his famous drawing of the Vitruvius Man. Hence, the hypothesis of this approach was that the body of the user, as a constant referent, would facilitate user understanding of objects of which we have no direct experience as those in the nanoscale. In accordance with this idea, Antle (2009) argued that through the physical manipulation of virtual objects and comparing their effects on the environment, children also learn to manipulate mental models of real-world settings. In other words, they can successfully tackle problems that require mental abilities and skills that they are still developing.

Another tendency in Full-Body Interaction design is built on the premise of context-specific learning. In this regard, research in embodied cognition highlights that knowledge is situated in the relationship between social, cultural and physical contexts (Kontra et al., 2012). Langer (2000) suggested that a meaningful exploration of the environment would foster the awareness of being in-situ, i.e. concrete actions in a specific place can allow users to contextualize their experience with certain behaviors of the environment. Full-Body Interaction can take advantage of it by promoting learning concepts which stand in direct or indirect relationship to socio-cultural contexts of the location. In recent research context-specific experiences have been used to complement learning concepts rather than being considered as an independent learning tool (Flynn, 2013; Pietroni and Adami, 2014). Full-Body Interactive experiences in museums and heritage sites that exhibit historical or archaeological artifacts can benefit from context-specific learning by promoting interpretations in relation to past cultures. For instance, the virtual heritage experience *We Hunters* (Kourakis et al., 2012) (Figure 4) allowed children to experience and learn about hunting strategies which were illustrated in a cave painting by using Full-Body actions. This helped them to "embody" certain enactments of people from those ancient cultures and to better contextualize underlying socio-cultural meanings in relation to the museum exhibition (Flynn, 2013). Previous studies have shown that learners' attention and learning gains increased when they were encouraged to employ a wide range of different actions in contrast to activities which were based on repetition of the same stimuli and physical activity (Langer, 2000). Thus, experiences based on the Full-Body Interaction concept should allow visitors to actively discover new things in different ways and contextualize them with the environment.

Figure 4: The installation 'Us Hunters' allowed children to experience and learn about hunting strategies which were illustrated in a cave painting by using Full-Body actions.
Image reproduced from Kourakis et al., 2012

Finally, in the case of public spaces, specifically the spatial aspects of the environment can have an impact on human behaviour in interactive experiences (Hornecker and Buur, 2006; Márquez Segura et al., 2016). Thus, it can be beneficial to take advantage of users' environment awareness and draw their attention (un)consciously to specific physical characteristics of a place. For instance, the distribution of the physical interface into two separate spaces (e.g. floor and wall projects) can influence users' understanding of the experience and direct their attention to one space more than the other (Price et al., 2015). The use of portable devices allows extending and augmenting the digital information to various locations in the physical environment thanks to their pervasiveness (Mentis et al., 2014; Rennick-Egglestone et al., 2013). Hybrid environments can provide different layers to explore the experience. For instance, in the *Pure Land* project the separation of the experience into two different interfaces showed to be highly beneficial. Visitors used a tablet device to explore close-up views on the CAVE wall which triggered layered interpretations of the environment (Kenderdine et al., 2014). Also, the use of certain materials (e.g. tools, the nature of projecting surfaces, etc.) may influence user interaction and the quality of the experience (Woolford and Dunn, 2013). Moreover, social contexts (e.g. distance to other users or audience, open space vs. small separate room, etc.) can shape user performance (Freeman et al., 2013; Hornecker et al., 2014; Ray and van der Vaart, 2013).

In our research, I have taken these features into account by designing experiences which try to understand the educational context, the specific features and children's interactions within a public space and support their development of abilities and competences through complementary Full-Body interactive experiences. For instance, in Chapter 4, our team designed the project *Magical Movements* to provide children with a different way to create meaning around Shakespeare's play *A Midsummer Night's Dream* in a local cultural institution. The application was based on a Full-Body interactive storytelling experience in which children explored a magical forest and naturally interacted with virtual characters. In Chapter 5, we developed a system based on the World-as Support interaction paradigm for the cultural heritage site *Refugi 307*. For this project, we implemented activities that provided opportunities for perspective-taking, collaboration and "embodying" experiences of people during the Spanish civil war. On the other hand, designing for these features requires a holistic approach that includes the embodied perspective of the child experience. Therefore, the involvement of stakeholders in the definition of user experience, interpretations of interactions, spatial configurations and proxemics is essential for a design project. Suitable design methods are necessary to guarantee an effective collaboration between stakeholders, to guide synergies within intergenerational design teams and to elicit embodied aspects of the child experience.

3 RETHINKING DESIGN METHODS IN FULL-BODY INTERACTION

The wide range of educational experiences that have been developed shed light on the promising possibilities of Full-Body Interaction to scaffold learning in non-formal educational contexts. However, since Full-Body Interaction is still a young research field, in practice no solid conclusions can currently be made for the enhancement of children's cognition. Results of learning outcomes and comparative studies report a heterogeneous panorama (Malinverni and Pares, 2014). Often designers have difficulties justifying their design choices because results do not show evidence of significant learning gains (Carreras and Pares, 2009; Johnson-Glenberg et al., 2011; Kynigos et al., 2010; Lindgren and Moshell, 2011; Malinverni et al., 2012).

According to Antle (2013), these shortcomings are provoked by design strategies that are built on traditional technology-driven approaches focusing only on the functionality of this medium and neglecting sensorimotor aspects. In addition, Malinverni and Pares (2014) highlight the lack of user involvement during the design process in some of the Full-Body interactive experiences as reasons for these deficiencies. To address the shortcomings, current research increasingly involves stakeholders such as experts, teachers, and children in the design process (Grønbæk et al., 2007; Smith and Iversen, 2014). Nevertheless, I identified that there are still significant challenges in the design for this medium and, especially, in the involvement of children.

The first challenge is the need to make sure that Full-Body Interaction is an adequate type of interaction for the contents that wish to be communicated. This implies in our research that designers are aware of the specific features of embodiment and Full-Body Interaction. Consequently, it requires understanding the potential that physicality and spatiality provide to convey meaning (Van Leeuwen, 2004) and the benefits of activities based on using embodied resources to strengthen the sensorimotor, cognitive, and socio-emotional aspects of the user experience (Antle, 2013). Building on this conceptual framework, designers need to decide which concepts and contents may be naturally expressed through Full-Body Interaction.

The second challenge concerns the need to carefully align the design features and contents of the embodied activities with children's comprehension level (Malinverni and Pares, 2014). Recent studies claim that the design of embodied learning technologies for children often ignore the variability in their cognitive development and behaviours and the contextual variables that influence the situated use of interactive products for them (Antle, 2013). Therefore, it is important to research aspects related to children's development, understanding and worldviews such as previous knowledge, interests, and values.

The third challenge refers to the need to develop methods that facilitate designing for and with the body. Designing for embodiment involves understanding users' sensations of bodily, spatial and social aspects of the experience. When working with children, adult designers cannot rely on their own childhood experiences to inform technological designs (Yip et al., 2017), particularly not when designing for children's specific felt-experience during play. However, most co-design techniques in Child-Computer Interaction have been mainly developed for traditional WIMP (Windows, Icons, Menus, Pointer) interfaces and primarily aim to co-define content-related aspects. Consequently, these approaches run the risk of focusing on the cognitive aspects of the experience only and neglect sensorimotor and experiential counterparts. Furthermore, for most designers, the notion of Full-Body Interaction is still a new experience, which makes it difficult for them to imagine how Full-Body interactive experiences could work. As a consequence, they struggle to contribute with new ideas to the design process.

To better understand which opportunities are still in the development of design strategies in Full-Body Interaction, I now review the current research efforts in this field. This previous work forms the basis of my research on design strategies presented in this dissertation and shows how I have addressed the aforementioned challenges in Full-Body Interaction design.

3.1 Methods in HCI and Embodiment

The role of the body has become key in design ideation across a wide range of research fields in HCI such as tangible interaction, wearables, virtual, augmented and mixed realities, Internet of Things, etc. (Wilde et al., 2017). Several scholars use somatic practices such as Feldenkrais (Loke et al., 2013b), Mindfulness (Höök, 2010; Schiphorst, 2011), Dance (Loke and Robertson, 2010; Schiphorst et al., 2013) and Somaesthetics (Höök et al., 2016) to develop theories and practices around core mechanics and experiential artefacts. Françoise et al. (2017) stressed the importance of kinaesthetic awareness in embodied design to understand the subjective experience of the user. Alaoui (2015, 2012) focused on movement qualities during dance performance. Höök (2010) researched in an autoethnographic study the qualities of horseback riding. The aim was to provide knowledge for the design of digital technology that is grounded on fostering physical experience; e.g. rhythm, balance, link movement, and emotion. Loke and Robertson (2010) studied, in collaboration with trained dancers, the qualities of the act of falling. The goal of their research was to understand the first-person experience and external representations of the movement for the design of motion-sensing technologies. These strategies challenge the WIMP approach by focusing on deep embodied characteristics of human motion in design.

On the other hand, many researchers derive their practices from other performance methods. For instance, Iacucci et al. (2002) used situated and participative enactments of scenarios to envision new ideas. To do so, the participants were provided with a simple mock-up of a future device, called the "magical thing". They were encouraged to act out possible scenarios related to service and product features of the device. Also, a number of scholars have shown the benefits of bodystorming in the form of role-play (Iacucci et al., 2000; Márquez Segura et al., 2016; Simsarian, 2003), as an effective design and evaluation method in human-centred design workshops. The outcomes confirmed that this technique facilitates effective design solutions, helps end-users to reflect upon their own behaviour, and allows the users' views to be incorporated in the design process. Other scholars explored using small-scale representations of humans and design elements. For instance, Lerdahl et al. (2002) proposed a technique using objects that represent users and objects. The approach has shown to provide participants with a contextual perspective in the task design. Iacucci et al. (2000) have investigated the use of toy characters and role-play as objects for confronting challenges in the design of mobile services and devices. They reported that role games using toy characters, and contextual and environmental representations, provided a platform that helped in the process followed by players to envision and enact new mobile product concepts. In this context, Lim et al. (2006) argued that the material used in prototypes has a direct impact on users' perceptions. Based on this framework, different materials and objects have been explored to represent users in the design process, such as paper silhouettes and ludo tokens (Jakobsen, 2012), pieces of foam (Brandt and Grunnet, 2000), and Lego characters (Pedersen and Buur, 2000).

Other researchers focus on elicitation techniques for physical actions (Connell et al., 2013; Malinverni et al., 2016b). For instance, Connell et al. (2013) used the Wizard-of-Oz approach to elicit children's gestures for object manipulation, navigation-based tasks, and spatial interaction. Wobbrock et al. (2009) suggested that often, user-generated gestures are easier for the user to handle than those defined by the designers only. These physical actions must be essentially automatically executed and not rely on a conscious step-by-step learning of a pre-defined gesture grammar (Antle et al., 2009; Pietroni et al., 2012).

Despite the diversity and richness of embodied design methods, I observed that in the Child-Computer Interaction community only a few studies have explored such techniques and their benefits when working with children. Filling this gap, I investigated which techniques were used with the young target group, their design qualities, and to which degree they are adequate for Full-Body Interaction design.

3.2 Design Techniques to research Embodied Awareness with Children

In the Child-Computer Interaction community, some studies have explored the benefits of embodied design methods to generate ideas and understand the child experience with a prototype. For instance, Giaccardi et. al. (2012) employ a technique based on embodied narratives using a Polaroid PoGo instant digital camera to collect ideas. In the project StoryRooms (Alborzi et al., 2000) children and other members of the design team enacted possible sensors, actuators, and the interactive system by using their bodies, spotlights and other low-tech material. Hemmert et al. (2010) compared the benefits of embodied and disembodied sketching techniques to develop design ideas and show how a technological solution might work. However, these studies focused often only on the generation of ideas and did not explore how the definition of specific contents could be aligned with spatial aspects of the application and the qualities of the bodily experience.

Other researchers have explored tools and techniques to better understand how users experience and interpret their surrounding spaces. For instance, Malinverni et al. (2016a) presented an approach for the project Lands of Fog aimed to stimulate social initiation between autistic and neurotypical developed children. The participants were assigned to two different roles, namely: "explorer" and "detective". The children in the "explorer" role were invited to enter a floor projection of an early prototype of a virtual environment and to take pictures of those aspects that captured their interest. In contrast, children in the "detective" role overlooked the environment from an indoor balcony above the projection. They were encouraged to explain what the environment looked like, what the explorers were doing, and imagine new content and interaction possibilities for the prototype. This example point towards the benefits of being in the location for which the interactive experience is being designed. During the creation of content, children's physical presence offers them the opportunity to look around the place and be in direct contact with the environment.

Research efforts of related works to understand the bodily experience mainly focused on design sessions exploring preliminary prototypes. For instance, Höysniemi et al. (2005) used Wizard-of-Oz (WOz) prototyping to evaluate the intuitiveness of game mechanics. In this project, children could control an avatar which had to run, jump or swim. The authors used the WOz method to simulate the playing experience and asked the children to imagine and perform the physical actions that they thought were best to control the avatar. Landry et al. (2012) used a similar participatory WOz approach to analyse the types of movements that children would enact while playing in an Interactive Slide platform (Soler-Adillon, 2009). An important aim of this study was to draw children's attention towards the physical potential of the slide within an interactive experience and to help them incorporate a diversity of bodily actions in their interaction design ideas and adapt them to these specific qualities.

Building on the findings that led to the above needs in related work, I also considered that further research was required to address the challenges in Full-Body Interaction and deepen into the strategies that promote children's embodied awareness in early stages of the design process. In this sense, I have explored opportunities for co-design methods that provide a stronger focus on empowering children as design partners. I will now describe which co-design practices have been prominent in Child-Computer Interaction research and how they have influence my work.

3.3 Co-Design Practices in Child-Computer Interaction

The design of educational technology is still too often based on traditional predictive research methods that focus on investigating the impact of the final product on the user (Kynigos et al., 2010; Roberts et al., 2014; Yoshida et al., 2015). Arising from this tendency, Reeves (2008) requested to recognize the design of technology as a process and highlighted the benefits of design-based research as promising research method on innovation and education. In my case, I have used design-based research to build stronger connections between educational research and real-world problems. Therefore, designers, researchers, and practitioners need to be engaged in long-term collaborations (Reeves et al., 2004). User involvement in HCI research is grounded on theories derived from Cooperative Design (Bødker et al. 1988), Participatory Design (Schuler and Namioka, 1993; Simonsen and Robertson, 2013), Contextual Inquiry (Beyer and Holtzblatt 1998), Activity Theory (Nardi 1996) and situated action (Suchman 1987). However, there is no unified view of how user participation should take place (Muller and Druin, 2010). Each theoretical perspective implies different underlying values and assumptions about users' roles and agency in the design process. These differences shape designers' understanding of co-design and the strategies that they employ in their projects. For instance, Participatory Design has its origin in the Scandinavian countries. Its theoretical perspective and epistemology imply understanding Participatory Design as "a different way of knowing" (Frauenberger et al., 2015), i.e. designers need to evaluate the why and what they want to know about a product or experience. This process of knowing is directly connected to participation and practice. In the early stages of the emergence of Participatory Design, users were involved to understand their use of technologies and how these affected their lives (Iivari et al. 2015). Later, the participation of both adult and children users was extended to roles such as design partners, informants, and testers (Nesset and Large 2004). Each of these roles has its own function, depending on project resources, designers' philosophy and intentions. The role of "design partners" arises from the idea that every stakeholder contributes with their own expertise during the design process (Druin, 1999). This starting point breaks traditional power hierarchies between experts and users but also between adults and children. Building on this, Yip et al. (2017) proposed a framework that examines the complementary roles between children and adults. They argue that adult-child partnerships in design processes are often composed of four main dimensions: (1) *facilitation* that refers to how much support and mediation takes place between the adults and children; (2) *relationship building* that refers to how much social interaction occurs in the co-design group; (3) *design-by doing* that refers to moments when design activities (such as prototyping, evaluation, etc.) take place and (4) *elaboration* that refers to how adults and children exchange and generate ideas together. The framework shows that defining the roles of adult-child partners in co-design as "balanced" or "unbalanced" is not an easy task. Each dimension has moments when participants dominate the design task or work collaboratively, i.e. the role of each partner and the range of interactions between each other can vary between individuals, groups and even between sessions.

Other approaches situate their view of the child-designer relationship between the user-centred and participatory perspective, following an informant design model (Scaife and Rogers, 1998). During informant design, researchers tend to involve children at stages in which they consider children's input as appropriate and critical (Walsh et al., 2013). However, this approach has been criticized to take the risk that only designers make the core design decisions (Iversen and Dindler, 2013) and that children's participation may "become decoration" (Iivari et al., 2015). To prevent this hazard, Read et al. (2002) proposed the IBF Participatory Continuum Model that distinguishes between design experts (academics) and domain experts (children and/or adult helpers). According to Read et al. (2002), the participation of domain experts in the Informant Design model is mainly limited to informing the design experts without any further agency. In contrast, the balance design approach aims towards an equal partnership between design experts and domain experts, and in the facilitated design approach, the domain experts are supported by design experts to implement their ideas.

From the standpoint of the original Scandinavian approach, Participatory Design embraces three political ideals: democracy, emancipation, and skilfulness (Iversen and Dindler, 2013). In practice, these underlying values shape the dialogue between stakeholders and designers and the design methods that are employed. However, when designing with and for children, there has been no tradition for an explicit consideration of these core values to guide design projects (Yarosh et al., 2011). Therefore, recent design efforts in Child-Computer Interaction are increasingly focusing on how to improve the dialogue and *symbiotic agreement* (Dindler and Iversen, 2014) in design teams. For instance, Frauenberger et al. (2015) proposed a "tool-to-think-with" to enhance the notion of accountability and rigor in the design process. They specifically aim to encourage design practitioners to reflect upon the collaborative work in a design team, decision-making and outcomes in a transparent way. Building on this work, Van Mechelen et al. (2016) proposed the GLID method to increase internal rigor and transparency in co-design practices and go beyond the surface level of ideas by identifying participants' values embedded in design outcomes. Furthermore, Iversen at al. (2017) claimed that a commitment to political participatory design requires the definition of a new role for children in participatory practices – the role of protagonist. This role implies not only giving children a voice in the design process – or letting them act as co-designers, but also empowering them adequately to influence the technological development and critical reflection upon the role of technology in their lives. However, none of these co-design strategies has specifically focused on methods and techniques that allow participants to explore, reflect or incorporate the notion of the body in their design proposals.

In this thesis, I address the previously described challenges by exploring novel design strategies with and for children (Chapter 4) that particularly focus on promoting embodied awareness to give young designers a better understanding of the design features of Full-Body Interaction. I also concentrated on methods to research children's understanding and worldviews around the educational contexts to adequately inform the Full-Body Interaction design (Chapter 5). Finally, I summarize the results of the presented design strategies and present a co-design method for intergenerational teams in Full-Body Interaction (Chapter 6).

My work has been inspired by the Scandinavian Participatory Design tradition aimed to engage children in Full-Body Interaction Design by focusing on their skills, capacities, and expertise that they bring as design partners into the projects. I also tend to generate mutually learning opportunities between the design partners, specifically between children and adults. Our research team positions ourselves between the Participatory Design (Iversen and Dindler, 2013) and the Informant-Design approach (Scaife and Rogers, 1998). On the one hand, I argue that our approach is more inclusive than Informant-Design, i.e. in our projects I specifically focus on researching design strategies that empower children and provide them with tools to increase their participation in the design process. These tools allow us as adults to see design aspects through children's eyes and to understand their worldview in relation to a specific context. On the other hand, our research team pursues a pragmatic perspective on children's roles in the design. In other words, we give importance to the needs, interests, and expertise of all co-designers in the project. Thus, project requirements may determine in which design stages and how much each co-designer is involved.

4 EMBODIED AWARENESS IN PRACTICE FOR CO-DESIGN OF FULL-BODY INTERACTIVE EXPERIENCES

In this chapter, I first introduce a novel approach to describe the potential of embodied design techniques with children (Section 4.1). Subsequently, I present two case studies in which our research team researched the benefits of seven embodied co-design techniques based on the notions of *physical prototyping*, *puppet play* and *physical theatre practice* (Section 4.2 and 4.3). These techniques are built on approaches from related fields (see Chapter 3). We adapted them to our research context. Their general goal was to elicit children's embodied awareness and awaken body sensations that would help them to better grasp the design features required in Full-Body Interaction design. For this purpose, we explored the following techniques:

The *Bodystorming Technique* is based on acting out different design ideas for physical actions that simulate the users' experience with a prototype. The term *Bodystorming* was first used by Burns (1994) to stress the importance of "reenactivating" the studied environment through performance techniques where designers themselves become "actors". Enacting the scenario provides the designer with an intensive understanding of the behaviour and needs of users. In our research, the children were instructed to use their own bodies as central design instruments to enactment Full-Body movement and gestures.

The *Puppet-Based Design Technique* is based on puppet play and was used on the premise that puppets are a common toy in children's everyday practices. In this regard, Bühler (1930) highlighted that the manipulation of play objects creates the inner impulses to continue with play and, additionally, support identification. This observation suggests that puppets do not only motivate children to participate in an activity but they also often represent the children themselves and allow them to gain a greater understanding of themselves as well as the world around them. In our research, the children were instructed to use puppets as design instruments to present physical actions of human bodies.

The *Signifying Space Technique* is based on the documentation of the physical space through photos to gain insights into aspects that children find interesting and engaging in the environment (Dindler et al., 2010). The technique has also shown to encourage children to think of situated narratives and to support ideation (Giaccardi et al., 2012). We used the technique to draw children's attention towards the features of a physical environment. Furthermore, we aimed to research children's worldviews around the selected theatre play to be able to focus on a context that would motivate them to participate in the design process. To do so, we were interested to see which meanings the children would assign to different spaces in the studied location as representations for scenarios in the play.

The *Small-Scale Prototyping Technique* is based on the production of a representation of the physical space in a reduced size and its exploration with self-constructed puppets. Space modelling and scenario play in small-scale have shown to help designers understand the complexity of design features and relations in a spatial way (Lerdahl and Pedersen, 2002). In our research, we used the technique to strengthen children's notions of spatial awareness and train them to incorporate this knowledge in their design ideas and in relation to users' body actions.

The *Situated Performance Technique* is based on the principles of the theatre exercise called 'the machine of rhythms' (Boal, 1992). This exercise is commonly used as a group warm-up or exercise to prime children to work collaboratively. It begins with one actor performing simple, repetitive movements of their choice, related to the space and idea chosen by their team. The other actors join in the exercise one after the other with a complementary movement. In this study, we used the technique to compare the performance of the same activity at different locations that are either contextually linked with or decontextualized from the original environment of the interactive experience. In our research, we used this technique as an exercise for the children to translate their co-created ideas with small-scale prototypes into human full-body actions and through this awaken children's embodied awareness in relation to their own felt-experience, situatedness, and proxemics.

The *Body Shadows Technique* is a variation of bodystorming based on physical theatre practice (Reusch, 2005). In contrast to shadowgraphy and hand-shadow techniques, the children use their full bodies to create the visual effect of shadow images on a projection wall. From a pedagogical perspective, researchers have highlighted the benefits of body shadow play to foster the capability of corporeal expressiveness and body awareness (Pérez-Pueyo et al., 2010). López-Villar and Canales (2007) stressed that shadow theatre is particularly powerful in child education because it hardly requires previous training and specific movement skills. In our research, we used the technique to offer the children a different way of expressing their visual design ideas that they had previously developed in drawings.

The *Group Environment Technique* is also a variation of bodystorming based on physical theatre practice. It consists of the performance and improvisation of a sequence of physical actions in accordance with an imagined environment. Each actor performs individually in front of the audience and adds a new physical action to the sequence. The technique is usually used as a game to stimulate children's creativity (Casado, 2016). In our research, we used the technique to make children think about physical objects that could be part of the interactive experience and the interaction with them. The general goal of the exercise was to define interaction design ideas that could be implemented in the prototype of the Full-Body interactive experience.

This chapter contributes to the goal of my thesis to explore and develop design strategies that, on the one hand, empower children to contribute with their specific expertise and skills in Full-Body Interaction design. On the other hand, I focused on the emergence of core design qualities for interactive experiences in public space such as the awareness of one's own felt-experience in relation to other performers and the situated environment. Specifically, I present our approach based on nine *Embodied Design Thinking (EDT*) qualities to extrapolate and communicate the potential of these design strategies with children in Full-Body Interaction design. In Section 4.3, I highlight and discuss the findings of these studies and their implications for consecutive work in my dissertation.

4.1 Research Framework: Embodied Design Thinking qualities

To describe the potential of the design techniques presented in this thesis, I developed a novel approach of nine *Embodied Design Thinking* (EDT) qualities, *(1) play practice, (2) emergence, (3) contingency, (4) playful engagement, (5) social dialogue, (6) embodied memory; (7) cognitive scaffolds, (8) reflective imaginary, (9) embodied awareness and (10) relationality.*

On the one hand, these qualities are derived from theoretical views on *Design Thinking*. This concept was originally coined by Simon (1981) in his book "The Sciences of the Artificial" and extended to the discipline of design engineering by McKim (1973). Schön (1983) criticized Simon's view for being based on approaches to solving well-formed problems. Instead, he claimed that in real-world contexts designers often have to face "messy, problematic situations". Building on this assumption, Schön proposed a design approach grounding on practitioners' reflective practice. Several scholars followed his approach by incorporating reflective design practice in their work (Brown, 2008; Cross, 2001; Löwgren and Stolterman, 2004; Smith et al., 2015). Hence, from a contemporary perspective on this movement, design thinking skills that are relevant to this process are related to *empathy*, *collaboration, communication,* and *reflection*. The emergence of these skills constitutes a fundamental requirement of the qualities that I developed for our framework.

On the other hand, the EDT qualities address specific characteristics that are related to embodied experiences. To define these characteristics, our research group conducted several meetings in which we discussed related work on design methods and their relevance for our own research. Among others, we discussed a framework of five lenses in the design for Full-Body Interaction proposed by Malinverni (2016). These lenses are:

(1) *Expressiveness*: the extent to which embodiment is the privileged channel for understanding in the design context;

(2) *Embodied Consistency*: the extent to which the relation between sensorimotor experience, physical/digital environment and learning goals is consistent;

(3) *Relationality*: the extent to which the system offers conditions to co-construct meaning and collaborative learning;

(4) *Salience:* the extent to which the system promotes becoming immersed in the experience and focuses on what matters in the experience;

(5) *Reflexivity:* the extent to which the system offers space for reflection and observation.

During my time as PhD student, we conducted two design workshops with master students in which these reflective lenses were employed and discussed. Our group discussions and my experience during these workshops allowed me to research in which ways these reflective lenses could shape the requirements for the EDT qualities.

Specifically, the two lenses *Embodied Consistency* and *Relationality* describe aspects that are in general relevant to the design of interactive experiences in Full-Body Interaction. These lenses focus on the coherence of the design choices with the underlying theoretical framework in embodiment and with the specific features of Full-Body Interaction.

Complementary to this view, we were inspired by the following two approaches. Wilde's et al. (2017) pointed out that embodied design methods are often idiosyncratic and practitioners tackle with difficulties to replicate them and transfer the underlying knowledge to their own work. Thus, Wilde et al. proposed a framework consisting of evocative questions to describe the fundamental properties of embodied ideation methods. These questions focus on features related to their way of *disrupting* and *destabilizing* practitioners' performance of a task and their signification in terms of *emergence* and *embodiment* of an idea. For our definition, we specifically focused on the latter aspect, i.e. on the ideas that come up through using the technique and their unfolded embodied meaning.

Additionally, we inspired by the work of Hummel et van Dijks' (2015). The authors used phenomenology-inspired embodied theory to introduce seven design principles for developing embodied sensemaking technology as follows:

(1) *Social Situatedness:* understood as on-going achievement of social coordination in a setting, which includes social interrelations, roles, norms, culture and politics;

(2) *Cognitive Scaffolds:* understood as tools and ad hoc recruited props in the environment that enable people to solve problems in ways that would have been much more difficult using purely brain-internal computing;

(3) *Traces:* understood as selected objects, photos and scribbles made and their relative position in space form traces of conversations can come again the scaffolding elements for further conversations;

(4) *Interactive Imagery:* understood as percept arising from sketches that can facilitate and amplify the imaginary for new ideas;

(6) *Dialogical System:* understood as the face-to-face interaction that consists of co-ordination sustained by curiosity for the exchange of ideas based on people's empathy for each other;

(7) *1er Person Perspective:* understood as the point of view from which we perceive ourselves in relation to objects in the world;

(8) *Catalysing Engagement:* understood as tools as a means to physically connect strangers and thus enhance engagement, empathy and respect.

For our approach, Hummel and van Dijks' framework helped me to structure the EDT qualities and to include aspects that are specific for embodied design techniques such as the ways that evoke embodied awareness and scaffold conversations around the properties for the design with and for the body.

However, none of the frameworks described above had explored their feasibility for the evaluation of design techniques with children. Thus, they did not incorporate essential aspects of children's play practice that is necessary to engage them in design activities (Giaccardi et al., 2012). To address this gap, I found inspiration in Karoff's (2015) approach aimed to describe children's play practice. We employed this theoretical framework on children's play practice as a means to understand children's use of a design technique. Karoff's (2015) phenomenological view of play focuses on two dimensions: *play practices* and *play moods*. Karoff's work stems from a standpoint that understands play as a way for people to be together and to take part in the world. Her perspective incorporates ideas of theories from Heidegger's concept of 'Dasein' (1927), Bateson's term of 'framing' (2006) and ideas of the production of meaning in the interplay between repetition and distance (Schmidt, 2011). Karoff described *play practice* as "the concept of all the doing in the playing activity". In addition to this, she regarded *play moods* as "the particular concept of sense and feeling of being" during the play activity. According to her, each play practice evokes a specific mood. Furthermore, the researcher also highlights the relationship between practice, space, and emotion. In this regard, she identified four play practice patterns in relation to play: (*1) sliding for devotion, (2) shifting for intensity, (3) displaying for tension* and *(4) exceeding for euphoria* (Table 1). These categories build on children's rhythms of bodily and social doings related to the surrounding space. The play practices illustrate opposed ways of engagement within a play activity and differently shape children's use of body movement and spatial characteristics of the environment. As Karoff described "each of these practices relates to the materiality of space; the material shapes the play event". Furthermore, each way of engagement promotes different levels for the capacity and acceptance of mindful thinking, collaboration, and creativity.

Table 1. Overview of Karoff's (2015) four categories of play practices and moods

Play practice and mood	**Description**	**Examples**
Sliding for devotion:	a repetitive and continuous play practice with little changes and variations. Consequently, the children involved make little use of space. They are very focused on their actions (e.g. play with toys or drawing). As Karoff (2015) described 'we abandoned ourselves to our doings and were open to seeing where they (the toys) would lead us'. Since during this activity the body is often quiet or moving in slow motion, the practice evokes a feeling of flow and lightness. The play activity evokes very little conflict and discussions on the play practice. The play mood promotes an openness towards new practice and common agreement on actions that are meaningful for the play activity.	Doing a puzzle, drawing activities, playing with Lego bricks, etc.

Play practice and mood	Description	Examples
Shifting for intensity:	a repetitive play practice that over time creates unpredictable surprises for other players through rapid changes of movement speed, direction, and height (e.g. playing on a trampoline or being on a roller-coaster) which continues until the player has returned to a strong, predictable and repetitive rhythm. The practice evokes an openness towards the active production of space and often requires the physical movement of the whole body exploring spatial qualities. The children involved tend to have an intense feeling of being in that moment, an expectation for fast change and excitement for more.	A trip on a roller coaster, sliding down a hill, jumping on a trampoline, etc.
Displaying for tension:	a play practice with constant changes over time. Play situations involve any kind of informal performing (e.g. dancing, singing or dramatic (role) playing). The focus in displaying is showing off yourself, putting yourself on a "stage" and to let the others players look at, learn from or critique the performance. The goal is to show 'one's own style' and through this attract the attention of the audience. In contrast to the categories 'sliding' and 'shifting', the rhythm of this play practice has a weaker beat and is actively changing over time. The involved children produce space by performing to an audience and becoming the audience themselves (i.e. performing space becomes their stage). They have a high expectation for changing the play rhythm, i.e. if the change does not happen the players would respond with disappointment and abandon the activity.	Dancing, singing, taking photos of each other, or dramatic (role) playing, etc.
Exceeding for euphoria:	the play practice stands in contrast to any notion of repetition. It is characterized by 'an intense expectation of silliness' and to come up with new acts of going wild to maintain the euphoric mood. The children involved explore space and produce it in unpredictable ways. The children involved have a high expectation for changing the play rhythm. They only play with the idea of repetition to contrast it with changing it, often explosively. The practice promotes an open-minded attitude and capacity for creativity in constantly seeking new ways of expression and moving beyond earlier practice to generate 'play space to maintain exceeding play practices'.	Bizarre doll play, jack ash tricks and stories of frivolity, etc.

Starting from these perspectives, I organized the EDT qualities in different categories. My proposal was then presented and discussed in several research meetings and adjusted in accordance with the collaborative reflections of the research team. Based on this analysis, I defined nine EDT qualities, that are presented in the table below (Table 2).

Table 2. Overview of the origin and description of the Embodied Design Thinking qualities.

Inspiration from theoretical frameworks	**Our Embodied Design Thinking qualities approach**
Karoff's (2015)*four categories on children's play practice: sliding for devotion, shifting for intensity, displaying for tension and exceeding for euphoria*	*Play Practice* understood as children's rhythms of bodily and social doings related to the surrounding space
Wild et al.'s (2017) *framework for Embodied Ideation Methods; qualities: emergence and embodiment*	*Emergence* understood as the ideas that come up through using the technique and their unfolded embodied meaning
Malinverni's (2016) *framework on Full-Body Interaction design qualities; quality: Embodied Consistency*	*Contingency* understood as the capacity to think of ways how to meaningfully augment the sensorimotor experience through digital technology and to couple with the physical space
Hummel and van Dijks' (2015) *framework on design principles for developing embodied sensemaking technology: quality: Catalysing Engagement*	*Playful Engagement* understood as the capacity to stimulate children's interest and motivation to participate in an activity
General Design Thinking qualities (Brown, 2008; Cross, 2001; Löwgren and Stolterman, 2004; Smith et al., 2015)	*Social Dialogue* understood as the capacity to promote empathy and a collaborative attitude between the participants of a design activity
Hummel and van Dijks' (2015) *framework: quality: Traces* *Wild et al.'s* (2017) *framework; qualities: emergence and embodiment*	*Embodied Memory* understood as the produced design elements or body knowledge of people's lived sensations that leave traces in their understanding about design qualities of an interactive experience

Inspiration from theoretical frameworks	Our Embodied Design Thinking qualities approach
Hummel and van Dijks' (2015) *framework: qualities: Interactive Imagery and Cognitive Scaffolds*	*Reflective Imagery* understood as the capacity of a bodily activity to overcome purely brain-internal thinking and promote reflection from different perspectives on the design task to obtain a holistic view on the available possibilities of solutions
Hummel and van Dijks' (2015) *framework; quality: 1er Person Perspective*	*Embodied Awareness* understood as the internal understanding of people's own felt-experience and unfolding inspiration to think of design solutions that involve body movement and situated action in a physical environment
Malinverni's (2016) *framework on; quality: Relationality*	*Relationality* understood as the comprehension of relationships and dependencies of situated interactions between people and the world during the use of the technique

These EDT qualities were used for the descriptions of the design techniques presented in Section 4.2, 4.3 and Chapter 5.

4.2 Towards playful embodied design techniques: Bodystorming and Puppet-Based Design

In our research, we made two primary steps for exploring the possibilities of including embodied techniques to facilitate the design of Full-Body Interaction experiences. First, we conducted an exploratory study with 68 primary school children to research how a warm-up activity based on bodily exercises would engage them to think of games based on full-body movement. Despite this bodily-based warm-up, our results indicated that children tended to still describe interaction design ideas related to standard device-based gestures (such as point, click, drag and drop) as opposed to using full-body movements (Schaper et al., 2014). This case study has been part of my Master project titled "Combining participatory design methods and formative assessment strategies to improve design and evaluation of Full-Body Interaction Learning Environments" that I carried out in the Cognitive Media Technologies group in 2013 to 2014. Similar findings reported scholars in gesture elicitation studies that explored strategies to reduce legacy bias, related to participants' user experience with digital products such as touchscreens and WIMP systems (Hoff et al., 2016). The researchers used strategies based on an increased production of gestures and covert kinaesthetic priming. However, in this study both strategies showed a low effectiveness. This gap motivated me to deepen my research in embodied co-design techniques and methods for and with children.

Second, we conducted in the context of the Barcelona Design Week 2015 a design activity titled 'Sketching through the body: Full-Body Interaction Workshop' in which we included a warm-up activity based on the Feldenkrais method, usually used as therapy to improve body movement and psychological states. Scholars have also explored its potential as a design technique in the context of embodied interaction (Loke et al., 2013b). The goal of the workshop was to reflect upon new interaction design concepts and techniques for Full-Body Interaction experiences. The main focus was to explore different techniques to foster creativity and the own internal physical perception of body and space using somatic practices. For the purpose of our workshop, we invited the Feldenkrais expert Laura Illanes to conduct a practical exercise of this somatic practice at the beginning of the session. Eight Full-Body Interaction design researchers and practitioners from the region of Barcelona participated in the workshop. Our discussions revealed several possibilities and limitations to include embodied design techniques based on somatic practices in Full-Body Interaction. On the one hand, some participants pointed out that the Feldenkrais session had helped them to "think with their body" and they had made a first intent to bodystorm their ideas instead of using traditional brain-internal design activities (e.g. brainstorming with paper and pencil). Other participants felt uncomfortable to become bodily engaged during the workshop and recommended a larger training period in somatic practices to be able to benefit from their use. On the other hand, the participants expressed their doubts about the suitability of the Feldenkrais method in design workshops with children and suggested using more playful techniques, for instance, inspired by children's everyday play and physical theatre practice.

4.2.1 The EcoSystem project – A Case Study

Taking this recommendation into account and addressing the issues in the exploratory study described above, we decided to incorporate embodied awareness elicitation techniques aimed to foster children's felt-experience not only at the beginning of the workshops. Instead, we explored their possibilities as a means to design for Full-Body Interaction throughout the entire design process. Therefore, we particularly focused on tools and techniques that would evoke children's natural playfulness and allow them to unfold the full potential of their skills and capabilities. A very common child practice is *role-play*. A large body of literature (Wood, 2009) has discussed its pedagogical value involving benefits in stimulating children's skills in imagination, collaboration, empathy, and communication. Building on these benefits, we decided to explore and compare the opportunities of two types of role-play activities as co-design techniques for children.

The first technique was based on the notion of bodystorming, i.e. physically experiencing a scenario to derive new ideas. In this study, the children were instructed to use their own bodies as central design instruments to enactment Full-Body movement and gestures.

The second technique was derived from puppet play. For the *Puppet-Based Design Technique*, the children were instructed to use puppets as design instruments to present physical actions of human bodies.

4.2.2 Procedure

We compared the possibilities of the techniques *Bodystorming* and *Puppet-Based Design* in a case study within the *EcoSystem* project (Schaper et al., 2015). Therefore, we developed a mid-fidelity prototype using the Woz method (Höysniemi et al., 2005) that was controlled by a researcher. The goal of the Full-Body Interaction Learning Environment (FUBILE) was to improve children's global understanding of environmental issues related to air-pollution. The prototype was based on a 2x3 meter floor projection (Figure 5) and represented a virtual simulation of a semi-urban ecosystem. It was designed for groups of four children. The players were invited to experiment with the existing relationships between CO^2 emission and strategies for its reduction and absorption.

In the game, the children could play three different roles, namely:

1. Produce wind energy to replace the amount of energy produced by a steam power station and hence reduce air-pollution.

2. Grow plants and vegetables to facilitate CO^2 absorption and contribute consuming local produce.

3. Recycle organic waste and produce compost to increase the growth of plants and reduce waste incineration.

The air-pollution was visualized as a cloud covering the game ground. Thus, as the cloud increased, the amount of space available for playing decreased. To make the cloud decrease children needed to understand the relationship between the elements presented in the game and properly collaborate between them. Its prospective application domains for the Full-Body interactive experiences were among others science centres, museums or playgrounds for children in public spaces.

Figure 5: Children interacting with the floor projection of the EcoSystem

The study was conducted on two days with students between 10 to 12 years from a different local school than the previous case study (described in Section 4.1) and was carried out in the installations of our university. Before the study, we provided the parents with a consent form in which they were informed about and asked for their agreement on data collection and dissemination (A typical consent form is presented in the Annex of this thesis). Nine children (5 girls and 4 boys) used the *Bodystorming Technique* and eight children (6 girls and 2 boys) in the *Puppet-Based Design Technique*. In this case study, we focused on how the children would use the co-design techniques to represent their ideas and inform the design process.

The overall duration of each design session was 60 minutes. In the beginning, the children were briefed about the session structure and the topic. We also explained to them that they were contributing to the design improvements of our prototype (Figure 5). We introduced the children to the common goal and the three different interaction roles (wind power, plant growing and recycling) to be performed during the game by using *role cards* (Figure 6). These cards were designed in collaboration with experts in environmental issues and reported main information about the different elements and their reciprocal relations. The cards were read aloud by one child at a time.

The children were then randomly organized into groups of four or five members. Each playing session lasted for about six minutes.

Figure 6: Role cards with game instructions

In both conditions, the children played first one time with the FUBILE. The goal of this activity was to make the children familiar with the learning environment. The children were then instructed to propose ideas which would make the relationship between wind energy and energy consumption of the city as well as the relationship between plants and compost more explicit. Therefore, we showed them a diagram depicting the reciprocal relationships between the different elements (Figure 7.1). We asked them how these elements were related and wrote the correct answers on a white board. The children were then randomly divided into groups. For the *Puppet-Based Design Technique*, we gave them flexible anthropomorphic puppets (Figure 7.2). The children were encouraged to use them to enact interaction design ideas that would represent best the relationships previously mentioned. For the *Bodystorming Technique*, the children were asked to use their bodies to perform and enact those actions (Figure 7.3). For both techniques, we provided them additionally with a graphical layout of the floor projection. The goal was to promote discussions on how specific physical actions could better represent reciprocal relationships in the environment. After this, we provided them with cameras and asked them to record videos of their ideas. Finally, each group presented the design solutions to their peers and the researchers.

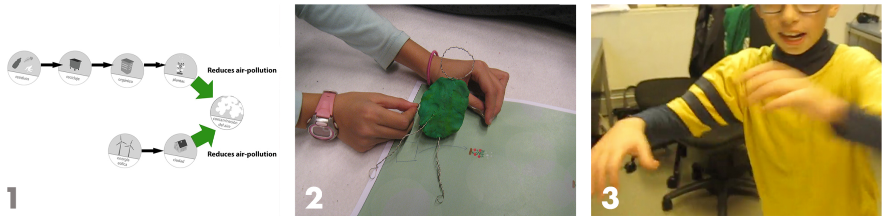

Figure 7: (1) A diagram depicting the reciprocal relationships between the different elements. (2) A student representing the relationship between plants and compost with the flexible anthropomorphic puppet. (3) Children use their own bodies to explore different ideas.

4.2.3 Data assessment and analysis

Children's behaviour during the design activity was video-recorded and two researchers made annotations. For this case study, we followed a Multimodal Analysis approach (Jewitt, 2013; Kress, 2010). One researcher reviewed all video footage of children's contributions and performed a narrative transcription of the groups focusing on children's verbal and embodied interaction, both individually and in relation to other children.

A total of four groups participated in the case study. Two groups were assigned to the *Bodystorming Technique* and the other two to the *Pupped-Based Design Technique*. We present our observations in the form of descriptive accounts and analysed them then according to the EDT qualities approach that I have described in Section 4.1. Details of the analysis can be found in Table 3.

4.2.4 Results

I will now present the results of our analysis of the techniques *Bodystorming and Puppet-Based Design*.

Bodystorming Technique

Group A was composed of four girls and one boy. The children started to discuss and role-play the different elements of the environment. The first idea was proposed by an enthusiastic girl moving her arms up and down saying: "I'm the windmill". She then called upon the other children in her group and encouraged them to play the role of the steam power station. Two other girls followed her suggestion and one piggy-backed on another while saying “We are the steam power station”. The group was very excited, laughing and proposing ideas. Another active girl proposed to a boy: “You can be the plant and I will water you”. During the design session, the researchers tried to direct children’s attention to the task by reminding them to think about how to enact the relationship between the different elements. Nevertheless, the group kept on repeating the same ideas. Thus, one researcher made the instructions more explicit and rephrased the question by asking about the relationship between the windmills and the city. Hence, one of the girls proposed: “Somebody should perform as the city and make a happy face when a windmill appears". The researcher then asked about the relationship between the plants and the compost. Another girl told the boy: "You are now the compost", and he obediently impersonated “being the compost”. During the group presentation, the children enacted the same scenarios. Our observations show that despite the explicit instructions, they did not propose any specific gesture for the relationships between the different elements.

Group B was composed of one girl and three boys. In general, the children were very excited and proposed many ideas. Especially, the girl in this group was very vivacious and delighted to take part in the activity. She started off by standing up and performing a dance "to be the windmill". Encouraged by her performance, a boy also stood up and proposed to raise the arms and move the fingers "to be a plant". Then, another boy suggested being the steam power station. The last child personified the compost by throwing himself onto the floor. None of the researchers intervened during the brainstorming activity. During the explanation children enacted the scenarios using their bodies to personify the different elements (windmills, plants, steam power station, compost). One researcher asked: “Have you thought about how you can represent the relationships between the game elements?”. This question referred to children’s design goals during the session, which consisted of making explicit gestures to convey the relationships between the game elements. The children realized then that they had not. This example depicts that the children had difficulties to focus on the task of enacting physical actions for the representation of reciprocal relationships between the design elements. This issue was not solved through the intervention and guidance of the research team.

The presented observations showed that the *Bodystorming Technique* promoted a play practice related to the view of 'displaying for tension'[1] (Karoff, 2015). In this sense, children's performance showed a high tendency for seeking novel "ways to express their own style" and being original. The children used their body as the primary design tool to think about physical actions. Hence, the technique allowed meaning to emerge directly from children's movements with their own body and in relation to bodily representations of their peers. The possibility of expressive movement explorations shaped children's understanding of the capacities and constraints of the body in motion (Wilde et al., 2017) and enabled new visions for collaborative interactions. The children produced space, often collaboratively, by performing to the audience and became the audience themselves (Karoff, 2015), i.e. they used the workshop room to put themselves on stage, receive and provide judgement on the performance. The design activity transformed into an informal competition between the children. As a consequence, they primarily focused on the goal of attracting the attention of the audience rather than solving the proposed design task. Instead of enacting possible interactions between players of the Full-Body interactive experience, they enjoyed personifying the game elements themselves. On the other hand, they imagined their own spatial arrangements for their performance without considering how the game elements were placed in the existing Full-Body interactive experience that they had explored at the beginning of the session.

[1] The main characteristics of the play practice 'displaying for tension' is related to the actions of staging space and the rhythm of swinging according to one's own style. The full description can be found in Section 4.1.

Puppet-Based Design Technique

Group C was composed of three girls and one boy. The children started by discussing how to enact wind energy. The boy was the first to propose an idea. He moved his arms in large circles to perform the representation of a windmill. At this point, a researcher gave them the following suggestion: "Think about how you could design the relationship between the energy produced by the windmill and the city". As a result, one of the girls took the initiative and proposed a verbal explanation which was accompanied by the bodily gestures of waving the arms. Another girl tried then to enact this idea with the puppet. She took a puppet and placed it on the printed version of the environment in the same position that had been physically performed by the first girl. The researcher now asked: "And how could you represent the relationship between the compost and the plants more explicitly?" One girl proposed connecting two different game elements. She took a puppet and bent its legs so as to place one foot on a plant and the other on the compost, hence connecting the two. Her schoolmate imitated the gesture with the puppets just as in the previous scenario. She enacted the open position of the legs. During their explanation, the group proposed the following three gestures as possible forms of making explicit relationships: (a) connecting the two elements by opening the arms and waving them, (b) connecting the two elements by opening their legs, and (c) connecting the two elements by making a human chain.

Group D was composed of three girls and one boy. The children were poorly engaged with the activity and presented some difficulties in starting with the activity. They did not work collaboratively or talk with each other; nor did they use the puppets. A researcher asked them about how to design the relationship between plants and compost. Two children took two puppets and made them hold hands to create a chain connecting the two game elements. Later they repeated the same action to connect the city with the windmill. During the presentations of the groups, this group explained their gesture proposal for creating a human chain.

The presented observations showed that the *Puppet-Based Design Technique* promoted a play practice related to the views of 'sliding for devotion' and 'displaying for tension'[2] (Karoff, 2015). In other words, the children constantly switched between two modes, using the puppets and then performing their interaction design ideas with their bodies. This continuity of shifting from one mode to the other mainly occurred when the children aimed to bodily explore their own ideas or those proposed by their peers. This repetitive play rhythm seemed to allow the children to obtain the feeling of "being in flow" (Karoff, 2015) and to focus on what matters in the design task. They proposed several bodily iconic representations based on both person-person and person-environment interactions for connecting different game elements (e.g. a straddle-vault or human-chain connecting one element with the other). For the enactments with the puppets, the children used only the space available on the small-scale layout of the Full-Body interactive experience and considered the existing spatial arrangements. However, this extract also spotlights certain drawbacks of the approach. On the one hand, the children who used only the puppets paid less attention to the enactment of realistic body actions and did not reflect upon certain body limitations such as its flexibility in relation to the enactment of an open position of the legs. On the other hand, we also observed a lower level of collaboration and playful engagement in the design activity in contrast to the children using the *Bodystorming Technique*.

[2] The main characteristics of the play practice 'sliding for devotion' is related to the actions of following space and following each other in the play rhythm. In contrast, 'displaying for tension' refers to the actions of staging space and swinging according to one's own style. The full description can be found in Section 4.1.

Table 3. Summary of the data analysis using the Embodied Design Thinking Qualities

EDT qualities	**Bodystorming**	**Pupped-Based Design**
Play practice	'displaying for tension': (1) unpredictable body movements according to own-style (2) the space is used as a stage to show off and to be judged by others (3) focus on attracting the attention of the audience	'sliding for devotion' and 'displaying for tension': (1) the body switched between being quiet and performing (2) using the puppets resulted in minimal spatial movements/ performing resulted in using the space as a stage to bodily represent the idea (3) "being in flow" and focus on the task
Emergence	bodily iconic representations for non-human actors (i.e. game elements)	bodily iconic representations for connecting different game elements
Contingency	difficulties to connect ideas to the physical constraints of the interface	used a small-scale representation model to explore ideas in relation to physical constraints of the interface and proxemics
Playful Engagement	enjoyed personifying different game elements	little enthusiasm using puppets
Social Dialogue	- group discussions - encouraged each other to represent interactions ideas	low collaborative attitude
Embodied Memory	felt-experience on physical actions	small-scale models of enactments
Reflective Imagery	- used body as a primary design tool to think about physical actions - experienced own proposals from an internal perspective	- used representation of body to think about physical actions - experimented with the body from an internal and exocentric perspective
Embodied Awareness	- helped them explore different physical actions - reflection upon felt-experience of enactments	- allowed them to project into the role of the user - puppets did not allow them to reflect upon certain body limitations
Relationality	- allowed them to explore person-person interactions related to collaborative representations and action-reaction mechanics - used the space only as "stage" to represent the performance - did not consider how the elements were arranged in the interface	- allowed them to explore person-person interactions related to the notion of "connections" within the small-scale representation of the interface

4.2.5 Discussion

We presented a case study in which we analysed the techniques *Bodystorming* and *Puppet-Based Design* based on the EDT qualities. Our findings indicated children's preference for full-body and iconic gestures (Anastopoulou et al., 2011; Markopoulos et al., 2008) and the potential of the techniques to overcome the tendency to describe only device-based gestures (such as point, click, drag and drop). Both techniques allowed grasping children's contribution on a multimodal level, i.e. verbally and through physical actions. This is particularly important because children often have difficulties making concrete verbal descriptions of physical actions (Kontra et al., 2012). We enabled children in our study to express their interaction ideas through both body and speech. Furthermore, the outcomes pointed towards the suitability of each technique in different design stages. The *Bodystorming Technique* could be useful to involve children in the ideation stage to imagine the general game requirements because its use tended to immerse children in the situation. The *Puppet-Based Design Technique* could then help them to reflect upon higher-level relations and explore concrete game features due to its potential to support children's capability to 'dive out' and provide them with a 'god's-eye view' (Ackermann, 1996) on their interaction design proposals. In this regard, Ackermann (1996) stressed how both the act of "diving in" and "stepping out" are equally needed to a reach deeper understanding.

4.2.6 Limitations and Future Work

Despite the potential of the *Puppet-Based Design Technique* for self-projection and switching between different viewpoints on the interaction, it did not allow the children to pay attention to the bodily feasibility of the proposed actions (e.g. how much a real person performing a straddle-vaulting can open his/her legs). However, projections of 'self-in-context' have shown to be a key to learning (Hatano and Inagaki, 1987). This drawback could be caused by the material used for the puppets and the fact that the researchers brought them 'ready to use' to the session. Future approaches should involve design activities that allow children to construct the puppets with the material of their choice. This may help them better understand their proprioception and felt-experience in relation to the position and coordination of the different body parts (Loke et al., 2013b).

On the other hand, the spatial arrangements of the activities limited children's possibility to think of a contingent augmentation (Malinverni, 2016) to couple their interaction design ideas with the available physical space of the Full-Body interactive experience. We assume that this shortcoming arose because the children worked only with a representation model rather than also with the original environment. In other words, we provided the children in both conditions with a printed version in small-scale of the floor projection (DIN A4 paper; Figure 7.2). However, only the children who used the puppets explored their proposals with the small-scale representation model. The children assigned to the *Bodystorming Technique* and those who switched from using the puppets to the body were "staging" space (Karoff, 2015) and imagining their own environment without considering the constraints of the existing Full-Body interactive experience. In this regard, Hornecker (2007) suggested how the properties of spatial representations influence interaction styles and variations of meaning. Particularly, the different scale references provide children with a context to better understand spaces (Bell, 2006). Developmental research has shown that the symbolic meaning of different scale models has an impact on children's judgements (DeLoache, 2004). Thus, to overcome these shortcomings, we suggest that working with both small- and large-scale models could allow children to explore their ideas from different perspectives. For instance, one possibility could be that children use the presented techniques in combination with the WoZ simulation of the Full-Body interactive experience.

Lastly, we observed that some children who used the *Puppet-Based Design Technique* showed a poor collaborative attitude during the design task. One reason could be that the activity of 'playing with dolls' was perceived as childish. Some children were already twelve years old and at the border to becoming teenagers. Another reason could be that the technique did not provide possibilities to 'break the ice' and motivate children in certain group constellations and in relation to personal relationships between them. These observations point towards the need for exploring of different ways how puppets and the notion of *self-projection* can be addressed and integrated into the design activities.

This case study has provided us with initial ideas on how to engage children through playful embodied design techniques as design partners. It highlighted relevant shortcomings in our approach that we aimed to address in further research. In the next section, I present a case study in which our research team explored different strategies of including design techniques inspired by physical theatre practice.

4.3 Exploring the potential of embodied design techniques based on physical theatre practice

After the playful employed design techniques employed in the *EcoSystem* project, we carried out a study was in collaboration with the local theatre school, *Plàudite Theatre – Espai d'Arts Escèniques*. The project started on the 400th anniversary of Shakespeare's death. At that time the theatre school was rehearsing for a special event devoted to Shakespeare's worldwide celebration. Thus, we decided to focus the design of an interactive Full-Body experience on Shakespeare's play *A Midsummer Night's Dream* that describes the unstable balance between the worlds of magic and reality. Action takes place in a mythical Athens of four teenagers and a group of amateur actors, their interactions with fairies in a magical forest, and the royal court.

Our decision to concentrate on physical theatre practice was motivated by research on children's pretended play as a means of improvisational, collaborative and conversational action (Sawyer, 2002). The goal of our project titled *Magical Movements* (Schaper and Pares, 2016) was twofold. On the one hand, we aimed to explore novel co-design techniques to elicit children's embodied awareness and allow them to incorporate the specific features of Full-Body Interaction into their design ideas. On the other hand, we expected to benefit from the expertise of theatre teachers in instructing bodily-based theatre exercises and obtain inspiration to develop embodied design techniques.

4.3.1 Magical Movements – A Case Study

The study was carried out during eight co-design workshop sessions over two years (2016-17); this temporal arrangement was given by the theatre afterschool activities to which we had to adapt our sessions. The director of the theatre school selected the children who participated in the case study. The children were between 10 and 12 years old at the beginning of the three-year project. Before the workshop, we organized an information session for parents and children to present ourselves and explain them the project goals and the procedure. We gave the parents then a consent form in which they were informed about and asked for their agreement on data collection and dissemination. (A typical consent form is presented in the Annex of this thesis). For the purpose of this study, we organized the sessions in five steps as follows:

1. *Defining Context*
   Researching children's interests and values within the theatre play.

2. *Awaking Embodied Awareness*
   Children's training in body and space awareness through playful co-design techniques and theatre exercises.

3. *Translating Embodied Experience*

- Brain- and bodystorming of concept ideas for visual design.
- Bodystorming of interaction design ideas.

4. *Prototyping the Embodied Experience*
   Integration of children's ideas for visual design and interaction design in a mid-fidelity prototype.

5. *Understanding the Embodied Experience*
   Evaluation of the alignment of the content and embodied experience.

The design stages of the case study are structured according to the outline mentioned above. In the remainder of this sub-chapter, I have numbered the design sessions in a chronological order and describe how they belong to each of the above design stages. Furthermore, each session is labelled with a description of the main goal of the employed techniques.

In this study, we focused on the exploration of five techniques, namely *Signifying Space, Small-Scale Prototyping, Situated Performance, Shadow Bodies,* and *Group Environment* derived from co-design approaches and physical theatre practice. The techniques were selected by one researcher and adapted by the theatre teachers according to the design goals of each session.

4.3.2 Data Collection and Analysis

Children's activity during the co-design sessions was video-recorded from two angles to capture their physical actions from different perspectives. Furthermore, manual contributions such as drawings and written descriptions (post-it notes, captions of drawings, etc.) were collected and digitized. For the evaluation stage, we also used an open-ended questionnaire and conducted individual interviews with the children to assess their feedback through different semiotic resources.

To understand children's contributions, we applied a multimodal analysis approach (Kress, 2010; Malinverni et al., 2016a; Sakr et al., 2016) to collect, analyse and interpret the multiple resources that children employed during the activities (e.g. body postures, verbal expressions, drawings, etc.). Multimodality is an interdisciplinary approach, derived from socio-semiotics, that aims to understand how people communicate and represent meaning in different forms (Price and Jewitt, 2013). In our study, the goal of the evaluation was to better understand children's meaning-making process in their co-design ideas by including their contributions from a perspective that went beyond the limits of verbal language. Due to children's limited linguistic competence, it is often difficult for them to express their thoughts and explain ideas adequately. During the evaluation, by focusing on different semiotic resources that are employed to construct meaning, we argue that this approach can provide us insights on how children express their interests, values, and worldviews through their body.

Video Analysis

One researcher first watched all the videos of the co-design sessions and interviews to obtain a general impression of the affordances of the employed technique, the proposed design ideas, and children's feedback. Subsequently, the researcher visualized the selected videos in slow-motion several times, with and without audio, to transcribe the resources employed by the children in a descriptive format. She also made screenshots of significant body actions and organized them in a storyboard format. The analysis was then performed during several meetings of the research team. In the videos, we focused on the following resources: body postures, facial expressions, gaze, verbal expressions, and social and spatial interactions.

Manual Contributions

The written contributions such as post-it notes and open-ended questionnaires were first transcribed. We then organized them in a tabular format in accordance with the descriptive transcription of the video-recordings. To analyse the drawings and photos, we followed a multimodal approach based on Kress' theoretical framework (Kress, 2010). This analysis was oriented towards interpreting which were the most important elements represented in the drawings. The outcomes were organized in the same way as the written descriptions. Finally, we analysed all material through a grounded theory approach. Therefore, by using the NVivo 11 software, we extrapolated results according to the key categories as follows. Co-design workshops: design ideas (content, visual, interaction), worldviews and values. Evaluation session: feedback about user experience, ideas for improvements (content, visual, interaction), performance of natural and instructed body actions, performance of alternative body actions. We finally performed a triangulation analysis of the multiple resources employed by the children to ground our interpretations of their contributions (Patton, 1990).

Design Techniques

For the analysis of the techniques, we used the same approach as presented in Chapter 4.2.3, i.e. first we identified the play practice that each technique evoked according to Karoff's (2015) view on play. We clustered then the data of the descriptive transcriptions and manual contributions for each technique into the EDT qualities (Table 4).

4.3.2 Procedure and results

Defining Context and Awaking Embodied Awareness

A total of 12 children (girls = 4; boys = 8) between 10 and 12 years old participated in this design stage. The workshop was coordinated with theatre classes that these children had signed up for as afterschool activities. Two theatre teachers were present during our co-design sessions and supported our research team during the activities. Each of the four sessions lasted for 90 minutes. During the first 45 minutes of every session, the teachers conducted warm-up exercises based on theatre practice (Boal, 1992). In the following 45 minutes, one researcher worked with the children on the design of the interactive experience. Our activities were built around Shakespeare's theatre play *A Midsummer Night's Dream* that was being rehearsed in the theatre workshops.

Session 1: Exploring and signifying space

On the first day, the workshop session focused on the exploration of children's interpretations and preferences towards the play. As mentioned above, the children had been previously introduced to it in the regular theatre classes. We first conducted an activity, titled *Signifying Space Technique*, in which the children defined their favourite scenes of the play and wrote them down on post-it notes. The children were then separated into groups of four and provided with one camera per group (Figure 8). The theatre teachers defined the group line up to balance them out. Each group member was asked to take one picture of a space in the theatre school in which these scenes could be enacted and to complete their mission in a time frame of ten minutes. The technique was aimed to draw children's attention towards physical space. Furthermore, we were interested to see which meanings the children would assign to different spaces. After the exercise, all groups came together and explained where they had taken the pictures at and why they had chosen those locations.

Figure 8: The children took pictures of locations in the theatre school that they imagined as potential scenarios for the play.

Our results showed that the *Signifying Space Technique* promoted a play practice related to the view of 'shifting for intensity'[3] (Karoff, 2015) i.e. the children were very excited about the opportunity to freely explore the theatre school and expanding their usual play space. Due to the time restriction, they moved quickly through the main entrance hall and actively looked for representative physical spaces of their favourite scenes. When something caught their interest, they suddenly stopped, discussed the possibilities of the space and took a picture. Their behaviour was directed by the expectation and time pressure to find something extraordinary to represent their idea.

These observations highlight that the *Signifying Space Technique* leveraged children's natural playfulness and motivated them to participate in the first session because we proposed an activity that allowed them to explore a familiar space in a usual way. Children's photos transformed into expressions of meaning-making about their personal interpretations of Shakespeare's play. Seven children took photos of locations in which they could imagine scenes that: occurred

[3] The main characteristics of the play practice 'shifting for intensity' is related to the actions of expanding space and changing the play rhythm now and then. The full description can be found in Section 4.1.

in the magical forest (the theatre school courtyard: 2 times); related to a magic potion (potted plant: 1 time; painting of a flower on the wall: 1 time); and related to dialogues of characters that belonged to the play (bench in the courtyard: 2 times; table as metaphor for enchanted human characters sleeping in a cottage: 1 time). Four other children chose spaces to represent scenes related to the royal court (stairs as the entrance of the palace: 2 times; two chairs as thrones of the royal couple: 1 time; courtyard as a metaphor for an amphitheatre for the performance of the royal wedding: 1 time). These examples depict that the technique forced the children to concentrate all senses on the sense of sight. Thus, the camera became a tool that helped the children fragment their view and focus on concrete aspects within the environment in relation to the scenes that they had selected of the theatre play. In a sense, the children explored a physical space that was familiar to them by adopting a different lens of perception. The photos produced were kept and incorporated in consecutive design activities of the next design session to support reflection and discussion upon the notion of spatial awareness. On the other hand, the activity required the children to collaboratively identify and negotiate the shared use of the camera. Thus, the device acted as a catalyst for collaborative and bodily exploration to express children's perceptions (Giaccardi et al., 2012).

Session 2: Definition of the core idea for the interactive experience

In the second session, we asked the children to classify their own contributions (post-it notes and photos) from the previous session into three main topics of the theatre play, namely: love, dream, and magic. Our choice to focus on these topics was motivated by studies that stressed the important role of these core concepts in Shakespeare's play *A Midsummer Night's Dream* (Calderwood, 1971). After that, we assigned each topic to a different corner of the workshop room. Through a playful bodily-based activity, we asked the children to position themselves in the space that represented the topic they liked the most. Through this activity, one child selected love, two children chose dreams and nine children decided on the topic magic. Due to these results, we decided together with the children to proceed with the theme magic as the core working topic for the design of the interactive experience. In the following activity, we asked the children to draw a picture showing what they understood under the selected topic "magic". Then, each child presented their drawing to the group and explained its meaning. The goal of this activity was to understand children's worldviews around the theme magic. Moreover, we expected that the drawings could be used later as visual references to define characters and scenarios for the interactive experience.

The content analysis showed that six children drew magical characters such as wizards (4 times), a cupid, a fairy, and a cat with superpowers (Figures 9.1 and 9.2). One child drew a human character that was under a spell. Three children drew magical accessories such as a spellbook (1 time) and a wand (3 times).

Figure 9: (1) A children's drawing showing a wizard; (2) A children's drawing showing the representation of a fairy with a magic wand.

Session 3: Using small-scale models of body and space

In the third session, we asked children to make flexible puppets (Schaper et al., 2015) with different materials such as straws, wooden sticks, wire, fabric in different colours, tape, glue, etc. After that, we showed them a map of the theatre school on which we had placed the photos they had taken in the first session. Each group selected one space and produced a small-scale model of it. They were instructed to represent only the main features of each space such as the spatial configuration of the walls and main elements such as columns, furniture, etc. We then asked them to tell us what concepts came to their minds when thinking about magic. The goal of the activity was also to allow children to express their worldviews through multiple resources. This activity was conceived to complement the outcomes of the drawings we obtained from the previous session. On the other hand, we aimed to draw children's attention again to spatial aspects of the environment. The purpose was to strengthen their notions of spatial awareness and to train them to incorporate this knowledge in their design ideas. We gave the children 20 minutes to think about how they would represent one of those concepts related to magic using their puppets and small-scale model. Finally, each team presented their proposals to the entire group.

Our results showed that the *Small-Scale Prototyping Technique* promoted a play practice related to the view of 'shifting for intensity'[4] (Karoff, 2015) i.e. the material models restricted the space of action and through this helped the children to concentrate on the remaining movement options (Hornecker, 2007) that were relevant to their situated narratives. Thus, the children mainly focused on the spatial exploration of the model and performed with the puppets repetitive movements such as the changing pace of spatial movements (i.e. walking, running, etc.) within the available space. The children expanded then their play space and created unpredictable surprises using their own bodies to emphasis extraordinary enactions of the puppets. For, instance the first group (girls = 1; boys = 3) chose the courtyard of the theatre school as location and designed a small-scale model of a vegetable garden with a scarecrow. A boy explained "Everybody is talking about their plants. But when they leave, the scarecrow suddenly becomes alive. It takes a wand and makes a giant appear. Then, the giant eats all the plants". Another child took then the puppet and made it jump into the vegetable garden. She enacted

[4] The main characteristics of the play practice 'shifting for intensity' is related to the actions of expanding space and changing the play rhythm now and then. The full description can be found in Section 4.1.

rapid movements in different directions with it, respecting the spatial limitations of the small-scale model. Instead, when she showed how the scarecrow performed magic, the girl used her own hand. She opened her fingers and made a throwing gesture. This shifting between exocentric to internal perspective allowed the girl to freely explore the body action in space (Schaper et al., 2015).

On the other hand, we observed that the models did not only materially embodied domain-specific constraints through physical affordances but also symbolically through cultural and perceived affordances that suggest particular actions (Norman, 1999). For instance, in the second group (girls = 3; boys = 1), the children chose the entrance area (Figure 10) of the theatre school for their small-scale model. In their proposal, they enacted a scene at the royal court between a narcissistic princess and her parents. The princess demanded to possess all the jewellery in the world, to become the most beautiful girl in the universe. Her father disliked her attitude and asked his royal wizard to transform her into a flower. This example points towards children's worldviews in relation to the notion of arrogance and intergenerational power relations. This extract also shows that the models transformed into "thinking props" (Hornecker, 2007) to understand movement mechanics and relationships between person-person and person-space interaction.

Figure 10: The children enacted their worldviews of magic through puppets and small-scale prototypes.

Furthermore, the children tended to imagine situated narratives that contrasted with the habitual use of the original physical spaces in the theatre school. Thus, the representative models were far from identical with the original spaces and filtered the quality of children's interest of the physical space in relation to their situated narratives (Lim et al., 2006). For instance, the third group (boys = 4) selected the kitchen area in the lounge room. In the group presentation, the children enacted a scene in a restaurant for wizards. They represented a male and a female wizard, which were the guests, and a waiter. The male wizard ordered "frog with explosive sauce". The waiter made a mistake and brought salamanders. A long discussion followed on the differences between magical frogs and salamanders. This extract shows that the prototypes were primarily designed with the purpose to reveal the imaginary world behind the situated narratives. Hence, the children used the physical characteristics of the kitchen to co-create scenarios and as a context in which an 'as-if world' was lived, explored or possible changes were prototyped (Giaccardi et al., 2012).

Finally, the examples point towards children's playful engagement with the activity. The possibility of crafting the models and puppets seemed to help them to take ownership for them and motivated the children to actively participate in the ideation of the situated narratives.

Session 4: Strengthening Embodied Awareness

In the fourth session, the children were introduced to the *Situated Performance Technique*, a bodystorming activity based on the physical theatre exercise 'the machine of rhythms' (Boal, 1992). The exercise was done in the previously defined teams. It started with one child performing simple, repetitive movements of their choice, related to the space and idea chosen by their team. The other children in the same team joined in the exercise one after the other with a complementary movement. In this exercise, we particularly encouraged the children to incorporate the space which surrounded their bodies in their proposals. Therefore, we asked each group to perform the exercise first in the workshop room, then in the location that they had represented in their small-scale models, and finally again in a group presentation in the workshop room.

Our results showed that the *Situated Performance Technique* promoted a play practice related to the view of 'sliding for devotion'[5] (Karoff, 2015) i.e. the children followed each other's actions in a continuous and repetitive rhythm. The physical sensation of rhythmic movement immersed the children in the activity. This sensation evoked a desire for little changes and exploration of movement variations in the shared space. For instance, the group that represented the magical vegetable garden positioned themselves in the workshop room in a circle and individually enacted different gardening actions such as hoeing, harvesting, and watering (Figure 11.1). These were physical actions that they had previously practiced with the puppets and the small-scale models (Session 3). During the exercise, they slowed down the movement pace so that it became clearer to them how various parts of the body interacted in the process of moving. The

[5] The main characteristics of the play practice 'sliding for devotion' is related to the actions of following space and following each other in the play rhythm. The full description can be found in Section 4.1.

movement repetitions helped the children to keep the focus on the sensorial experience in relation to the situated environment to compare sensations that they had imagined using the *Small-Scale Prototyping Technique* in the previous session.

In contrast, when we asked them to repeat these actions in the original space (Figure 11.2) that they had represented in the small-scale model, we observed that the children reinterpreted the use of space through the performance of the same gardening actions but this time in relation to their surroundings. For instance, one child incorporated real plants from the courtyard in his performance. Thus, being situated in the real environment and placed in dialogue with other forces and real objects seemed to help them to explore questions of person-space interactions (e.g. timing, coordinating and synchronizing body actions) and led to understanding related to the capacity and constraints of the body actions. Performing these actions with their own bodies allowed them to explore and become aware of the effects of inter-relating movements between the different actors from an internal point of view. Furthermore, the children paid attention to the movement to other actors sharing the same action space. Back in the workshop room, we observed a significant evolution from the children's first ideas to the final proposal with respect to the quality of actions that incorporated bodily and spatial features of the environment. In this sense, the previous experience had provided them with a body memory (Loke et al., 2013b) and gave them physical strategies to replicate them without having the real physical environment present.

Figure 11: (1) The children enacted different gardening actions such as hoeing, harvesting and watering in the workshop room; (2) in the courtyard of the theatre school.

We made similar observations in the other two groups. In the second group that represented the royal court, the children first individually role-played the specific body actions of each character without paying attention to the enactments of their peers in the workshop room. They stood far away from each other and did not form any logical spatial configuration. At the specific location, the group performed similar body actions. However, this time they managed to focus on the relation of their body actions with each other. The two girls who represented the royal couple sat on chairs and looked at the girl who performed the princess. One girl (the king) made a pointing gesture towards "the princess". In response to this action, a boy (the wizard) stood in front of "the princess" and performed body action as if he were casting a spell on her. The girl representing the princess then dropped to the floor. During the final presentation, back in the workshop room, the children used two chairs for the performance of the narrative and tried to recreate the same action-reaction mechanics between each other as in the in-situ rehearsal. In the third group that represented the restaurant for wizards, the children performed different cooking actions, such as stirring and chopping gestures, in the workshop room. When in the specific previously chosen location, the children incorporated to their performance a bar that was located in the lounge room. Furthermore, two children proposed to perform the collaborative task of washing and arranging the food. These examples highlight that the technique helped the children to reflect upon interaction possibilities between each other and the space in which they performed their proposals. In this regard, Hornecker (2004) showed how physical actions are often tied to the physical surrounding, using it as a frame of reference and integrating elements of the environment into the expression. Furthermore, it seemed that during the performance a common point of view was created through the shared experience between the actors (Buchenau and Suri, 2000).

Translating the Embodied Experience

A total of 12 children (girls = 5; boys = 7) participated in this design stage. Two boys and one girl from the previous set of sessions had left the course, while three new students (two girls; one boy) had joined the group. The three workshop sessions were carried out ten months after the previous design stage because we were required to adapt to the yearly time schedule of the theatre school; i.e. only the first trimester of the academic year was available for special afterschool activities. The rest of the year, the students rehearsed for the annual theatre play that was presented at the end of the course. Again, each session lasted for 90 minutes. They were organized in the same manner as the previous year, i.e. 45 minutes of warm-up exercises that were instructed by the theatre teacher and 45 minutes of co-design workshop facilitated by one researcher.

Session 5: Defining concrete scenarios for the interactive experience

As mentioned above, we had three new students in the group and the last co-design session in which the others had participated, had been carried out several months ago. Thus, to re-connect the participants with the topic of the co-design workshop, we asked the former members to briefly summarize the plot of Shakespeare's play *A Midsummer Night's Dream*. After that, the children randomly divided themselves into groups of four members. We asked them to draw a scenario of the play, which was related to the theme they had chosen in the past; i.e. magic. We then asked the children to enact the content of their drawing using the *Body Shadows Technique.* The technique consisted of representing their visual idea for the scenario through their body shadows. Before the session, we had setup a white projection wall using a blanket and spotlights to light it from behind. We turned off the main lights of the room and gave each group five minutes to bodystorm their group performance. After that, each group performed a final proposal in front of the rest and explained their idea.

Figure 12: (1) A group representing the magical forest and a giant's hand picking apples; (2) a group presenting a royal court with a king and his servants; (3) a group representing the magical forest and characters moving in a vertical and horizontal direction.

Our results showed that the *Body Shadows Technique* promoted a play practice related to the view of 'sliding for devotion'[6] (Karoff, 2015) i.e. after finishing the drawings, the children discussed briefly how to represent their ideas with body shadows and positioned then quickly with a pre-defined composition in mind on the stage. Their bodies moved very slowly and hardly expanded their subjective space to make small adjustments in their postures. The children started to play with different distances to the light source to increase or minimize the size of their shadows. For instance, the first group (girls = 2; boys = 2) represented in their drawing several trees, human figures walking in different directions and a small hand (Figure 12.1).

[6] The main characteristics of the play practice 'sliding for devotion' is related to the actions of followings space and following each other in the play rhythm. The full description can be found in Section 4.1.

During the *Body Shadows Technique*, the group incorporated a large sized hand in their scenario by acting with a real one right in front of the light source. After the enactment, the performing group explained that it represented a giant picking apples from a tree. The third group (boys = 4) also played with their shadows in relation to the possibilities of scale. In their drawing, they represented the magical forest with two characters climbing up the trees (Figure 12.2). During the *Body Shadows Technique*, they represented one of the trees by the shadow of a human torso in large scale.

Another strategy using the technique was to superimpose the shadows of different body parts. The second group (girls = 3; boys = 1) drew a scenario about the royal court. During the *Body Shadow Technique*, two children used their hands placed against their heads to simulate pointed ears as if they were fairies. This observation suggests that their performance went beyond a simple movement exercise and allowed them to dive into the realm of an imaginative and aesthetic experience. Furthermore, switching roles between performers and the audience, gave everyone the chance to compare different ways of performing shadows and apply this knowledge to their own enactments. Lastly, the possibility to experience and control subtle changes in posture, playing with the nuances of movement changes allowed them also to focus on aspects related to their felt-experience and interactions between their bodies.

On the other hand, the technique allowed the children to represent the ideas of their drawings in a different modal resource and thus to extend and refine them. Particularly, the drawing of the second group (Figure 12.3) showed to be overloaded with symbols and small details. They represented a throne with a crown, a king, a flower, several characters standing upside down and symbols of dollar notes. During the *Body Shadows Technique*, the children managed to focus only on the core meanings represented in the picture. The first child sat down cross-legged to represent a throne and the second child, representing the king, took place on her lap. Both children held their arms horizontally to the floor. The third child kneeled on the left and used his arms to blow air towards the “king’s face”. The fourth child kneeled in front of the “king” and enacted holding a recipient with food. The “king” enacted eating food served by the fourth child. The other two children stood next to them and enacted being magic characters. This example suggests how children’s drawings can represent abstract meanings that are difficult to grasp for adults. However, pretend play and ‘acting-as-if’ of physical actions can be more intuitive for children (Hemmert et al., 2010) and reveal meanings behind other disembodied representation formats.

Session 6: Defining objects for the interactive environment

In the seventh session, we asked the children first to draw one object each that they imagined could exist in the interactive experience. We proposed then to use the *Group-Environment Technique* to bodily represent actions related to these elements. To contextualize this, we first established with the children that they had to imagine they were in a magical forest. This activity was performed individually and the actions of each player were built upon the previous participants. That is, one player “entered” the forest, created one object (e.g. a flower), and left the forest area. Each subsequent player that entered had to use the object that the previous players had created, and then introduce one new element. Hence, the last player to enter had to remember everything that was used before him/her. Once the final player had performed, the group reflected upon the scenario and each player explained what object they had created and why.

Our results showed that the *Group Environment Technique* promoted a play practice related to the view of ‘displaying for tension’[7] (Karoff, 2015) i.e. the children reinterpreted the physical actions that their peers had performed and enacted them according to their ‘own style’. Furthermore, dealing with the tension and expectation to perform an

[7] The main characteristics of the play practice ‘displaying for tension’ is related to the actions of staging space and a rhythm of swinging according to one’s own style. The full description can be found in Section 4.1.

original idea, each child proposed a complementary action for the unfolding interaction sequence. On the other hand, although the children perform individually, the technique required a strong involvement of the entire group. The children in the audience had to pay attention to the performance of their peers and build their new action upon the previous ideas. Thus, the children first imagined their own performance and felt-experience while they observed the enactments of their peers on stage. Exploring differentiated movement in the imagination can give the actor time to think it through and become familiar with it (Loke et al., 2013b). In this regard, Dalsgaard and Hansen (2008) described the 'notion of the performative spectator and the spectating performer', i.e. this idea entails the assumption that 'perception' is also performative. In other words, people in the same situation always tend to shape each other's behaviour in body expression and social interaction (Goffman, 1971).

Figure 13: A girl enacting bird watching with binoculars using Group Environment Technique.

The objects and characters that were created by the children for the interactive experience were the following: a bush, a mountain, a potion, a flight of stairs, a pair of binoculars, a mobile phone, a stone with a face, a dog, an apple, and a "strange animal". The last child that went through the *Group Environment Technique* performed the sequence as follows. The child entered the magical forest through a gate. She walked around and took an apple from the tree. She bit the apple and spat it out. She then looked around, saw the strange animal and started to chase it. With her hands, she then formed the shape of a pair of binoculars (Figure 13) and walked around the room to watch birds. She stumbled over the potion bottle and dropped it on the floor. She picked it up, drank from the bottle and dropped it on the floor again. She pretended that someone was calling him dialing number 112 on the mobile phone. She then crawled on the floor until she found an antidote for the potion. She drank the antidote and stood up immediately. She found a stone, picked it up, and put it down again. She then climbed up the stairs to get to the top of the mountain. When she arrived at the top, she lied down on her back and looked up to the sky. She looked at her watch and stood up. Finally, she left the forest through the gate. Particularly, the sequence related to the magical potion was exaggerated and used by several children as an opportunity to express themselves in original ways. The children played with power postures, dramatic effects of enchantments and expressions of desperation for reaching the mobile phone. Each time a child entered on the stage meaning was enacted and renegotiated through their situated and social interactions with each other. This example also highlights how the children explored not only the available space on stage during their performance. Instead, they made also use of ‘imaginary space’ e.g. when climbing up the stairs, they pretended moving in a vertical direction up to the mountain without having a physical reference present.

Prototyping the Embodied Experience

Due to time limitations and availability of the theatre school, the concretion of the core ideas and prototype were done by the research team and five game designers. One researcher summarized these ideas in a written game scenario. One of the game designers developed visual concept ideas of the virtual characters. Another designer created a “look and feel” video of the interactive experience. The interactive experience is not a videogame, since it is meant to be a complementary installation that collaborates in the acting of the group of children in front of an audience. However, the children understand it very much like a videogame they play while they are acting. Because of this, we will call the children "players" in the description below.

Narrative of the Full-Body Interaction experience

The narrative of the interactive experiences described the scenario of a magical forest that was inhabited by different magical creatures (Figure 14) and objects: a fairy, a wizard, an explosive frog, a living stone called Rocky, a giant picking an apple tree, the fairy king and his servants, an eight-legged fox, a cupid, and four human characters. The cupid and the fox enchant the other creatures with drops of a magical potion. The mission of the players during the experience is to save the forest creatures by finding the antidote against the potion spell. In return, the fairy promises to show the players how to find the exit of the forest, which is impossible to find without her help. The ideas were taken from content proposals and observations on children's worldviews that were embodied in their physical contributions and enactments across the sessions.

Figure 14: Visual design concepts of the magical creatures.

Physical Interface

We decided to develop a prototype using a wall projected Full-Body interactive experience (Figures 15.1 and 15.2). This decision was motivated by the fact that several of the proposed physical actions (e.g. bird-watching, climbing up a mountain, etc.) required providing the player with a vertical viewpoint on the magical forest.

Figure 15: Two examples of game screens. (1) Apple tree in the magical forest; (2) dialogue of the fairy.

Co-Designed Body actions

In accordance with the narrative, we decided to integrate in the prototype the following gestures based on children's proposals for body actions that they had mainly developed mainly using the *Group Environment Technique*: open the gate of the forest; walk through the forest; shape hands as a pair of binoculars to look for a specific bird; dial number 112 on a mobile phone to get in touch with a virtual character; lift a stone to discover the antidote; climb up the stairs to reach a mountain.

Session 7: Feedback on narrative and visual design

Twelve months after the co-design sessions, we presented our proposal for the narrative and visual design to the 12 children (girls = 7; boys = 5) and the theatre teachers. Eight children had been co-designer partners in the first two design stages. Four girls were new incorporations in the theatre course. The researcher took notes about their feedback and potential improvements as they tried the interactive experience.

The results showed that the children were in general satisfied with the outcomes of their ideas. They made only a few suggestions to improve the visual design of the characters. For instance, they highlighted that the clothing was too modern. In their opinion, the characters needed to wear clothes from the Middle Ages. They also stressed that we did not consider their idea of a giant's hand picking apples (*Body Shadows Technique*, Session 5). Finally, they proposed to increase the level of difficulty of the game. They suggested that the player had to find a password to obtain the antidote that was protected by a guardian.

Understanding the Embodied Experience

Session 8: Evaluation of the alignment of the content and embodied experience

In the last session of the workshop, we aimed to evaluate children's user experience with a preliminary version of the interactive experience using a mid-fidelity prototype. This session was held one month after presenting the game scenario and lasted for around three hours. The same children from the previous session participated in this final one. Two researchers led the session and introduced themselves to the children. The first researcher controlled the prototype. The other researcher gave instructions and organized the activities with the children. She explained the procedure of the evaluation session to the children. They were told that they would play in teams of two during five minutes. The experience was projected on a 2.5 by 2-meter screen (Figure 16). The purpose of the analysis was to understand if the prototype would evoke the same interaction design ideas that we had defined as co-designed body actions and if the children would naturally perform them. This approach was grounded on research on guessability methodology as a means of deriving child-defined gestures (Connell et al., 2013). Guessability studies usually involve a Wizard-of-Oz approach (Markopoulos et al., 2008) in which gestures are elicited from non-technical users. To do so, the effect of a gesture is first illustrated by an unseen technical 'wizard' manipulating the system. The users are then asked to perform its corresponding feedback (Wobbrock et al., 2009). Interactive experiences usually provide "natural" or "intuitive" interaction when they offer users ways to "uncover, explore and develop the meaning of the use of the technology as it is incorporated into practice" (Dourish, 2001).

Figure 16: Two children interacting with the mid-fidelity prototype. The situation shows the moment when they find the antidote under a stone.

In this study, the researcher informed the children that the system worked in a WOz method to simulate the game mechanics. The prototype was based on an interactive presentation with short video clips of consecutive scenarios that were executed by a researcher according to children's interactions. The dialogues of the characters were presented as written texts. The children were encouraged to read them out loud. After the playing session, the children were asked to fill out an open-ended questionnaire to evaluate their user experience using the proposed body actions. In addition, the researcher interviewed the children individually to clarify answers which were only briefly explained and to give the children the opportunity to extend on their reflections. The aim of this assessment was to understand children subjective experience with the prototype and allow them to propose improvements and alternatives to the presented body actions.

Analysing the video recordings of children's interaction with the prototype showed that most of the proposed body actions were naturally (74 times) used and similar to children's proposals during the workshop sessions. Thirty times the researcher had to indicate the children which body action was expected from them. In addition, the children performed alternative actions for opening the portal (pushing action with both hands: 3 times), using the phone (dialing directly in the palm of hand: 2 times) and walking (jumping: 1 time;

riding a bicycle: 1). Furthermore, they performed 11 times in total body actions that we did not expect, i.e. touching a virtual character (7 times), gestures of performing magic (2 times) and imitating movements of virtual characters (2 times). In the questionnaires and during the interviews, the children reported the need for improvements on body actions such as walking (7 times), using the binoculars (4 times), climbing up the stairs (5 times). However, these improvements were mainly caused by the prototype level we used during the session, i.e. their improvements concerned mainly the synchronization of the animations and game mechanics with real-time actions (e.g. the speed of climbing up the stairs) and visual effects (zoom-in effect when using the binoculars).

4.3.3 Discussion

We have presented an interactive storytelling creation workshop in collaboration with a theatre school class and analysed the embodied co-design techniques used during these sessions. By unpacking the potential of techniques using the EDT qualities, we can observe that their primary goal was to elicit children's embodied awareness and train them to incorporate Full-Body Interaction features in their design proposal. However, they have also shown to reveal children's worldviews in relation to the proposed context and have led to the definition of content, visual and interaction ideas for a first design iteration of a Full-Body interactive experience. Furthermore, our study has depicted that the sequence and combination of the first four techniques titled *Signifying Space*, *Small-Scale Prototyping*, *Situated Performance* and *Body Shadows* were very useful to awaken children's felt-experience. Instead, the *Group Environment Technique* allowed the children to think of concrete interaction design ideas for the prototype. Nevertheless, we argue that this case study scarcely scratches the surface of this topic and provides only a brief snapshot of the potential that the present techniques can provide for co-design with children in Full-Body Interaction. We will now highlight shortcomings that we observed during the employment of the techniques and provide suggestions to unfold their full potential.

Table 4. Summary of the data analysis using the Embodied Design Thinking qualities of the five theatre-inspired embodied design techniques

EDT Qualities	Signifying Space	Small-Scale Prototyping	Situated Performance	Shadow Bodies	Group-Environment
Play practice	'shifting for intensity': - changed movement rhythm between free exploration to concrete observation in a specific place - excitement due to the possibility to expand usual play space and time pressure of the activity	'shifting for intensity': - focused on the spatial exploration of the model - performed with the puppets repetitive movements - created unpredictabl e movements to emphasis extraordinary enactments of the puppets	'sliding for devotion' - followed each other's actions in a continues and repetitive rhythm - desire for exploration of movement variations in the shared space	'sliding for devotion' - positioned with a pre-defined composition in mind on the stage - expanded their subjective space to make small adjustments in their postures	'displaying for tension' - reinterpreted the physical actions that their peers had performed - tension to propose a complement ary action for the unfolding interaction sequence
Emergence	- attention towards specific features of the physical space - triggered associations with context - allowed them to assign meaning to the photos taken	situated narratives that contrasted with the habitual use of the original physical spaces	body actions that are coupled with the constraints of a physical environment	representatio n of visual ideas in a different modal resource	improvisatio n of body actions in relation to imaginary objects
Contingency	- understand the notion of embodied meaning embedded in spatial features of an environment	- connect embodied meaning to the ideation of physical actions	- understand the impact of scale on body actions and movement mechanics	- understand the notion of simplifying interaction design ideas to express a core meaning	- understand how a social environment shapes the enactments of a performer

EDT Qualities	Signifying Space	Small-Scale Prototyping	Situated Performance	Shadow Bodies	Group-Environment
Playful Engagement	- explored a familiar space in a usual way to their everyday practice	- motivated by crafting process of the models - puppets allowed them to take ownership of their artefacts	- physical sensation of rhythmic movement	- collaborative performance - dived into the realm of an imaginative and aesthetic experience	- offered them the opportunity to express themselves in original ways - showed off in front of their peers
Social Dialogue	- needed to collaboratively negotiate the shared use of the camera	- allowed them to collaboratively create narratives around the proposed topic	- needed to coordinate and synchronize their movements to maintain the rhythm of repetition and continuity	- needed to coordinate and synchronize their movements to represent visual enactments	- audience had to pay attention to the performance of their peers - built their new action upon the previous ideas
Embodied Memory	- photos support reflection and discussion upon spatial awareness	- models embodied domain-specific constraints	- felt-experience on physical strategies to replicate performance without having the real physical environment present	- photos support refinements for visual ideas	- video clips of interaction design ideas that are represented in the narrative

EDT Qualities	Signifying Space	Small-Scale Prototyping	Situated Performance	Shadow Bodies	Group-Environment
Reflective Imagery	- the device acted as a catalyst for exploring the environment	- shifted between exocentric to internal perspective allowed them to freely explore the body action in space	- compared aspects related to the notion of scale - compared abstract enactments with concrete body actions in a situated environment - movement repetitions helped them to keep the focus on the sensorial experiences in relation to proxemics	switching roles gave them the chance to compare different ways of performing shadows	- forced them to be focused – encouraged them to seek for possibilities to imitate, refine and variate their enactments - allowed them to embody meaning in their enactments
Embodied Awareness	- forced them to concentrate all senses on the sense of sight	- the models helped them to concentrate on the remaining movement options	- help them to explore questions of person-space interactions - led to understandin g related to the constraints of the body actions	- played with different distances to explore the size of their shadows - created specific visual effects through superimposit ion of body parts - experienced subtle movement changes	- audience became familiar with movements through imagination

EDT Qualities	Signifying Space	Small-Scale Prototyping	Situated Performance	Shadow Bodies	Group-Environment
Relationality	- adopted a different lens of perception on the physical space	- models transformed into "thinking props" to understand person-person and person-space interactions	- allowed them to explore and become aware of the effects of inter-relating movements from an internal point of view	- played with notion connectedness to represent still images of interaction idea	- renegotiated body expressions in accordance with their peers

4.3.4 Limitations and Future Work

First, using the *Small-Scale Prototyping Technique*, we observed that the act of crafting and personalizing the puppets engaged the children stronger in the activity than in our study presented in Chapter 4.1. However, among the wide range of available material, the children chose only static elements such as wooden sticks to represent body parts that are required for natural human movement (e.g. for arms and legs). Thus, due to this limitation, the children used the puppets only to represent simple spatial movements and variations in pace. In further research, we believed it is important to provide the children with clear instructions on how to construct the puppets and make sure that they are feasible for the representation of a wide range of interactions. In this regard, Jakobsen (2012) offered a practical guide pointing towards three aspects that designers in the crafting process of miniature user representation need to consider. One aspect is its *manageability* which refers to the scale of the puppet in relation to the represented environment and its visibility to all participants of the activity. Another aspect is its *appropriation* which refers to the use of material and size that support modification by the participants. A final aspect is its *human appearance* which refers to how the facial expression, clothes and body form of the puppet supports those of the represented user in a specific design situation.

Second, we used the *Body Shadows Technique* to represent only still images of children's ideas. However, we argue that the enactment of movement could allow the children to embed a deeper meaning into the elements of the shadow performance and reveal concrete interaction design ideas. For instance, the actors could play with slowing down or increasing the speed of the movements to evoke specific body sensations and draw the audience's attention to different types of visual effects. In this regard, the work of the theatre artist Fabrizio Montecchi (2015) can provide interesting accounts in modelling contemporary shadow practice. Montecchi does not only focus on the performance of the human body. The actors in his plays tend to use accessories (e.g. masks representing animals) to modify the appearance of their shadows. On the other hand, future work should also use the effect of superimposing not only with different body parts but also between different actors to explore social interaction and qualities of shared interaction space.

Third, further research is needed to understand how these techniques inform designers about digital augmentations that are adequate for the interactive experience. Our first prototype was based on a wall projection because it was a 'fast and easy' solution to evaluate the appropriateness of our design ideas with the project goals. However, in another design iteration, we envision a prototype that particularly supports sensations that could be perceived as magical and immerse the children in the experiences. For instance, exploring design ideas based on augmented and mixed reality experiences (Carreras and Sora, 2009; Lindgren and Moshell, 2011; Müller et al., 2016) could offer different layers of reality and, hence, transmit better the core idea of Shakespeare's play *A Midsummer Night's Dream*. On the other hand, we believe that it is necessary to explore possibilities to enrich the collaborative experience of the prototype. In our first iteration, we observed that the children who participated in the same session tended to perform simultaneously the similar actions. Novel approaches should research possibilities to promote social interaction and complementary actions between the players (Carreras and Pares, 2009; Malinverni and Pares, 2015; Rogers et al., 2004; Verhaegh et al., 2006).

Four, our results indicated that the instruction of theatre-inspired techniques required the help of professional teachers. This finding suggests that at least one designer in the team needs to be sufficiently trained in the technique used during the workshop. Another solution would be to incorporate practitioners (e.g. physical theatre, somatic practices, etc.) in the design team and accompany those design stages which requiring their expertise.

Five, these techniques have only been tested with children that are trained in physical theatre exercise. These children are used to express themselves with their bodies. Future work needs to explore these co-design techniques in different contexts to evaluate their naturalness for children in general.

Lastly, the techniques proposed in this study were employed in the context of interactive storytelling. Nevertheless, we argue that they are also suitable for their application in other design contexts in Full-Body Interaction design. On the one hand, the techniques support general design thinking skills such as empathy, collaboration, communication and reflection (Brown, 2008; Cross, 2001; Löwgren and Stolterman, 2004; Smith et al., 2015) that are relevant to real-world design contexts. On the other hand, the use of the techniques draws children's attention towards core features in Full-Body Interaction such as embodied meaning-making, the impact of situatedness and social awareness on one's own felt-experience, interrelational aspects between interactions of people and the world, etc. Finally, the techniques have been particularly developed for its use with child designers. Our results highlight how the presented techniques actively engaged children, supported their skills and enabled them to provide valuable contributions to the design of a Full-Body interactive experience. In this sense, the proposed embodied co-design techniques may be inspirational in a broader context for researchers, designers and practitioners of related fields in the Child-Computer Interaction community.

4.4 Reflection upon the contributions of embodied awareness in the co-design process

In this chapter, I have presented seven embodied co-design techniques, namely *Bodystorming, Puppet-Based Design, Signifying Space, Small-Scale Prototyping, Situated Performance, Body Shadows, and Group Environment* aimed to elicit children's embodied awareness and enable them to understand their body and space as a mediator of ideas and meaning-making processes. Our results indicated that the proposed techniques allowed the children to 'design for the senses from the senses' (Wilde et al., 2017), i.e. opened them opportunities to explore multisensory qualities and complex interrelations of a design context.

Furthermore, the techniques offered also the children with little experience in physical performance, an opportunity to appreciate ways of sensing and moving that connect with their play practice and natural engagement with the world. In that sense, the techniques make visible new opportunities to involve children in the design process. We posit that such dynamics are necessary when designing for the body with children, as young users differently engage with the world and are 'aware' of other aspects in it than an adult.

Finally, my research in this dissertation has brought together three different modes of enquiry into HCI: embodied interaction, play practice and theatre performance. I have discovered a profound connection between these three modes in the way that they frame experience, shift attention and invite for reflection. I believe that continuing with this line of enquiry could allow extrapolating more detailed insights into the potential of the presented embodied co-design techniques. One possibility could be to explore their appropriateness in different design stages both as embodied awareness elicitation technique, as well as in ideation of concrete interaction design proposals.

5 LEARNING THROUGH SITUATEDNESS, EMBODIED EXPLORATION AND DIGITAL AUGMENTATION

In this chapter, I extended my research by exploring the impact of "body practices in space" (de Certeau, 1988) on user experience. This research has been carried out in the context of a cultural heritage (CH) location, namely *Refugi 307*. The site is one of the 1,402 bomb shelters that were built by civilians during the Spanish Civil War in Barcelona in order to protect the population. Today, the shelter is part of the Barcelona History Museum (MUHBA), which provides guided visits through the cultural heritage site to schools and the general public. The aim of the project was to design a Virtual Heritage (VH) experience to complement the current educational experience of the guided visit. Within this research, I specifically focused on how children's felt-experience was shaped by their own situated interactions and embodied practices of others from the past (Bonini, 2008; Flynn, 2013) that used the shelter during the war. From this research emerged a set of learning strategies to complement educational experiences in public spaces.

The first part of the chapter is structured according to the chronological order of the case study. The study was divided into four design stages: (1) defining the requirements for the project (Section 5.1); (2) design and evaluation of a preliminary prototype to understand the possibilities of the implemented design strategies for an educational Virtual Heritage experience (Section 5.2); (3) design improvements (Section 5.3) and evaluation of a second iteration of the prototype to understand the full potential of the educational approach, and hence complement the guided visit of the archaeological site (Section 5.4). Subsequently, Section 5.5 begins with a summary of the co-design techniques that have been used during this project. We analysed three of these techniques (*Dwelling Space Technique, Pictionary Technique, and Reflective Drawing*

Technique) using the *Embodied Design Thinking* qualities (Section 4.1) to illustrate their potential in the design of Full-Body interactive experiences in a non-formal learning context. We close this chapter by presenting a critical analysis of the design process in which we specifically reflect upon children's role as co-designers and power relations between the stakeholders of the project (Section 5.6).

5.1 Refugi 307 – The design of a Virtual Heritage experience

Schaper, M.-M., Santos, M., Malinverni, L. Zerbini Berro, J. and Pares, N. (2018). Learning about the past through situatedness, embodied exploration and digital augmentation of cultural heritage sites. *International Journal of Human-Computer Studies.* 114, 36-50.
Link: http://hdl.handle.net/10230/35513

Digital technologies are transforming traditional learning experiences in museums. In history education, interactive media can provide meaningful and enriching supports for learners to experience exhibitions and Cultural Heritage (CH) sites. They often entail a meaning-making process that actively engages visitors in multiple acts of recollection, interpretation, and communication (Giaccardi and Iversen, 2010). In this regard, they contribute to better understanding of historical events, preserving cultural values inherited from the past, and making them available for today's generations.

The role of emerging technologies in the communication of these contents is increasingly at the forefront of the concerns of museums and other heritage custodians. Novel approaches tend to experiment with different augmented modes of visitor experience such as immersion, responsive environments and haptics (Flynn, 2013). In this landscape, learning experiences for spaces such as archaeological sites have become an important field for the design of virtual cultural heritage (Ciolfi and McLoughlin, 2012). They physically differ from enclosed museum spaces in a number of ways. First, they allow visitors to approach the archaeological remains and artefacts. Furthermore, being situated in a specific space offers visitors a multisensory and immersive experience that cannot be provided by exhibitions in museum buildings that often display only representations or simulations of the cultural heritage site. The onsite felt-experience entails, for instance, visual and auditory stimuli, sensations evoked by physical contact with the historical site, and so on.

Although these types of learning spaces allow visitors to become immersed in the site, the learning experiences provided often end up being little engaging. On the one hand, these sites are often empty of objects which are probably housed in museum buildings. Hence, they often display only the remains of architectural structures. Moreover, the weather can become an important barrier for having fixed information displays and even more so for audiovisual or interactive material. Finally, notwithstanding the weather, archaeological sites often have the disadvantage that they cannot be altered by the addition of physical objects or multimedia installations (Petrelli et al., 2013). Hence, many archaeological sites provide guided tours or audio-guides to direct visitors' attention towards aspects that are not necessarily obvious without further explanation. However, there are still aspects of historical contexts and people's practices in past cultures that are difficult for visitors to imagine (Ciolfi and McLoughlin, 2012). Therefore, there is a growing trend in the exploration of the benefits of ubiquitous advanced computing interfaces (Gena et al., 2016) and context-aware digital augmentation to provide additional information layers within the physical world (Price et al., 2015). In this context, relevant contributions can be found in augmented reality (AR) solutions. In particular, mobile projective AR can help to overcome challenges at CH sites in relation to climatic conditions (e.g. humidity, rain or extreme heat) and heritage conservation policies (e.g. restrictions of modifications to the physical space) because they do not require the permanent installation of the hardware on-site. Furthermore, they allow visitors to explore site-specific CH locations in meaningful ways and use navigation, exploration, gesture to generate meaning around historical contexts. Building on these benefits, we are exploring the potential of a recently defined interaction paradigm named the World-as-Support (WaS) (Malinverni et al., 2017). This paradigm offers augmentation by projecting the digital content onto the physical world surrounding the user via a handheld device. The portable system, based on a handheld device with computer vision capabilities and a pico-projector, potentially recognizes the surrounding physical world dynamically (i.e. topography, objects, users, gesture and motion) and projects the context-aware digital information directly onto it. In this paradigm, the world becomes not only a physical support for the projected content but also, and most importantly, it is a support for meaning-making due to its intrinsic and situated value and meaning. This allows interaction designers to take advantage of the benefits of Reality-Based Interaction, such as environment awareness and social awareness (Jacob et al., 2008). Moreover, as users act within the physical world to interact with digital content (Dourish, 2001) it affords the potential of bodily and tangible interaction such as tangible manipulation (Horn, 2018), spatial interaction, and embodied facilitation (Hornecker and Buur, 2006). In previous studies, we compared the affordances of the WaS and the WoW paradigms in the context of a storytelling application for primary school students. Our results provided strong evidence of the potential of the WaS paradigm to support environment awareness, context awareness and shape the social relationships between users (Malinverni et al., 2017).

In the context of interaction design for archaeological sites, we argue that using the WaS paradigm can provide the following advantages:

(1) It addresses the risks of students focusing only on the on-screen experience. Consequently, it provides a balanced addition of historical contents without disrupting the immersive experience of being on-site.

(2) It provides opportunities for multi-user engagement and collaborative tasks that can help reveal new layers of the experience and promote different viewpoints of historical events. Thus, this shared action of meaning construction allows students to obtain a holistic understanding of the historical context.

(3) Furthermore, this paradigm allows students to interact with digital content directly on the physical world. This provides an interesting potential related to the user's body and its relation with the world and objects, such as: spatial interaction, tangible interaction and embodied interaction. Thus, the embodiment of actions of people from past civilizations offers students emotional anchors and strengthens their empathy.

Nevertheless, the benefits of this new paradigm need to be carefully evaluated. Research in educational technologies has shown that the affordances of a specific medium can affect learning (Nathan and Robinson, 2001). Furthermore, when designing educational experiences for children, technological solutions and content must be aligned with the specific capabilities and interests of each target group. Therefore, the main purpose of this research is to design an educational experience based on the WaS paradigm for primary school students in a CH context and to evaluate its benefits for in-situ learning. We present the design process of a functional prototype based on this paradigm in the context of a bomb shelter built by civilians during the Spanish Civil War. The cultural heritage site called *Refugi 307* is currently part of the Barcelona History Museum.

5.1.1 Procedure

Consulting Experts

We first conducted a contextual inquiry (Wixon et al., 1990) and co-design study with (10 to 12-year-old) students and teachers of a local primary school and a team of experts of the history museum. During the co-design approach, the researchers involved the stakeholders in stages for which they considered their input as appropriate and critical (Walsh et al., 2013). The aim was to analyse the requirements for the design of the educational experience based on the WaS interaction paradigm and include different needs and viewpoints of the stakeholders involved. Subsequently, we implemented a set of educational activities in a first prototype. We then evaluated students' educational experience of the prototype during a guided visit of the shelter. Before the study, we provided the parents of the students with a content form in which they were informed about and asked for their agreement on data collection and dissemination (A typical consent form is presented in the Annex of this thesis). We will now outline the methodology applied in each design stage.

To analyse the educational goals of the project, semi-structured interviews were conducted with four teachers and three guides at the facilities of the shelter after a visit (in addition, one teacher sent us her answers by e-mail). The questions focused on how they perceived children's reactions during the guided visit, which interests students had in the historical context of the Spanish Civil War, and how the visit could be improved. At the time of the study, the general visit with school classes was structured around a session of 90 minutes. The group was accompanied by the explanations of a guide who stimulated students' participation and reflections through questions about the historical context. At the end of the visit, a short video was projected in the shelter that showed general scenes of civilians in Barcelona during the Spanish Civil War.

Furthermore, before the study, three project meetings were carried out at the premises of the museum in which three researchers, a curator, a museum educator, and a visit guide discussed topics concerning the goals of the study, the proposed technological approach and the procedure of the activities. The team from the museum was specialized in CH and educational museum activities. Our design team contributed with an interdisciplinary background in design and engineering.

Involving children

An important requirement for our project was to involve the viewpoints of all stakeholders. Specifically, we aimed to give students, the main users of the educational experience, a voice in the design process. Hence, we observed their behaviours in-situ during the visit. Furthermore, to obtain additional information about their understanding and interests, we explored different strategies of on-site and classroom activities that could elicit contributions by the children.

Session 1

The first session lasted 120 minutes (a 90-minute guided visit to the shelter and 30 minutes of workshop activities). In total 40 children (girls = 18, boys = 22; mean age = 10.78 years) of two school classes participated in this design stage. We accompanied two guided visits of 20 students each. The students in each group were peers from the same school class. Both visits followed the same procedure. The children were first introduced to the historical context using posters placed at the entrance area, just outside the shelter. They depicted historical photographic material and written descriptions (Figure 17.1). The content was then contextualized within the shelter. The guide drew the children's attention towards specific physical features and illustrated content through anecdotes and historical facts about the Spanish Civil War and contemporary events (Figure 17.2). Two researchers accompanied each guided visit. The two sessions were video recorded. Furthermore, the researchers took notes about (1) students' interactions within the space (movements, gestures, body posture), (2) facial and verbal expressions, and (3) social interactions with each other, with teachers and with the guide at the different locations in the shelter.

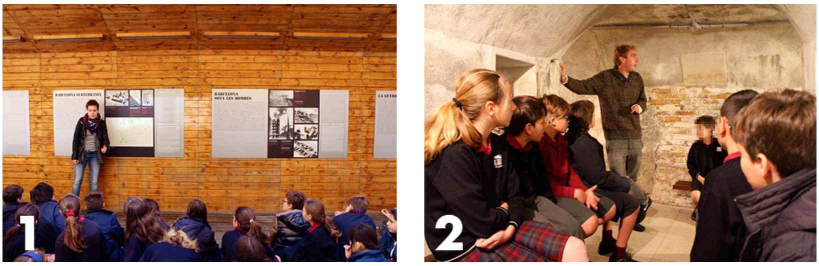

Figure 17. The procedure of the guided visit was divided into two parts: (1) an introduction outside the shelter, (2) a visit inside the shelter to contextualize the learning contents.

After the visit to the shelter, we divided the children into groups of 3-4 members and instructed them in the *Dwelling Space Technique* (a detailed analysis of the technique is presented in Section 5.5.1) based on the KidReporter technique (Bekker et al., 2003). Each group was asked to record a 2-minute video interview about the place in the shelter they found most interesting. To do so, we handed out a map of the shelter to each group and gave them 10 minutes to choose one place of interest and brainstorm how they would perform their recorded interview. The aim of this activity was to give the students an opportunity to revisit locations of their interest that they had previously seen during the guided visit. We assumed that being in-situ would help them to better reflect upon the historical context and connect with civilians' feelings during the Spanish Civil War.

After this activity, we handed out a questionnaire to each child aimed at assessing their interests, their understanding of the site, and their preferences in accordance with the learning topic and the physical space. The questionnaires were based on open-ended questions that the children were asked to complete such as "What I most dis/liked about the visit was … because…", "The place I found most interesting was … because…", "I was disappointed by…"

Session 2

The second session was held at school a few days later and lasted 180 minutes. The children were again divided into the same groups. Using the maps of the shelter, they were asked to indicate and explain the places that they remembered and that had most caught their attention (Figure 18.1). The children wrote their comments on post-it notes and placed them on the map. We interviewed each group individually during the activity. The purpose of this activity was to provide the children with a link between the content of the visit and subsequent activities during the workshop session. We assumed that the activity would draw the children's attention particularly towards the physical features of the shelter and its relation to the historical context. This was important for the design of the educational experience based on WaS because one of its main features consisted of the possibility to interact with digital content onto the physical world.

Then, each child received a different storyboard template (Figure 18.2) that was already filled out with a first scene. Each template depicted a different drawing made by children during the Spanish Civil War. They were encouraged to think of a narrative related to the drawing presented. The aim of this activity was to evaluate the children's interests and personal values in relation to the historical context, and how they contextualized it in their present time.

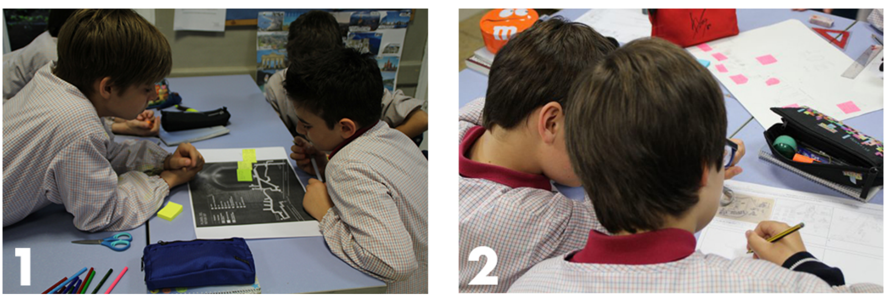

Figure 18. (1) The children received a copy of a pre-defined map of the shelter and used post-it notes to indicate their interests. (2) They then received a storyboard template and were invited to think of a narrative related to the drawing presented.

Subsequently, the children were instructed to re-design the guided visit according to their own interests and preferences. To introduce this activity we presented them, for the first time, with the concept of the WaS system based on a Philips PicoPix PPX3414 pico-projector. Subsequently, we asked the children to help us to redesign the educational experience of the guided visit to the shelter. The children were then asked to produce low-tech prototypes using "projection flashlights"; i.e. drawings on transparent plastic, placed at one end of a paper roll with a flashlight inside to simulate the projection capabilities of a handheld device based on a pico-projector (Figure 19). During all workshop activities, we recorded short video interviews with each group while they were working on their proposals. Finally, each group gave a 5-minute presentation to explain and enact their ideas with the low-tech prototype.

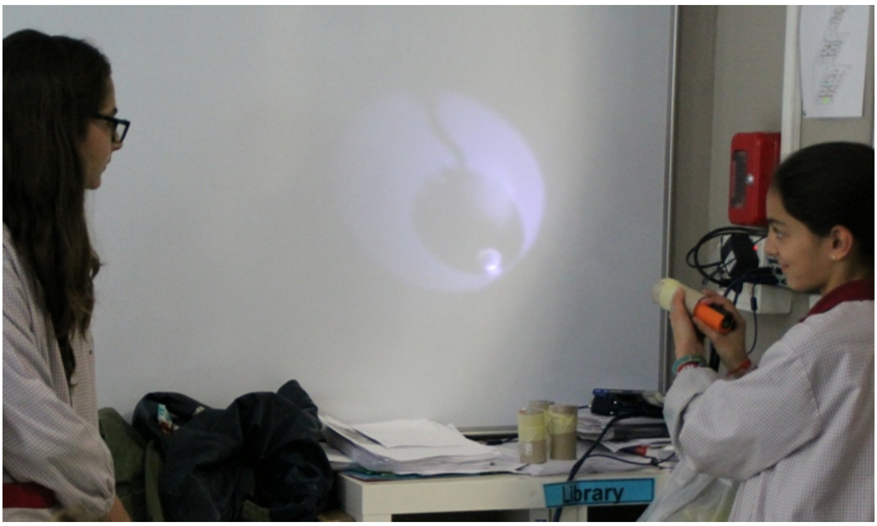

Figure 19. The children presented their ideas for the improvements for the guided visit using a low-tech prototype.

5.1.2 Analysis of requirements

The aim of this design stage was to conduct an analysis of the current learning experiences on-site and to compare them with the educational goals defined by experts. This comparison allowed us to identify aspects of the existing guided visit that could be complemented using the WaS paradigm. To analyse the children's contributions, we applied a multimodal analysis approach (Kress, 2010; Malinverni et al., 2016a; Sakr et al., 2016; Van Mechelen et al., 2016) to collect, analyse and interpret the multiple resources that the children employed during the activities (e.g. body postures, spatial interaction, facial expressions, gaze, verbal expressions, drawings, etc.). Multimodality is an interdisciplinary approach, derived from socio-semiotics, that aims to understand how people communicate and represent meaning in different forms (Price and Jewitt, 2013). In our study, the goal of the evaluation was to better understand stakeholders' meaning-making of the educational experience in the shelter by including their contributions from a perspective that went beyond the limits of verbal language. Particularly, when working with children the multimodal approach has been seen to effectively inform the design process (Malinverni et al., 2016a; Van Mechelen et al., 2016). Due to children's limited language skills, it is often difficult for them to express their thoughts and explain their ideas adequately. By focusing the evaluation on different semiotic resources that are employed to construct meaning, we argue that this approach can provide us with insights into how children express their worldviews in relation to the educational context through their bodies and person-environment interaction. Hence, this approach could help us to understand how in-situ learning during the guided visit influenced the children's meaning-making processes.

Therefore, the material from video and audio recordings, annotations and the children's contributions (drawings, post-it notes, storyboards, maps, etc.) was transcribed in a descriptive format and analysed using NVivo 11 software. We used a coding scheme derived from the five dimensions of experience in physical space proposed by Lentini and Decortis' (2010), namely *Geometrical and Geographical experience, Sensorial experience, Cultural experience, Personal experience,* and *Relational experience*. According to these authors, these analytic lenses combined aspects of both computing research and environmental psychology by considering the complexity of relationships between humans and the physical space. This framework is meant to inform the design of technologies that support meaningful interactions with and in the physical space. We decided to build our analysis on this coding scheme because it focuses on user situatedness. In our study, we claim that the WaS interaction paradigm unfolds its full potential when it is employed in site-specific contexts. Furthermore, we argue that the separation of the in-situ learning experience into different layers could help us identify deficiencies in the current experience and specific requirements for our technology-enhanced learning approach. However, the original framework was not specifically aimed at analysing learning experiences. Thus, for our purpose, we extended and regrouped the original lenses (Table 5). Finally, we defined the following four-layer model for our analysis:

Physical Space Layer: Analysis of (1) the specific physical features of the shelter and (2) possible opportunities and restrictions for using technology on-site.

Narrative Space Layer: Analysis of the content of the guided visit in relation to (1) the specific features of the physical space and (2) the learning goals of the educational experts.

Personal Space Layer: Analysis of the interest and in-situ experience at an individual level that are promoted by (1) an understanding of the historical context, (2) emotional engagement, and (3) sensorial contact with the physical space.

Collective Space Layer: Analysis of (1) social interactions during the guided visit that offer opportunities for collective learning activities and (2) the understanding of socio-cultural values among children and experts.

Table 5. Overview of the similarities and differences between Lentini and Decortis's and our approach of dimensions for experiences in physical space

Lentini and Decortis's Dimensions		**Our approach**	
Geometrical and Geographical experience	The apprehension of the spatial qualities of the environment, i.e. estimation of distance, structure, shape of the setting, and the spatial disposition of the different elements composing the setting.	*Physical Space*	The specific physical features of the shelter and possible opportunities and restrictions for using technology on-site.
-	-	*Narrative Space*	The content of the guided visit in relation to the specific features of the physical space and the learning goals of the educational experts.
Personal experience	The meaningful experiences-in-place that are mainly experienced at an individual level. These are the opportunities that places offer for reflection, introspection, self-understanding and personal growth.	*Personal experience*	The interest and in-situ experience at an individual level that are promoted by the understanding of the historical context, emotional engagement and sensorial contact with the physical space.
Sensorial experience	The apprehension of the sensorial qualities of the environment: the colours, the smells, the material, and the textures.		
Cultural experience	The apprehension of the behavioural appropriateness, of the cultural expectations and understanding of behaviours, and the corollary of the activities that are expected (and accepted) to occur in a particular setting.	*Collective Space*	Social interactions during the guided visit that offers opportunities for collective learning activities; the understanding of socio-cultural values among children and experts.

Lentini and Decortis's Dimensions		Our approach	
Relational experience	The opportunities for interpersonal relationships and interactions that take place in places, contributing to our development as individuals and as members of a community.		

The analysis was performed by two researchers. After a process of individual coding, a common agreement was reached through a number of meetings and discussions about the results.

5.1.2 Results

Physical Space Layer

The shelter consisted of a long twisting tunnel of approximately 200 metres in length, with a height of 2.10 metres and width of between 1.5 and 2 metres (Figure 20.1). The narrow space limited visitors' movements. For instance, only one group of a maximum of 20 children and four adults was allowed in the shelter at any time, and they were asked to walk in pairs due to the spatial constraints. Visitors can get an impression of the living conditions during the Spanish Civil War and some facilities inside such as bathrooms, benches, an infirmary, a children's room, a chimney built into the mountainside, etc. The general light conditions in the shelter were very poor. Therefore, the guide illuminated certain spaces with a flashlight to direct the children's attention towards specific physical features and traces of objects (e.g. the original lighting system, signs with instructions on behavioural rules, holes to fix stretchers to the wall, etc.) that were once installed inside. The high degree of humidity in the shelter prevented permanent multimedia systems from being installed. Safety policies for the shelter stipulated that visitors should always be accompanied by a member of the museum.

Furthermore, direct physical contact with the walls or artefacts inside the shelter should be avoided to preserve the cultural heritage site.

Figure 20. A school class on the guided visit of the Refugi 307 cultural heritage site (1) in the shelter and (2) the guide explaining the tunnel structure.

Due to these restrictions, we discussed the benefits and possible limitations of our technological approach with the museum experts. During the interviews, the museum experts expressed the need to maintain the sensation of "simplicity and sparseness" of the shelter. The aim was to illustrate its original "living" conditions in similar ways to how civilians may have experienced them during the war. One expert explained:

"We do not want to fill it with museography because it would lose the feeling of entering an empty place that (originally) did not provide anything". They saw potentials in the pervasiveness of the WaS interaction paradigm and the possibility to selectively augment the physical space without altering it. *"These projections you describe, should allow projecting at one moment and then everything disappears and the walls remain as they were"*.

On the other hand, one guide pointed out the risk that using augmented content may not leave sufficient space for children's imagination and own reflections, particularly if too many interactive learning contents are presented during the visit.

Narrative Space Layer

The analysis of the visit showed that the museum had organized the contents inside the shelter in chronological order and in accordance with the spatial configuration (Figure 20.2) of the cultural heritage site. The construction of the shelter was started from three different entrances at once which were meant to connect to each other. However, only the tunnel parts of the eastern and central entrances were finalized while the western entrance remained isolated. During the post-Civil War period, the western part of the shelter was extended and the entrance finally connected to the rest of the shelter. Due to the different building methods, we can easily recognize these two construction periods. Whereas the older parts had a solid construction based on brick walls and Roman arches, the newer part consisted only of simple excavations into the mountain. The tour guides used these physical references to distinguish between historical contents during the Spanish Civil War and the time after (post-war period, contemporary topics, etc.). Therefore, the visit began at the eastern entrance and followed a linear narrative finishing at the western entrance. (The part of the tunnel that led to the third entrance was not accessible during the visit.) The guides explained historical events and anecdotes in the context of the Spanish Civil War from the year 1936 to the present time.

Personal Space Layer

The analysis of this layer involved two main aspects. On the one hand, we investigated the experts' educational goals related to the visit. On the other, we focused on how the students themselves understood the historical context during the visit, with which topics and locations engaged them emotionally, and which sensorial experiences triggered reflections and interpretations.

A) Experts' educational goals

The findings from the interviews with the educational experts from the museum and school determined that one of the main goals of the interactive experience should be to foster children's competence in understanding the relationship between historical events of the Spanish Civil War and similar contemporary conflicts occurring today (e.g. the civil war in Syria). This aim involved strengthening feelings of solidarity and empathy with people who have suffered and/or are still suffering war. To offer children emotional anchors to the learning context, they recommend linking the content of the experience to situations children can relate to their own identity; e.g. family members from previous generations or children in war zones in other countries. Furthermore, the teachers proposed to use (1) audiovisual material such as testimonials, original documents, photos, (2) real objects (e.g. a pickaxe, stretchers, medical supplies, etc.), (3) actors performing specific situations, and (4) post-activities to contextualize the content explained during the visit and to support children's interpretations.

Students' understanding and interests

Our analysis of the children's behaviour during the guided visit and their contributions during the workshop sessions helped us to obtain an in-depth understanding of their understanding and interests towards the historical context and in-situ experience. During the visit, the children showed surprise and astonishment when they were told anecdotes about civilians in the shelter which contrasted with their own "protected and comfortable" lives. For instance, the guide explained that some women put their children under the benches so that they could stretch out to sleep and were protected in case the ceiling collapsed. In response to this explanation, some children looked disbelieving under their bench and made comments about how uncomfortable that must have been. Another example is when they expressed disgust at the fact that people were forced to eat parts of food that people usually would throw away (e.g. soup made out of mashed fish bones). Several children pointed out that they would never eat something that they did not like.

We observed that several children tended to enact the explanations of the guide to have an embodied understanding of the described contents, e.g. one child slapped her hands on the legs when the guide talked about children sleeping on parents' laps. Other children that were sitting on benches started shaking their bodies when the guide mentioned walls shaking from bomb explosions. With the physical space, the children interacted mostly with their eyes, searching for more details in relation to the explanations. In certain spaces the children looked for direct contact through touch, for instance in the "infirmary", they knocked against the wall to explore the sound it made because of the hollow space inside. Another example is when the children touched the wall of the mountain while the guide was contrasting pickaxe marks made by children and adults. The darkness and humidity in the shelter had a particular impact on the children. They responded to the low temperatures by expressing uncomfortable feelings through behaviours such as moving from one foot to the other to keep themselves warm, tightly closing their jackets, blowing hot air into their sweater, and so on. Also during the workshop activities, they stated several times that it was very uncomfortable to stay inside for a long period of time and they were glad to be able to leave after the visit. We also observed moments when the children were distracted from the guided visit. Some children started playing with each other or pulled a face expressing boredom. This behaviour tended to occur in situations when they were asked to remain still, e.g. in the introduction outside the shelter and during the explanations while sitting on the benches.

The analysis of the interviews during the *Dwelling Space Technique* gave us specific insights into the children's interests and understanding of the historical context. Six out of 10 groups chose to perform the interview in the "infirmary". They focused on the fact that the place was located in the middle of the tunnel and thus the safest place in the shelter (which has an entrance door at either end). The children also expressed the importance of having a place where injured people could be treated and their respect for volunteer nurses who had only very limited medical resources available to help them. Three groups performed the interview about the "fireplace". They expressed their admiration for the person who had built a chimney and ventilation system into the stone of a mountain. They recounted two anecdotes related to the place. First, despite the harsh conditions in the shelter, a family from southern Spain lived in it during the post-war period for ten years. Second, a man in the nineteen-eighties used the shelter to illegally grow mushrooms on the walls as the main source of income for his family. Only one group performed the activity in the "children's room" and expressed their sadness at an event in which the ceiling collapsed during a bomb attack and two children were injured.

The results extracted from the open-ended questionnaires revealed further interests of the children. Several children mentioned the physical characteristics of the shelter; e.g. the zig-zag shape of the entrance aimed at preventing shrapnel from bomb explosions from entering to the inner part of the shelter; the rounded finish of the walls around corners to facilitate the transport of injured people on stretchers, etc. Furthermore, other children reported their interest in aspects related to people; e.g. dead bodies, the blood of injured people, getting to know a Spanish Civil War survivor, etc.

During the subsequent map activity in class (Figure 21), in addition to the previously presented places, all groups reported on at least one other location related to people's basic needs: toilets (9 groups), a water fountain (8 groups), and a power generator for the lighting system (3 groups). In addition, they explicitly mentioned that they were interested to see the original wall signs on behavioural rules (1 group), they asked to see images of bombs and shrapnel (1 group) and expressed their curiosity about tunnel segments that were not included in the guided visit (2 groups).

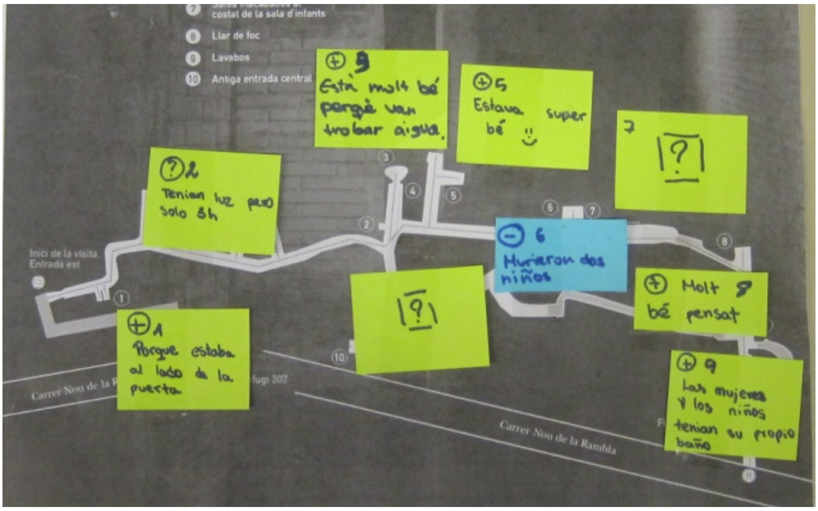

Figure 21. Results from the map activity. This group was particularly interested in the water fountain and the power generator. The children expressed their sadness at the accident in the children's room. They also expressed curiosity towards parts of the shelter that were not included in the guided visit.

In the redesign activity, the children mainly proposed changes related to making the experience more participative. They proposed several hands-on activities, e.g. (1) a treasure hunt activity with clues to provide a playful experience during the guided visit; (2) an activity where the children could dig up the destroyed children's room and discover what was hidden under the stones; (3) to perform a drill activity of the bomb alert and the experience of entering the shelter.

The children's main misconceptions concerning the different design activities were related to their expectations of finding weapons in the shelter of people who tried to protect their family against dictator Franco's army (6 out of 40 children). In other words, they did not understand that the shelter represented a "passive" form of defence, in contrast to "active" defence that involved using weapons. Further analysis showed that particularly boys (83% in total) tended to report a higher number of misconceptions than girls related to this topic. Moreover, two children expected to find a fully equipped kitchen in the shelter. Another child thought that the room in which children waited during the bombings was used as a playground. These findings indicate that these children had difficulties to imagine the living conditions in the shelter and how civilians had probably felt and behaved in it. Another child thought that men were not allowed to work on the construction of the shelter. The boy was not aware of the fact that during the Spanish Civil War men were forced to go to the frontlines.

To sum up, triangulating different semiotic resources (verbal explanations, body language, manual contributions such as drawings, etc.) that the children expressed during the activities helped us to obtain a holistic picture of their personal perspective of the historical context and in-situ experience during the visit. Our results illustrated that, in general, the children showed a much interest in the historical context and were very engaged in the explanations during the guided visit. Individual fate, civilians' living conditions in the shelter and particularly anecdotes that involved children as protagonists caught their attention. Furthermore, the students were intrigued by the physical characteristics of the shelter and their functions. The children's felt-experience in the physical space, their enactment of explanations and sensorial contact triggered reflections and meaning-making of the historical context. Nevertheless, the students showed some misconceptions in relation to situations that were unfamiliar to them or involved abstract concepts (such as "passive defence"). Furthermore, they reported the need to visualize missing and hidden artefacts of the physical space. Finally, they proposed participative activities as improvements to the guided visit. Also during the visit, we observed that the children preferred to move around and explore the space than to sit still and listen to the guide.

Collective Space

The museum experts highlighted that one main purpose of the guided visit was to transmit to children the benefits of collaboration and the implications of being part of a community. On the one hand, the shelter itself was a symbol and reflection of social values because people of all ages contributed to its construction in order to protect themselves, their family and friends against bomb attacks. On the other hand, the museum experts emphasized the fact that the war had caused a collective trauma and influenced civilians' attitudes towards certain political and social movements in society. From a historical perspective, understanding these two aspects was important to prevent such past mistakes from repeating themselves.

The storyboard activity helped us to gain a deeper insight into children's socio-cultural values. The goal of this analysis was to identify differences in the understanding of the children's socio-cultural values and the educational goals defined by the experts. In almost all groups, the children tended to describe their stories from a third person perspective. Four children wrote their stories about the lack of food and how people had to find provisions to survive. One child wrote about men who went to the frontlines. Another child mentioned that people had lost their houses. Two children explained how people were forced to leave their country. However, many of these stories had a "happy ending", i.e. as soon as the war ended everything went back to "normal" (Figure 22). This result can be interpreted in multiple ways. On the one hand, the results could be primed by common narrative structures of contemporary children's literature (e.g. fairy tales). On the other hand, these findings could point towards children's generally positive attitude to solving problems (Van Mechelen et al., 2016). Finally, these outcomes could indicate that the children were not conscious of the long-term effects of the war. Comparing these results with the educational goals defined by the expert indicated that the educational experience in the shelter could benefit from activities that promote reflection on socio-cultural values and help children to understand the concept of "collective trauma", such as the need for collaboration and solidarity.

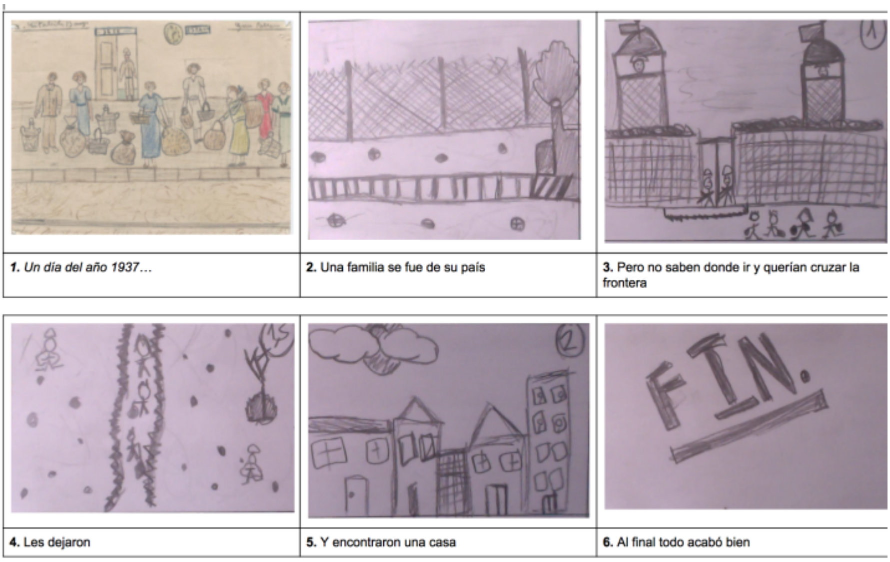

Figure 22: A girl explained in her storyboard how a family had to leave their home and found a "happy" life in another country.

Due to the educational goals defined by the experts, we focused our analysis on the children's social interactions and interpretations evoked by the guided visit and aimed to foster the aforementioned concepts and underlying values. Our results depicted that the enactment of content that was explained during the guided visit not only took place on an individual level but also involved interactions among different children at the same time. For instance, in the "infirmary" two girls re-enacted pulling up an injured person from the ground. Furthermore, the children interacted with each other by pointing at certain things in the shelter while the rest of the class followed with their gaze. In other situations, they answered their questions among themselves and discussed aspects of the guided visit that caught their attention. By analysing the children's proposals for redesigning the guided visit we looked for opportunities for interpersonal relationships and interactions that could take place within the space using the WaS paradigm. Interestingly, almost all of the children's proposals for redesigning the guided visit were group activities. They proposed specific participative and hands-on activities, such as performing a treasure hunt game, digging up the collapsed part of the children's room together, etc.

5.1.3 Definition of requirements for a first prototype

Our approach helped us to define key requirements for the design of a learning experience for this cultural heritage site. Our observations confirmed that the guided visit already had a high educational potential to introduce the historical context and some underlying values to the children. However, we saw several opportunities to complement it by using a virtual heritage experience based on the WaS paradigm (Table 6).

Table 6. Overview of requirements for the design of a first iteration

Layer	Affordances of current learning experience and limitations	Opportunities for WaS
Physical Space	(1) Spatial constraints restrict movement; (2) Poor lighting conditions; (3) Climatic conditions do not allow permanently installing multimedia systems; (4) Visitors must always be accompanied by a guide; (5) Direct contact with the physical space should be avoided; (6) Maintenance of the sensation of "simplicity and sparseness"	(1) Pervasiveness and selective use; (2) Projective Augmented Reality content does not alter the space and prevents direct contact with it; (3) Allows highlighting and completing traces of missing objects; (4) Allows balanced use of augmented content and verbal explanations to leave room for children's imagination
Narrative Space	(1) Guided visit is organized in chronological order and makes reference to the building process of the shelter and physical differences in its features	(1) Recognition and exploration of specific surfaces in the shelter to contextualize historical events and anecdotes
Personal Space	(1) Aim to strengthen feelings related to empathy and solidarity; (2) High impact of felt-experience in the shelter; (3) Guided visit triggers enactments and reflections on the harsh living conditions in the shelter; (4) Children are bored in situations when they just listen and keep still; (5) Guided visit fails to transmit the difference between active and passive defence; (6) Children had problems to understand difference in cultural values during the Spanish Civil War and today (e.g. the role of women and men in society)	(1) Participative and hands-on activities that involve the visualization of rule signs and bomb impacts; (2) Fostering children's interest in people and contrasting changes in cultural values by using testimonials and material showing civilians during the war; (3) Activities based on embodiment of actions from people in the past
Collective Space	(1) Aim to transmit benefits of community values was well understood by the children; (2) Children showed problems to relate to the significance of collective trauma (stories had a happy ending)	(1) Participative activities that foster social interaction and mutual reflection; (2) Connecting with contemporary contents such the problematic of refugees from Syria

Our findings showed that due to the spatial constraints of the shelter that the guided visit could benefit from the WaS paradigm as follows. Projective AR content allows drawing children's awareness to specific features in the environment and to augment objects missing from their original locations (e.g. the signs of behavioural rules can be projected onto the empty holes on the walls) without altering the physical space. These projections, based on surface and object recognition, may contextualize contents and help children to imagine objects they have never been in contact with. Furthermore, the WaS allows flexible utilization and can, therefore, be used selectively to complement the guided visit, i.e. only at moments when the guide considers that additional information is required to foster certain understanding and reflections on the learning topic.

We propose providing opportunities for children during the guided visit to explore and engage with the physical environment in different ways. For instance, participative activities could allow them to contextualize the physical aspects of the shelter with certain learning contents. In this regard, our results showed that children were able to grasp social values related to empathy, respect, safety and a sense of cooperative work. However, the guided visit failed to transmit underlying values and interpretations that could help the students to understand abstract topics such as changes in society (the social role of women during the war and today), different standpoints on historical events (passive vs. active defence), and long-term effects of the civil war (e.g. collective trauma). The visualization of multiple location-based events allows presenting content from different perspectives and comparing them, e.g. observing civilians from different parts of the city during a bomb alert; linking the Spanish Civil War to contemporary topics such as the problem of refugees from Syria, etc. These activities could help children to understand the aforementioned concepts that are currently not fostered through the guided visit alone.

Conceptual changes in children's understanding in relation to these topics could also be achieved through social-aware AR activities. Participative activities based on social interaction have been seen to promote mutual reflections among users (Roberts et al., 2014). Thus, we envisioned implementing activities based on using projections of multiple content fragments and a common task (e.g. two children project one piece each of a larger image that together represent a stretcher. They have to move their images in a synchronized fashion to take an injured person safely to the infirmary). We argue that by performing and embodying similar actions (Antle et al., 2013; Flynn, 2013; Lyons et al., 2012) to those performed by civilians during the war that these activities could help children better understand feelings of solidarity and empathy with people in these situations.

5.2 Exploration of a first prototype

Building on the results, we defined seven activities based on the use of two Philips PicoPix PPX3414 pico-projectors (Figure 23). The system allowed the children to carry the device around and project audiovisual contents directly onto the physical environment. In this study, we focused on exploring how projective AR and participative activities that promote social interaction could enhance the educational experience. The surface recognition system and specific user interaction were still not implemented in this design iteration. Therefore, by pressing a button, the children could switch between and display different audiovisual contents that were uploaded onto the projector's digital library. The content was organized in chronological order and the guide indicated when it should be projected.

Figure 23: The children holding two Philips PicoPix PPX3414 pico-projectors. The system allowed them to augment the physical space with digital content and perform collaborative activities.

5.2.1 Procedure

Six months after the design workshops, a user study was carried out with a preliminary prototype. A few days before the study, we met the guide in the shelter to test the WaS system one last time and discussed the procedure of the visit using the prototype. The guide selected the locations in which the digital content (Figures 24.1, 24.2 and 24.3) would be displayed during the visit. Due to time restrictions, she decided to reduce the original content of the visit and focus on the locations in which we would use the WaS prototype.

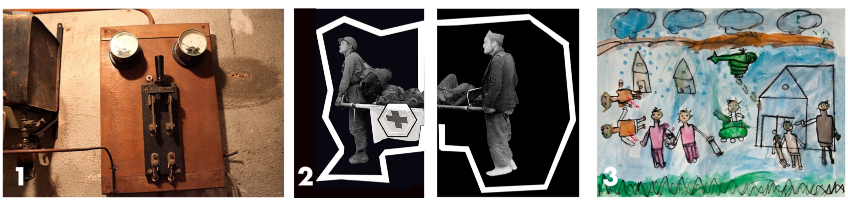

Figure 24: Examples of projected content. (1) Power generator; (2) two parts of the stretcher; (3) drawing by a child during the war.

A total of 20 children (girls = 11; boys = 9; mean age = 9.95 years) participated in the study. Before the study, we provided the parents of the students with a content form in which they were informed about and asked for their agreement on data collection and dissemination (A typical consent form is presented in the Annex of this thesis). The guided visit lasted 90 minutes. We carried out seven activities based on the WaS system (Table 7) to complement the educational experience. Two researchers present during the visit video recorded and took notes about the children's behaviour and interactions with the prototype. We interviewed the guide about her impressions and reflections upon the activities with the mid-fidelity prototype after the visit. A few days later, we conducted a workshop session in school that lasted 30 minutes to evaluate the children's retrospective experience with the prototype. Two researchers facilitated the activities and the session was video recorded.

Table 7. Overview of the seven activities using the prototype during the guided visit

Activity 1: Bomb attack	The guide pointed at the floor with the projector and an animation of an air raid on the city of Barcelona was reproduced.
Activity 2: Benches	One child pointed towards the wall. A video was reproduced where the group could see people waiting inside a metro station and hear the sound of bombs exploding in the background.
Activity 3: Behaviour rule signs	One child pointed at a stain on the wall and a picture of an old sign containing the rules of the shelter was displayed. The guide asked the children to read out aloud the content of the sign.
Activity 4: Power generator	Two children projected onto two different parts of the original location of the generator: (1) a switch on the wall, and (2) the power source on the ground.
Activity 5: Infirmary	Each of two children projected a part of an image representing a stretcher. They were asked to synchronize their movements and to take a virtual person on the projected stretcher safely into the infirmary.
Activity 6: Construction of the shelter	One child projected an image of a group of children helping with the construction of the shelter.
Activity 7: Children's drawings about the war	Two children compared two different images. One child pointed at the wall with the projector and a child's drawing from the late 1930s was displayed. Another child projected a child's drawing from Syria next to the first one.

We started the workshop with the *Reflective Drawing Technique (A detailed analysis of the technique is presented in Section 5.5.3)*. Thus, the children were asked to draw themselves in the shelter using the projector (performer role) or, if they did not use it, in the role of the "observer" of the interactive experience. After that, the researchers went around with cameras and recorded a short interview with each child. The children explained briefly what they had drawn and why they had chosen that particular representation of themselves and the situation. The aim of the activity was to elicit the children's feedback on the educational experience and on using the prototype (Nicol and Hornecker, 2012). The drawings also facilitated prompting group discussions about the user experience. Therefore, we divided the children into groups of 3-4 members. They were asked to collaboratively reflect upon the educational experience and use of the prototype based on the drawing they had produced. The children wrote their reflections down on post-it notes. The researchers again went around with cameras and recorded a short interview with each group. The aim of the activity was to understand the children's perceptions of the user experience. At the same time, the procedure allowed the children to compare their attitudes and interpretations with those of other peers and to extend their own reflections.

5.2.2 Analysis

In this part of the study, the analysis focused on researching the *personal space* and the *collective space* of the experience. For this analysis, we summarized our findings in subcategories, namely (1) educational experience, (2) user experience, and (3) interaction with the prototype. The *physical space* and *narrative space layers* were not relevant to this design stage because they represented requirements of the guided visit which we did not aim to influence. Our main goal was only to complement the existing educational experience by not altering the physical space and predefined learning contents.

5.2.3 Results

Educational experience

Using digital augmentations in the shelter proved to enhance the children's understanding of the historical context in several aspects. In general, the children stated that the projected pictures helped them to imagine certain artefacts and situations in the past. One child said, "It was like travelling in time". Another child particularly appreciated that content was displayed in its original locations, for instance, the rule signs or the power generator. Two children explained how the activity about the children's drawings had particularly impacted them (Figure 25). One boy said: "It is not normal for a six-year-old child to draw something like that". Another child explained: "I drew this because it made me sad that a child drew something like that and had to go through this in his country. The child was from Syria".

Other interpretations were evoked by the children's situatedness in the shelter. During the guided visit, the children expressed fear when the light was turned off. Several children complained about the cold. They also mentioned that they were afraid of getting lost in the tunnel and they doubted that they would find the exit.

Furthermore, the results indicated that activities based on embodied exploration triggered the children's reflections on underlying values in relation to the historical context. For instance, with regard to the activity in the infirmary, one child in the observer role stated "you needed two carriers for each injured person. If they had to do this for each one who needed help, it was impossible". This finding suggests that observing the enactment of actions by people during the war, helped the child to empathize with the severity of such situations.

Figure 25: The guide explained the drawing by a child from the war in Syria.

User experience

Analysing the children's drawings and interviews revealed relevant differences between the user experience of (a) the children who held and interacted with the device (performer role: 10 children) and (b) those who observed and interacted with the projection of the prototype (observer role: 10 children). Six children in the *observer role* represented themselves in a larger group (Figure 26.1) during the activity in the "infirmary", "rule signs" and "construction of the shelter". One of these children drew himself facing the opposite direction and looking at the children's room. The child also explained during the interview how much he was impacted by this space because it was destroyed during a bomb attack. Three children drew about their experience with a video that showed civilians using a metro station as a shelter. Interestingly, they represented themselves sitting on a bench and another person projecting. One of these children added details to her drawings to depict that the shelter was built into a mountain (Figure 26.2). One child represented himself alone.

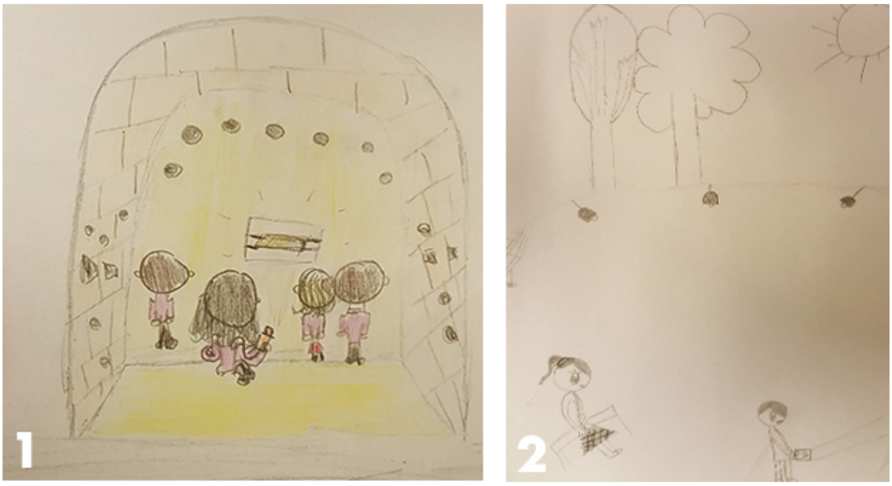

Figure 26: The children in (1) the observer role represented themselves in a group and (2) as passive spectators

In contrast, only one girl in the *performer role* represented herself in a group. Eight children represented themselves alone and often in the centre of the picture (Figure 27). One girl reported during the interview that she was particularly proud to be chosen to use the projector. One boy mentioned that he liked the activity but he could not remember what it was about. Despite having used the projector in a different space, one child in her drawing focused only on the children's room and did not depict any other child. Interestingly, after the visit, the guide mentioned that she had perceived that using the projector gives the children a task with a high degree of responsibility. The reason for this perception was probably that they must make sure that the content was well displayed for a certain amount of time. This interpretation was in alignment with the values related to "being a community" that the museum aimed to provide during the visit.

Figure 27: The children in the performer role represented themselves alone and in the centre of the picture.

These findings (Figure 28) showed that the children perceived the activities during which they were forced to remain still and only watch the augmented content as a passive and less interesting experience. As a consequence, during these activities the children tended to focus less on the augmented content and instead explored the physical features of the shelter with their gaze. Furthermore, we observed a relevant difference between children using the WaS system and those who observed their peers interacting with it. Whereas the children in the observer role mainly lived the activities as a group experience, those who performed the activities using the WaS system were immersed in their task and concentrated on their individual experience. However, the current features of the mid-fidelity prototype did not allow them to feel part of the collective experience during the activities.

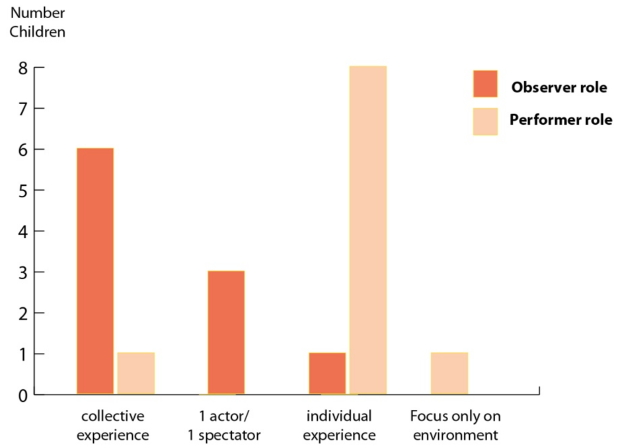

Figure 28: Overview of the children's perception of the experience in observer and performer roles.

Interaction with the prototype

Using the prototype in the shelter during the guided visit allowed us to analyse how the children were intuitively interacting with it. We observed several direct interactions with the augmented content. For instance, during the activity at the entrance when a bomb raid was projected, one child cringed when the virtual bomb exploded. Furthermore, one child projected a random image on the head of his peer who started to interact with it. On the other hand, the children tended to point at details in the projection directly with their hands (Figure 29.1) or indirectly with their own shadows (Figure 29.2). One child tried to interact with the displayed content by enacting that he would turn off the switch of a power generator (Figure 29.3). During the activity in the infirmary, two children immediately understood that the two image parts belonged together. They said, "It's like a puzzle". Furthermore, they easily managed to perform the pre-defined enactment of synchronously moving the stretcher to one part of the space.

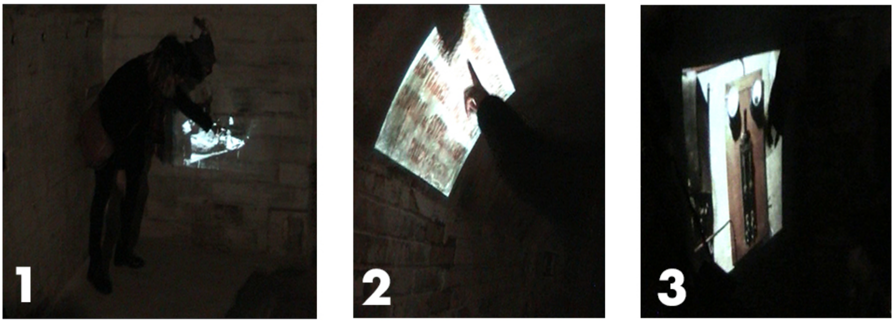

Figure 29: (1) One child interacted directly with the displayed picture; (2) one child interacted through his shadow with the displayed picture; (3) one child enacted switching off a projected power generator.

We observed that the use of videos vs. still pictures triggered different interaction behaviours. Whereas video tended to produce a "cinema effect", i.e. the children watched the displayed content attentively, still pictures left room for the interactions previously described. In general, the children enjoyed activities that required the active participation of the entire group. For instance, during one activity, they collectively participated in reading the rule signs out loud. In this regard, one child mentioned that he liked the fact that he could actively take part in the guided visit instead of only listening to the guide's explanations. At the same time, they liked to investigate and discover different sources, e.g. during the power generator activity. A general summary of the results is presented in Table 8.

Table 8. Overview of outcomes of the first design iteration

Understanding content	• The displayed content supports children's imagination • Enactments of people's actions from the past help to empathize with war-related situations • Comparative tasks stimulate reflection-in-action about past events and contemporary topics • Situatedness triggers different emotions and helps to foster certain aspects of the learning content
User Experience	• Most activities are perceived by the children in the observer role as a collective experience • Projections that do not promote specific activities cause a "cinema effect" and are perceived as a passive experience • Children using the projector perceive themselves as protagonists, but its use prevents active involvement and being part of the collective experience

Interaction with Prototype	• Children perform enactments in relation to displayed content • Children point directly with hands and indirectly through shadows on the projected content • Using two image parts triggers the association with a puzzle • Children enact that the displayed images would be interactive and trigger behaviour changes by certain interactions • Participative activities stimulate reflection and dialogue

5.2.4 Discussion

We have presented the evaluation of a first design iteration of a virtual heritage experience for an archaeological site to explore the potential of an educational experience based on the WaS interaction paradigm for primary school students. Our results indicate benefits to complement the learning experience during the guided visit by (1) supporting activities that involve the digital augmentation of the physical space and (2) by encouraging embodied explorations such as spatial interaction, tangible manipulation and the performance of collaborative tasks. We will now discuss these aspects in more detail and outline opportunities for improvements of the prototype.

Digital augmentation

Employing the WaS system in the shelter allowed the children to visualize missing objects in the physical space and contextualize the guided visit at specific locations through audiovisual material that illustrated certain aspects of historical events. These projections helped the children to better understand the learning contents that were difficult to imagine. Furthermore, this feature allowed the students to compare different contents at the same time and some preliminary results pointed towards the potential of supporting children's capacity for perspective-taking (Ackermann, 1996). However, the museum experts warned of the risk that too frequent a use of the system could limit the children's imagination and their own reflections. Consequently, the use of projective AR needs to be carefully balanced with other activities aimed at encouraging the interpretative construction of meaning.

Embodied exploration

In this design iteration, we found evidence that activities involving embodied exploration can enhance children's understanding of topics requiring emotional engagement (Sakr et al., 2016), critical thinking (Rowan et al., 2016) and the notion of collaboration (Stanton et al., 2001). However, we argue that due to the limited functionality of the current version of the prototype, this feature is still not fully explored. Previous studies (Malinverni and Pares, 2014) have demonstrated that embodied interaction (Dourish, 2001) can support the learning of abstract concepts. We envision, through the improved functionality of the prototype, fostering the students' understanding of underlying socio-cultural meanings such as the notion of identity (Smith et al., 2011) and solidarity. We believe that particularly activities building on collaborative learning (Doise et al., 1975; Malinverni and Pares, 2015; Nelson, 1994) and a shared construction of meaning (Ackermann, 2004) can promote a better understanding of these concepts.

Perception of agency

Moreover, we assume that the limitations of the prototype also caused the children who used the WaS system to experience some activities on an individual level or even passively. Further research is needed to analyse if this shortcoming was caused by the design of certain activities or by the user experience that evoked the features of the system. In this context, it is also important to evaluate how the agency between the different users should be distributed. For instance, for some activities, it may be more appropriate for the guide to use the device. Conversely, other activities could be guided by children holding the device or, in different contexts, by the group physically interacting with the projected contents.

5.3 Design improvements to support students' participation and collaborative learning

To address the shortcomings that we observed with the preliminary prototype, we conducted a co-design study with 16 primary school students of a local public school. The main goal was to analyse the benefits of a set of embodied collaborative learning activities using the same mid-fidelity prototype of the WaS system as in the previous study and low-tech prototyping material in the bomb shelter. On the other hand, we gave the students the opportunity to reflect upon the experience of the WaS prototype during a co-design workshop. We again involved a teacher and the museum staff in the evaluation of the prototype. The findings informed the definition of improvements for the design of a functional prototype.

5.3.1 Procedure

Sixteen primary school students (girls = 6, boys = 10; mean age = 11.67 years) participated in the co-design study. Before the study, we provided the parents of the students with a content form in which they were informed about and asked for their agreement on data collection and dissemination (A typical consent form is presented in the Annex of this thesis). The study was organized in three consecutive sessions. The first session was held in the school and had a duration of 30 minutes. Two researchers and one teacher facilitated the activities during the session. The main goal was to introduce the children to the learning context. Therefore, we first watched a 5-minute-video clip of a documentary on the Spanish Civil War. The documentary also introduced the issues of other civil wars that are still occurring in other countries in the world and showed refugees leaving their home. After the video clip, we briefly discussed the topics described in the documentary. We then explained to the class the procedure of the guided visit that took place the next day.

Table 9. Overview of the activities using the WaS prototype during the guided visit

Activity 1: Bomb attack	One student pointed with the WaS system at the ceiling of shelter. A video of an airplane dropping a bomb was displayed. Two other children were then asked to take one WaS system each and explore how far the shrapnel of the bomb entered the shelter.
Activity 2: Testimonies	One student projected the name of a child from the Spanish Civil War on the wall with original pickaxe marks from people from the civil war. An audio with a testimony was reproduced. Another child repeated the same activity with another testimony.
Activity 3: Construction of the shelter	One student projected a virtual character during the Spanish Civil War on the wall. The girl explained the group that she participated in the construction of the shelter and asked for their help. The students were then provided with physical cardboard boxes to collaboratively built an arch next to a wall of the shelter.

The second session was conducted during the visit to the shelter of the archaeological site. The visit had a duration of 90 minutes. The aim of the session was to observe students' in-situ interactions with the WaS prototype during three interactive educational activities (Table 9, Figures 30.1 and 30.2). A guide, three researchers and two teachers participated in the session. The guide had been previously briefed about the procedure. She adapted the guided visit to the research goals and integrated the interactive activities at locations in the shelter that she considered adequate. The researchers provided technical support with the prototype, video-recorded the session and took notes about children's behaviour and interactions during the activities. After the visit, we conducted semi-structured interviews with the guide, a curator and one teacher about their impressions during the educational activities using the WaS System and to involve them in the definition of improvements of the prototype.

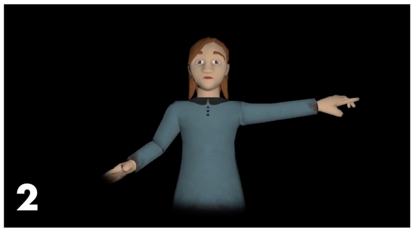

Figure 30. Digital content used during the WaS activities. (1) Bomb attack and (2) the virtual girl that introduced the activity 'construction of the shelter'.

The third session took place in the school and had a duration of 90 minutes. Two researchers and one teacher facilitated the activities during the session. We began the session with the *Reflective Drawing Technique*, i.e. the children were asked to draw themselves in the shelter during one of the learning activities they liked the most. After that, the researchers went around with cameras and recorded a short interview with each child. The children explained briefly what they had drawn. The aim of the activity was to prompt children's reflections upon the guided visit and provide them a visual support to explain their ideas. After the drawing activity, the students were divided into groups of four members. Each group received a map of the shelter and a sheet with visual references (Figure 31). We explained to the students that the guide would like to use the WaS system with other children from their school in a guided visit of the shelter. Each group was asked to brainstorm ideas about new activities for the visit and write or draw them on a large sheet of paper. After some time, the researchers went again around with cameras recorded a short interview with each group about their proposals.

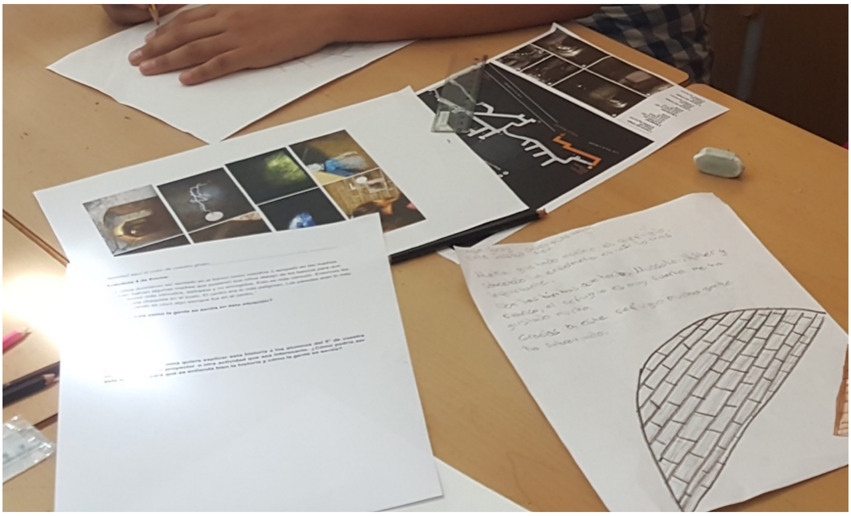

Figure 31. Material used during the redesign activity

5.3.2 Data collection and analysis

In this study, we also focused on researching children's experience during the WaS prototype activities, students' and educational experts' proposals for improvements of the WaS experience. The data collection and analysis was performed in the same manner as in the two previous studies (Section 5.1 and 5.2).

5.3.3 Results

The results of this study focus on three main aspects: (1) *children's experience during the WaS prototype activities; (2) students' proposals for improvements of the WaS experience and (3) the feedback from educational experts.* I will now describe each aspect in detail.

Children's experience during the WaS prototype activities

Four students represented in their drawings the projected image of the 'construction of the shelter' activity (Table 9). Analysing the retro-perspective interviews highlighted that the students particularly liked the activity because it was participative and, in contrast to the usual guided visit, the activity allowed them to physically "touch" something in the shelter. Three children compared the activity to video games such as *Minecraft* or *Tetris*. However, the students criticized that the animation of the girl in the introduction did not express specific emotions (e.g. hunger, fear, etc.). They explained that realistic representations of civilians would give the visitor a better impression of how those had experienced the war.

Five children drew the 'bomb attack' activity (Table 9). The findings of children's experience during the guided visit showed that the activity evoked uncomfortable sensations in the students. We observed verbal and facial expressions illustrating their fear and astonishment about the projected content. For instance, two girls hugged each other at the moment when the virtual bomb explored. Two different children covered their mouth with one hand and watched the scenario in shocked amazement (Figure 32). In the meantime, their peers were commenting on the activity as follows.

Student 1: What is this?
Student 2: Ahh! Probably the bomb.
(The video showed an airplane dropping a bomb)
Student 3: It's falling down!
Student 1: That's scary!

Children's feedback in the retro-perspective interviews confirmed this observation. When the researcher asked a student which was the most interesting activity for him, he explained:

Student: The one with the airplane.
Researcher: And why?
Student: I don't know, I felt uncomfortable.
Researcher: In which way, uncomfortable?
Student: Well, I could hardly breathe.

Figure 32. The students expressing their fear and astonishment during the bomb attack activity.

In addition, one child explained during the interview that the projected animation gave him the sensation of living an authentic bomb attack. Another student imagined the civilians in the shelter being very scared. In contrast, the second part of the activity, which consisted in exploring how far the shrapnel of the bomb had entered the shelter, was perceived by most children as boring. Another child mentioned that the projection was difficult to see because some of his peers covered them with their bodies due to the limited space in the narrow tunnel and a large number of students in the group (Figure 33.2).

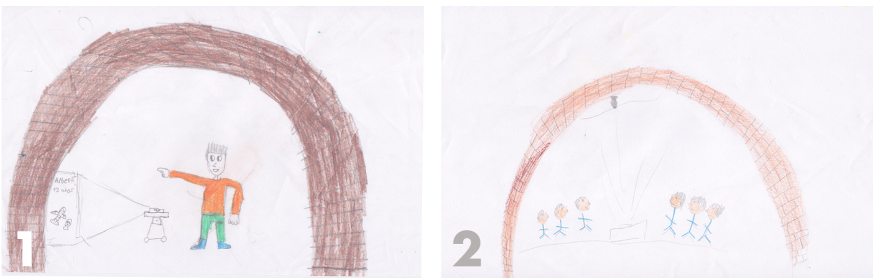

Figure 33. The students drawing their experience during the activity 'bomb attack' (1) from a first-person perspective and (2) in a group

The 'testimonies' activity (Table 9) was drawn by seven children. Four students drew only the projected image. One child drew herself with her best friend and the rest of the school class (Figure 34.2). Two of the students who drew the previous activity included in their drawings the projected image (Figure 33.1) of one of the testimonies. In addition, during the visit, the guide asked a student to imagine the situation described in one of the testimonies in which the narrator explained that during a bomb attack they hid in the tunnels of the metro. The student responded that the narrator probably referred to the first bomb attack that they had seen in the previous WaS activity. These results may indicate how the students tried to find connections between the activities to obtain a better understanding of the educational context.

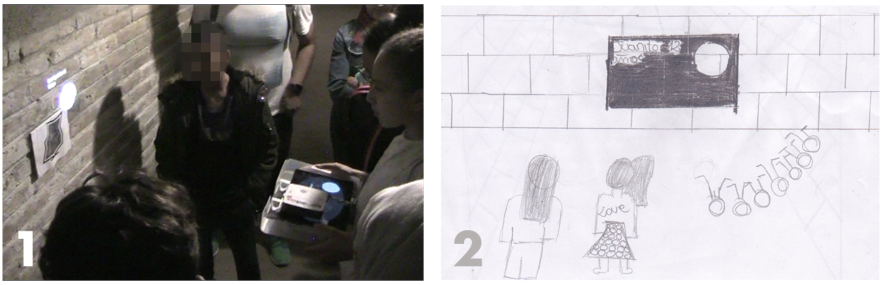

Figure 34. The students during the activity 'testimonies' in the shelter (1); One child drew herself with her best friend and the rest of school class (2).

Our analysis also showed that the projection of the child's age represented in the audio narrative may have influenced the students' perceptions on the testimonies. For instance, one researcher asked in the retro-perspective interview the students about the differences between the two testimonies.

Student 1: You understand better the older child.
Student 2: Because he explains better.
Student 1: The first child (7-years-old) explains it in a funny way, and the other one (12 years old) explains it…
Student 3: …with more emotion.
Student 1: No, with more seriousness. It seems that the 7-year-old child was scared.

It is also possible that this effect was caused by the audio recordings themselves. We had used original testimonies of adults that remembered the war when they were children. They were then audio recorded with two different children. However, due to the complexity of expressions and structure of the sentences, particularly one child (the 7-year-old one) had problems to fluently read aloud the text. This means he spoke very slowly and made several mistakes.

Furthermore, the students expressed that they would prefer to see a photo of the real person behind the narrative.

Students' proposals for improvements of the WaS experience

In the co-design workshop, the students were able with the previous experience in mind and the help of additional information material (e.g. map of the shelter and photos of the physical space) to think of a wide range of ideas to improve the educational experience. One child suggested using sounds that evoke sensations related to fear. The boy explained:

"One way would be to use loud sounds in the shelter, people screaming and also a wail of a siren. (…) I would not like to experience this by myself but it would seem more realistic."

On the other hand, another girl mentioned that she did not like the activities during which she had to remain still. In this context, this girl and another student expressed their preferences for activities that promote a playful exploration of the shelter as follows:

Student 1: It would be nice to do more fun activities.
Research: How would they be funnier?
Student 1: Well, you learn things about the shelter but while you are playing.
Researcher: Do you have an idea how this could be?
Student 1: We were not able to play, touch anything, yell…that's not fun. We had to walk the whole time like this (she embraces her body with her arms).
Student 2: Like discovering pieces…making a mini-game. That means while we are playing they explain us the things. You know, learning things while playing or walking in the "shoes of the civilians".

In alignment with this proposal, one child suggested a role-play game consisting of a battle between people from the two parties – Republicans against people in favour of the dictator Franco. Although this idea stood in sharp conflict with the notion of passive defence, it pointed towards possibilities to connect the WaS activities with higher level issues on the political situation during the war. The students proposed also other strategies such as briefly closing their eyes during the visit and imagining certain feelings that civilians had experienced in the shelter (e.g. cold temperature, losing friends and family, etc.). Another proposal was to draw these experiences after the visit and reflect upon certain sensations related to historical events and individual fate. These two proposals depict that the students recommended activities that stimulate their reflection upon the contents of the visit to get a deeper understanding of the educational context. Furthermore, two children suggested to include actors in the visit that represent how the civilians lived during that time and, instead of the guide, would conduct the visit in the shelter and talk about their personal experiences. One student explained:

"For example, if they are a family and their children are in another country, that they talk about it."

Another student even proposed to invite war survivors to participate in the visit. A girl explained: *"We want that a person who has lived this, who was there, explains us their experiences."*

Feedback from educational experts

A few weeks after the visit, we interviewed one of the teachers who had participated in these three last sessions. The teacher particularly argued for the educational value of the 'bomb attack' activity. However, she pointed out that the students had problems understanding the second part in which they projected the shrapnel. In relation to the activity 'testimony', she recommended including visual references. She explained:

"*The students did not understand the content very well. This part needs a visual support. At least for our students, so that they are able to identify themselves with it. It's interesting that the testimony of the children gets a little bit emotional because this way they live it more. You could put a picture of a child. It does not need to be the same who speaks. Or in general photos of children of their age."*

Finally, the activity 'construction of the shelter' was positively valued by the teacher because of its participative and collaborative characteristics.

We also organized a meeting with the guide and a curator in the installations of the museum. For the meeting, we prepared an overview of the results of the last studies and a short video with highlights of student's in-situ interactions and contributions during the co-design sessions. In addition, we made a live demonstration of a set of selected activities of the WaS prototype. The aim of the meeting was to reflect collaboratively upon the findings and define improvements for the next design iteration.

The guide stressed that the 'bomb attack' activity could be too abstract for the children because they had to understand events that happened outside the shelter and connect them with their possible consequences inside. As an alternative, she proposed using sound effects of the explosion of a bomb and then encouraging the students to explore the expansion of the shrapnel on the walls of the shelter. In relation to the activity 'testimony', she suggested using a slideshow of pictures showing different scenarios of children during the war. We also discussed different options to simplify the language of the testimonies and adapt them to the level of a primary school child. However, we decided that this procedure could take the risk of changing too much the original content and we were worried that it could decontextualize the testimony. On the other hand, the guide explained that the wall with the pickaxe marks, on which the activity was performed, worked very well by itself and actually did not need any technological support to generate meaning. At the same time, the testimonies described general experiences about the war and did not specifically refer to the shelter *Refugi 307*. She argued for using only material that directly linked to the cultural heritage site and the people who inhabited it during the war. Finally, she appreciated the participative character of the activity 'construction of the shelter' but explained that she could not imagine how it could work with a functional prototype.

Subsequently, we discussed which of the activities of the first design iteration should be included in the next study. In general, the guide recommended splitting classes into two smaller groups and to include only a few WaS activities in the visit so that there was enough time to explain other aspects of the visit that work well without the support of the VH experience (e.g. the children's room). We decided to include the activities 'behavioural rule sign' and 'infirmary' (Table 9) due to their potential to foster participation and collaboration. They were performed in locations that offered a larger space and allowed group-based activities. We also included the activity 'children's drawings about the war' because the guide particularly highlighted its possibilities to end the guided visit with an activity that stimulated further reflection about the civil war and similar events happening around the world nowadays. In addition, the curator pointed towards the potential of activities that are based on auditory information to evoke emotions and create a shared group experience. She proposed to include an activity in which the students would listen to a radio program originally broadcasted during the war.

5.3.4 Discussion

We have presented a co-design study with primary school children to research the possibilities to include a set of embodied collaborative learning activities using the WaS paradigm in the guided visit of the bomb shelter *Refugi 307*. Our results indicate students' desire for participative and reflective activities. In this regard, we observed a high potential of audiovisual material focusing on auditory contents. Our study showed how using audio can particularly have an influence on how children related to different contents during the guided visit. In the case of the 'bomb attack' activity, the sound effect supported the projected contents and evoked sensations that helped the students to 'step in the shoes' of the civilians. In the 'testimonies' activity it triggered children's imagination and helped them to build connections between different aspects of the educational context. Furthermore, both examples show how audiovisual contents focusing on sound effects do not only immerse the person performing the activity in the experience but also creates a collaborative and shared learning space within the audience. This confirms Hornecker's work (2014) describing how auditory information can add a new sensory layer on the experience that allows the participating students to equally engage in the activity. Furthermore, the students expressed their preference for realistic representations of civilians during the war that transmit their emotional perspective in different situations. Therefore, we decided to use mainly original material provided by the museum library and employ virtual representation only of contents that did not involve the visualization of people.

5.4 Evaluation of learning strategies in public space: a case for Virtual Heritage

The main purpose of this study was to evaluate the user experience with a functional WaS prototype based on a marker-recognition system (Betsworth et al., 2014). We used the markers strategically to trigger contents in specific locations of the shelter in a simple manner. The device recognized markers in physical space and projected virtual content next to the marker on any type of surface. It was composed of an Android Aquaris BQ tablet, a Bluetooth loudspeaker, and a pico-projector. All components were enclosed in a specially designed casing for our prototype (Figure 35).

Figure 35. Functional WaS prototype based on a marker-recognition system

Therefore, we implemented six interactive learning activities in the WaS experience. Five of the learning activities had been explored in previous studies (Section 5.2 and 5.3) using low-tech material and a mid-tech prototype of the WaS system. For these activities, our results indicated a high potential in enhancing student's collaborative learning and perspective-taking in relation to emotional aspects of Spanish war civilians. We employed them again in this study to observe their potential using a functional prototype. Details about the implemented improvements in this design iteration are outlined in Table 10. Furthermore, in this study we aimed to extend our research on children's understanding and the benefits of auditory material (Section 5.3).

Table 10. Overview of the activities using the WaS prototype during the guided visit

Activity	**Description**	**Improvements made for this design iteration**
1: Bomb Attack	One student pointed with the WaS system at a marker at the ceiling of shelter. A video of an airplane dropping a bomb was displayed.	We included the sound of a siren at the beginning of the activity. Due to the interaction limitations of the prototype, we decided to exclude the exploration of the expansion of the shrapnel.
2: Behavioural rule sign	One child pointed on the marker at the wall and a picture of an old sign containing the rules of the shelter was displayed. The guide asked the students to read out aloud the content of the sign.	Located-based projection using the marker-recognition system.
3: Radio documentary	One child pointed on a marker in a shelve. The image of an old radio was displayed. The group listened then to an extract of a radio program that was broadcasted during the Spanish Civil War.	We included this new activity to extend our observations on the benefits of auditory material.
4: Infirmary	One student pointed at a marker placed on the entrance of the infirmary and one part of an image representing a stretcher was displayed. Another student pointed then on this image and the other part of the stretcher was displayed. They were asked to synchronize their movements and to take a virtual person on the projected stretcher safely into the infirmary.	Located-based projection using the marker-recognition system.
5: Construction of the shelter	Eight students were divided into two groups. In each group, one child was in charge of the WaS system. The other three students received a model of a brick that was used as a prop for the activity. They were asked to place each brick in front of a different marker and to point with the WaS system on it. This way, step by step, a virtual arch of a new part of the shelter was displayed.	Exploration of student's interaction with virtual elements and located-based projection using the marker-recognition system.

Activity	Description	Improvements made for this design iteration
6: Children's drawings about the war	Two children compared two different images. One child pointed on a marker at the wall and a child's drawing from the late 1930s was displayed. Another child pointed on a different marker and projected a child's drawing from Syria next to the first one.	Located-based projection using the marker-recognition system.

On the other hand, we aim to research how the WaS experience could enhance students' understanding of underlying socio-cultural values related to the educational context. We decided to focus on socio-cultural values because the initial definition of the project requirements had highlighted that the understanding of these values in the historical context is important to prevent that mistakes from the past be repeated (Section 5.1). Furthermore, the national curriculum of Spanish primary schools foresees teaching socio-cultural values as an essential mission to appreciate norms of our living together, learn to act in accordance with them, prepare for the active exercise of citizenship by respecting and defending human rights, as well as the pluralism of a democratic society (Consejería de Educación Juventud y Deporte de la Comunidad de Madrid, 2014).

In this study, we understand the concept of values as the fundamental elements of the culture. They define the meaning and significance of people within a society. The rules and norms of a society are derived from its values (EuropeanValues.info, 2018). Building on this definition, we focus on the socio-cultural values that were relevant to the understanding of the educational and historical context as follows.

Human Dignity is understood as the rights of a person to be valued and to be ethically tried.

Solidarity is understood as the agreement between and support for the members of a group bonded together due to their same interests, values, and sympathies.

Pluralism is understood as the existence of different types of people who have different beliefs and opinions within the same society.

5.4.1 Procedure

Sixteen primary students (girls = 7, boys = 9; mean age = 11.27 years) participated in the evaluation study that was organized in three consecutive sessions (WaS condition). We compared the outcomes with the findings based on a study using the same procedure with sixteen students participating (girls = 8, boys = 8; mean age = 10 years) in the traditional guided visit. The children came from the same school (Section 5.3) but from a different class than the students in the previous study (TGV condition). Before the study, we provided the parents of the students with a content form in which they were informed about and asked for their agreement on data collection and dissemination (A typical consent form is presented in the Annex of this thesis).

The first session was held in the school and had a duration of 60 minutes. Two researchers and one teacher facilitated the activities during the session. Its main goal was to introduce the children to the learning context and to evaluate their previous knowledge and comprehension of socio-cultural values about the learning context. First, we handed out a questionnaire to each child aimed at assessing their understanding of the educational context. The questionnaires were based on open-ended questions that children were asked to complete such as *"Which situations did the civilians experience during the war? How did it make them feel?"* The children were encouraged to give multiple answers. We then facilitated an activity based on the board game *Pictionary (A detailed description of the analysis of this technique is presented in Section 5.5.2)*. In previous studies, we have used this technique as a playful strategy to elicit and understand children's previous knowledge of conceptual learning goals (Schaper et al., 2014). Our approach follows a three-step procedure. First, the researcher selected a set of terms and concepts related to the addressed socio-cultural values (Table 11) and wrote them down on post-it notes that were stored in a box. The selected terms were previously discussed with the teachers and museum educators to focus them on the main educational goals of the visit. Second, during the activity, one child at a time was asked to randomly pick one of the notes and to represent the term on it through drawings on a large blackboard. If the child did not know the term s/he could discard it and pick a new one. The rest of the children had two minutes to guess the term. Third, to finalize the activity, researchers, the teacher and the children revised and discussed the discarded terms together. Subsequently, we watched the same 5-minute video clip of a documentary on the Spanish Civil War as in the previous studies. After the video, we asked the students if they had any questions about the Spanish Civil War and the visit to the shelter for the next day.

Table 11. Terms used during the Pictionary Technique

Human Dignity	**Solidarity**	**Pluralism**
war refugee collective trauma soldier	individualism citizen association	protest coup exile passive defence dictatorship

The second session was conducted during the visit in the shelter of the archaeological site. The students in the WaS condition were divided into two groups so that each child had the opportunity to use the WaS system during an interactive learning activity at least one time. The students in the TGV condition went all together into the shelter. Each visit had a duration of 60 minutes. We proceeded in the same manner as during the second session of the previous study. After the visit, we handed out a questionnaire to each child. The goal was to research how their worldviews around the educational context had changed. Therefore, we asked them *"How do you feel about the civilians of the Spanish Civil War after the guided visit?*

The third session took place in the school and had a duration of 90 minutes. Two researchers and one teacher facilitated the activities during the session. We conducted the *Reflective Drawing Technique* in the same manner as in the previous study. After that, the students were randomly divided into groups of four to five members. We gave each group a different term that was related to one of three socio-cultural values (human dignity – collective trauma; solidarity – citizen association; pluralism – passive defence). We provided each group with the same fifteen photos depicting different situations during the Spanish Civil War. A description of each photo is reported in Table 12. (Due to copyright restrictions, we are not allowed to publish some of the photos described in this table). The material was provided by the library of the Barcelona History Museum. The students were instructed in selecting pictures that would represent their understanding of the different terms and to complement them with a written description. The researchers then went around with cameras and recorded a short interview with each group about their reflections. The purpose of this activity was to evaluate if the children had a deeper understanding of the concepts related to socio-cultural values after visiting the shelter and participating in the learning activities using the WaS system.

Table 12. Descriptions of the photos used for the collage activity

Photo number	Description
P1	Children digging up a hole for the construction of the shelter.
P2	Two children hiding under a bridge.
P3	Two children playing in front of a destroyed building.
P4	Civilians on a street escaping with their families.
P5	Destroyed buildings of the city Barcelona.
P6	A bomb attack on the city centre of Barcelona.
P7	A group of civilians digging up a tunnel for the shelter.
P8	A warfighter in the air.
F9	Soldiers at the front
P10	A woman volunteering as a nurse in the shelter.
P11	A group of people carrying an injured person on a stretcher.
P12	A group of women demonstrating for their rights.
P13	Three women sitting on the benches in the shelter
P14	A person waiting during the bomb attack in the shelter.
P15	Empty tunnels of the shelter.

5.4.2 Data collection and analysis

To research how the activities based on the WaS system shaped the children's experience during the guided visit, we triangulated data from the analysis of (1) open-ended questionnaires, (2) video recordings of workshop activities and in-situ interactions with the prototype, (3) the analysis of the drawings and (4) the analysis of the interviews. We followed the procedure as follows.

Analysis of open-ended questionnaires

The open-ended questionnaires were first transcribed. The written contributions were analysed using the NVivo 11 software, we extrapolated results according to the three common values of the European Union defined as *human dignity, solidarity,* and *pluralism* (EuropeanValues.info, 2018). We compared then student's previous worldviews with those after the visit.

Analysis of video recordings

We first watched all videos of the sessions and interviews of the drawings and the collage activity. Subsequently, the researchers visualized the selected videos in slow-motion several times, with and without audio, to transcribe the resources employed by the children in a descriptive format. We also made screenshots of significant body actions and organized them in a storyboard format (Figure 36). For the analysis, we focused on the following resources: *body postures, facial expressions, gaze, verbal expressions, and social and spatial interactions.*

A child points at the marker and the first part of the projection appears	The other child points at the first projection and the second part of the image appears	The guide asks the other children to make space for the activity	The two students move the virtual stretcher in a synchronized way along the wall	One student looks at the rounded finish of the wall at the end of the tunnel

Figure 36. Example of significant body actions during the WaS activity 'infirmary' organized in a storyboard format

Analysis of drawings

To analyse the drawings, we employed a mixed approach that combined content analysis and multimodal analysis according to the approach presented in Malinverni et al. (2018). One researcher reviewed all the drawings to define a set of grounded categories based on the elements that were included in the drawings (see Table 13 for a summary of the identified elements). The researcher analysed then the drawings to mark the elements that were included or excluded from each drawing.

Table 13. Categorization of the elements included in the drawing

Category	Description of pictorial element
Device	The child draws the device
Props belonging to physical space	The child draws any physical elements of real space where the action took place.
Virtual element	The child draws any virtual elements of the story
First-person agent	The child draws himself carrying the device
Peers	The child draws his peers

After this preliminary activity, we analysed the drawing according to a multimodal approach based on Kress' theoretical framework (Kress, 2010). This analysis was oriented toward interpreting what were the most important elements of the drawings. To this end, we analysed the layout of the drawing, the relative arrangement of the elements in the drawing, their relative size, their position on the paper, the presence of other elements, and the level of detail (Kress, 2010). The outcomes were first analysed for the students that participated in the Virtual Heritage experience and then contrasted with the findings with the group in the TGV condition.

Analysis of interviews

To analyse the interviews, we employed a content analysis approach. Specifically, one researcher completely transcribed the interviews. The transcripts of the interviews about drawings were analysed focusing on children's user experience. Instead, the transcripts of the interviews about the collages were analysed using the coding scheme based on the three common values.

Analysis of the collage

To analyse the collage, we counted how many photos the students used in each collage and how many aspects they described in their written and verbal contributions. These findings were then compared between the two conditions.

Finally, we merged (1) the data of in-situ interactions, drawings and interviews to interpret the user experience of the students with the prototype and (2) the data of open-ended questionnaires, *Pictionary Technique*, collage and interviews to grasp children's changes in socio-cultural values.

5.4.3 Results

In this section, we first report the results obtained for the students in the WaS condition (Figure 37). Specifically, we focused on students' user experience (*first-person agent, collaborative experience, potential to foster imagination, influence of digital augmentation and situatedness and interactions during the educational experience*) and conceptual changes of socio-cultural values related to the educational context (*human dignity, solidarity, and pluralism*). Subsequently, the outcomes of each category were compared with students' contributions in the TGV condition.

Figure 37. The six educational activities based on the WaS prototype: (1) bomb attack; (2) behavioural rule sign: (3) radio; (4) infirmary; (5) construction of the shelter; (6) children's drawings about the war

5.4.3.1 Students' user experience with the WaS prototype

The WaS activities that the students remembered the most (Figure 38) were the 'bomb attack' (4 out of 16 students) and the projected drawings comparing the Spanish with the Syrian Civil War (4 students). Our findings based on the in-situ interactions and interviews depicted that both activities had a strong emotional impact on the children and helped them to empathize with civilians from the Spanish Civil War. During the activity 'bomb attack', the students made scared faces when the sound of the alarm began. When the virtual airplane dropped the bomb, the students followed the animation with their gaze, expressing astonishment by opening their eyes and mouth wide (Figure 37.1). After the activity, one child concluded: *"The people must have been scared. They probably couldn't eat or sleep."* In the interview, two children explained that they had been scared during the activity. One girl even stressed that during the activity she had wished not to be there. Another student concluded that the civilians during the war constructed the shelter because they were afraid of the bomb attacks. During the WaS activity 'children's drawings about the war', the students were astounded that the drawings included the representation of bomb attacks and dead people (Figure 37.6). They also explained that the drawings transmitted the feelings of sadness and compassion. One child explained: *"I felt bad because the children thought a lot about the war and how they suffered."* Three students drew the activity 'radio' (Figure 37.3), two students the activity 'behavioural rule sign' (Figure 37.2) and two students the activity 'construction of the shelter' (Figure 37.5). One student represented the activity 'infirmary' (Figure 37.4). This student expressed that he was particularly worried about the virtual person on the stretcher and imagined that this person could die during the transport. This comment may indicate that the children could empathize with the health conditions of injured civilians during bomb attacks and understood the time pressure to bring them to the hospital.

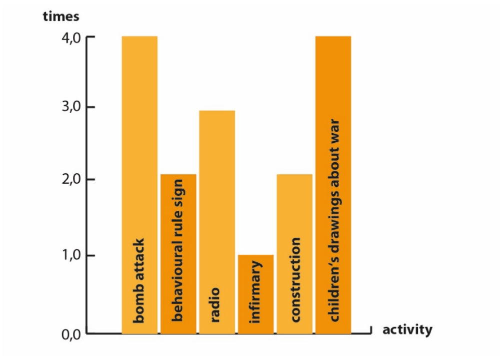

Figure 38. Distribution of the WaS activities that the students found most interesting

Further analysis revealed that children's educational experience was influenced by several aspects such as if the students were in charge of using the device, the presence and actions of others during the activity, the content of the audiovisual augmentation and the locations they were located. I describe each aspect now in detail and compare them with results of the *Reflective Drawing Technique* in the TGV condition.

First-person agent

In the WaS condition, most children (10 times) drew the activity in which they were holding and interacting with the prototype. During the interview, five children explicitly highlighted that they liked the activity the most because they had been in charge of the WaS system (bomb attack: 1; radio: 2; construction: 1; drawing: 1). A possible reason for this preference could be the first-person experience which caused a sense of ownership for the activity. For instance, in one interview a student explained (Figure 39.1):

Student: *"My drawing is about the activity in which they drew the war in Spain and in another country."*
Researcher: *"In Syria. Why did you draw this?"*
Student: *"Because I did the activity."*
Researcher: *"Was there another activity you found interesting?"*
Student: *"No, I did only this one."*
Researcher: *"Yes, you did this one. But did you like one of the others in which you did not use the projector?"*
Student: *"No."*

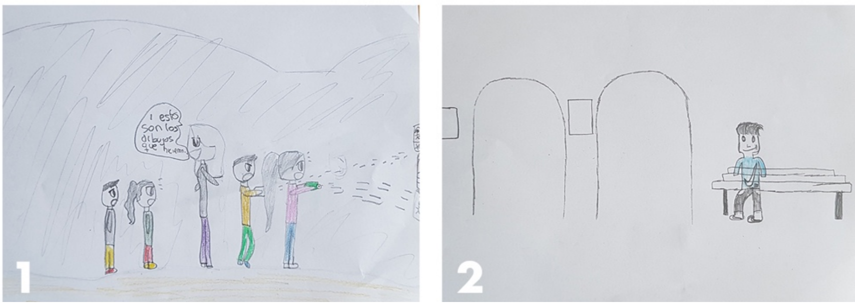

Figure 39. (1) A girl drew herself using the Was prototype during the activity 'children's drawings about war'; (2) A student during the traditional guided visit representing himself alone in the physical space.

In contrast, four students in the TGV condition drew themselves alone in the physical space (Figure 36). In the interview, three of these students described mainly the physical space that surrounded them in the drawing (e.g. the zig-zag shape of the tunnel, the benches, the children's room, the infirmary and the bathroom's space (Figure 39.2). These findings could point towards the potential of the WaS prototype to actively involve the students in the guided visit and to direct their attention to the educational contents. Another interpretation could be that students' desire to interact with the device caused that they paid less attention to the physical space.

Collaborative experience

The results of the first design iteration of the WaS paradigm (Section 5.2) has revealed that the students who did not use the prototype represented themselves in a group and as passive spectators. Thus, our goal in this study was to increase the participation and collaborative experience of the students. This aim involved both students using the device and observing their peers that interacted with it. In the WaS condition, 8 out of 16 students represented groups of their class members in their drawings. Specifically, four students (children's drawings about the war: 3; infirmary: 1) acted as *collaborative performers* (Figure 41), i.e. they drew themselves and their peers who were performing the WaS activity together with them. For instance, in the 'children's drawings about the war' activity, a girl represented herself next to her classmate, each one projecting a different image (Figure 40.1). Three children (bomb attack: 1; behavioural rule sign: 1; radio 1) acted as *participative spectators* (Figure 41), i.e. they drew their peers performing and themselves participating in the activity through verbal and non-verbal interactions. For instance, they collaboratively read aloud the behavioural rule sign (Figure 40.2) and pointed at different details in 'children's drawings about the war' (Figure 37.6). Only one child acted as a *passive spectator* (Figure 41) and drew other students from the class.

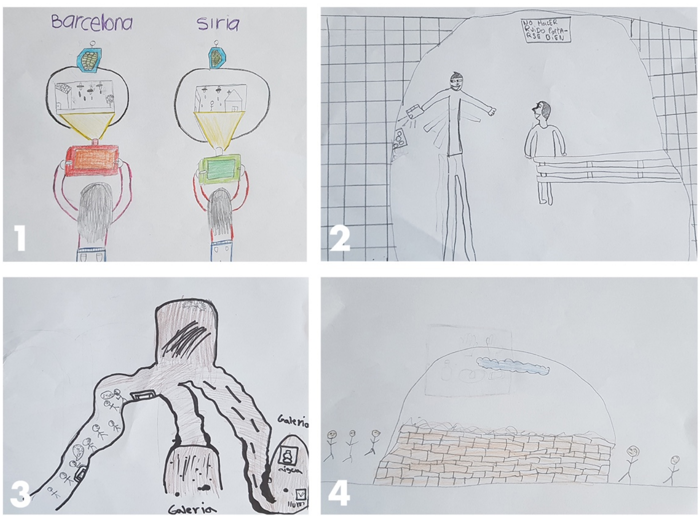

Figure 40. The students represented themselves with other peers: (1) using the WaS prototype in a collaborative activity; (2) participating in the WaS activity performed by others; (3) Students commenting on the guide's explanations during the traditional guided visit (TGV); (4) A student represented other students of his class during the traditional guided visit (TGV).

In the TGV condition, 7 out of 16 students drew group representations. Only one student highlighted verbal interactions between the guide and a child in his drawing (Figure 40.3). In the remaining six group representations, the students acted as *passive spectators* of the shelter (Figure 40.4). Four students represented themselves alone (*individual experience*) and only five the *physical space*. These results (Figure 41) indicate that the students in the WaS condition tended to feel more involved during the WaS activities than during the traditional guided visit.

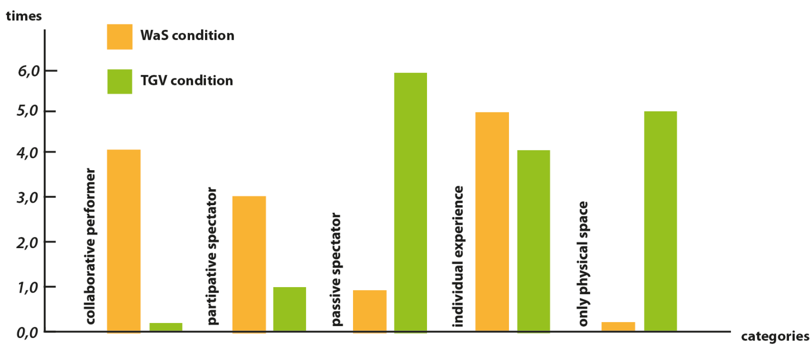

Figure 41. Drawings of the students representing their experience during the World-as Support (WaS) activities and traditional guided visit (TGV)

Potential to foster imagination

In the WaS condition, three students (1 bomb attack; 2 radio activity) drew presentations of war scenarios they imagined. Specifically, they included representations of civilians during bomb attacks. During the interviews, one student who drew the activity 'radio' specifically mentioned the presence of children in the shelter. She imagined them scared of the bombs and anxious about losing someone in their family (Figure 42.1). In addition, our observations of in-situ interactions of the 'infirmary' activity showed that the children tried to personify the virtual character on the stretcher asking for his name and inventing one. When the students arrived at the end of the tunnel, one boy asked:

"What is the name of this guy?" The guide said: *"Who?"* The boy pointed at the injured person in the projection and said: *"This one."* Another child answered: *"Pepe!"*

Instead, in the TGV condition, the students represented only details of one specific location (9 students) or a general floor plan depicting several locations (7 students) that had caught their interest (Figure 42.2). This result may show how the WaS activities added an additional imaginative layer on the experience. In a sense, the virtual experience brought the physical space alive and revealed the presence of people from the past embodied in the physical space.

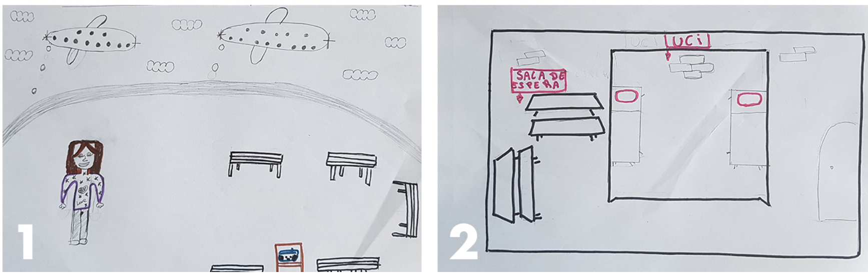

Figure 42. (1) A child imagined the presence of a civilian in the shelter during a bomb attack (WaS condition); (2) A child represented the infirmary with its physical characteristics (TGV condition).

Influence of digital augmentation and situatedness

Twelve students in the WaS condition represented the device in their drawings. The size of this pictorial element was proportional to the rest of the image. Ten students represented the physical space of the shelter in their drawings through benches, walls, arches, etc. Interestingly, in nine of those drawings the physical space was very dominant, i.e. proportionally larger than the rest of the elements and people represented. Also in the interviews, the students often highlighted features of the physical space. For instance, a student explained that the activity 'bomb attack' was done next to the bathrooms. For the activity 'radio', one student mentioned the benches on which they were sitting during the visit and another two described the tunnel of the shelter. Finally, in the activity 'construction of the shelter' one student mentioned that they had been in an enclosed space. Another student reflected upon the capacity of the shelter to hold many people.

Twelve students drew the virtual elements of the projections. Six times the virtual elements were represented in a dominant size e.g. in the middle of the picture and very detailed. The representation recalled the main context of the activity but the content was often invented. For instance, for the activity 'behavioural rule sign' one student wrote on his representation *"In the shelter, it is not allowed to be nervous"*. The original sign asked the civilians to be silent in the shelter to avoid agitation. For the activity 'children's drawing about the war', the students produced different compositions. All of them included the main pictorial elements of the original projection, i.e. houses, airplanes dropping bombs and injured people or people defending themselves with weapons. Five children drew the virtual elements proportional to the rest of the image. Only one child represented the virtual elements in a subordinate way by "squeezing them" in one corner of the image.

In contrast, all sixteen drawings in the TGV condition focused on the representation of the physical space and details related to each location. The students did not include any pictorial elements that were related to the explanations of the guide in the traditional visit. These findings may suggest that the students in the WaS condition were still aware of their presence in the shelter. However, they could make connections between the physical space and the educational content that was supported by the digital augmentation.

Furthermore, analysing the interviews highlighted deficiencies in the activity 'construction of the shelter'. Our goal of the activity had been to collaboratively construct an arch of the shelter. The guide had chosen this activity to illustrate the specific method of building that was typical for the region of Barcelona. However, two students explained that during the activity they constructed a wall. Another three referred in their explanation to *"the activity with the bricks"*.

Also, our observations during the visit showed that some children did not understand that they had constructed an arch. This issue may have been caused by a low visibility of the projection during the activity. The resolution of the projector allowed the user to visualize only fragments of the image (Figure 43). At the end of the activity, the guide had demonstrated how the different fragments were connected and formed the arch. Probably, due to the group size and narrow space in the shelter, not all students had the same visibility and attentively followed the demonstration of the image. On the other hand, this activity could point towards the benefits of directing student's attention to small details in the physical space rather that large-scale projections.

Figure 43. A girl representing herself during the activity 'construction of the shelter' visualizing one part of the virtual arch.

Interactions during the educational experience

During the guided visit, we could observe that the WaS activities triggered a wide range of verbal and non-verbal interactions between the participants as in the elements described in the following paragraph (Table 14).

The activities prompted *group discussions*. For instance, during the 'bomb attack' activity, the students discussed which emotions the civilians experienced during bomb attacks. In the 'radio' activity they talked about historical events during the war and how nowadays shelters were constructed considering the technological advances in military weapons.

The activities *supported explanations* of the guide. For instance, students and a teacher pointed at different details within the projected drawings (Figure 37.6). Another example is the activity 'construction of the shelter' (Figure 37.5). The students collaboratively constructed brick by brick a virtual arch. The projection helped the guide to better explain the typical way of building in the region of Barcelona.

The activities *directed the gaze of the observer* through the physical space, e.g. the trajectory of the airplane dropping the bomb on the ceiling of the shelter (Figure 37.1). Another example is the 'infirmary' activity. While the students carried a virtual stretcher out of the shelter, their attention was directed towards one specific physical characteristics of the space. The focus was on the rounded finish around the corners on the walls that allowed a faster and safer transportation of injured people during the war.

The activities encouraged collaborative actions. For instance, during the activity 'behavioural rule sign' (Figure 37.2).

One child pointed towards the marker at the wall and immediately the sign appeared. Several children who were sitting on the benches stood up and started to read out aloud the content of the sign. The guide explained that the sign was original and it was timeworn. She encouraged the children to read it out again and pointing at different words of the sign. She helped them read those that they could not decipher. The child who was using the WaS system also actively participated in the collective reading.

The activities encouraged role-play within the entire group. For instance, during the activity 'infirmary' the guide explained:

"Usually you needed two people but also other people helped with the injured person. So now two of you will do the same. Let's see how you manage it." The guide asked the other children to leave a corridor between the wall and them so that the two children using the WaS System could pass. The guide said: *"So you two would be the doctors."* One researcher indicated the first child to point at the marker and one half of the projection appeared. The guide pointed at the projection and asked*:*

"Who do you see here?" One child answered: *"A man."* The guide added: *"The man is carrying a stretcher."* The researcher indicated the other child to point at the first projection to initiate the second image. He also explained that now the two children had to move their images in a synchronized way towards the other end of the tunnel. Otherwise, the second image would disappear and they had to start the activity again. The guide pointed at the direction the children had to go. The children started moving very slowly and carefully. The guide said: *"And the rest has to make space for the doctors."*

The activity 'infirmary' is also an example of the potential of the prototype to promote a 'notion of effort' (Lyons et al., 2012) that may help children to empathize with sensations that civilians experienced during the war. In other words, due to the technical features of the prototype, in this activity the children had to move very slowly and carefully to carry the stretcher. Otherwise, the second image would disappear. Similarly, during the activity 'construction of the shelter' one student in the interviews described the building method as difficult. Another child mentioned that you needed a lot of patience for the construction and that the projector was very heavy. Finally, in the activity 'children's drawings about the war', the two performing students had to remain still so that a focused image was projected and their peers could observe the details. This technical issue of the prototype turned out to be a useful feature to promote interactions between the students. On the one hand, the students who analysed the drawing indicated the performing students to keep the image stable to project it on specific surfaces of the wall that increased the contrast and visibility of the image. On the other hand, the performing students assumed an important role in leading and maintaining the collaborative activity among them.

The activities fostered children's abilities in perspective-taking. For instance, the activity 'drawings of children about the war' allowed the students to compare different viewpoints on war in two different countries. In the activities 'infirmary' and 'construction of the shelter', the students performed similar actions to those of civilians during the war.

Table 14. Overview of possible interactions promoted by the WaS prototype during the guided visit

Activity/ Interaction	Prompt discussions	Support explanation	Direct gaze	Collaborative actions	Role-Play	Notion of effort	Perspective-taking
Bomb attack	civilians' emotions during the bomb attack	alarm system of Barcelona during bomb attacks	ceiling and trajectory of the plane	shared auditory experience	-	-	step in civilians' shoes during a bomb attack
Behavioural rule sign	-	organization of people using the shelter	original, timeworn sign	- collaborative reading - guide helped to decipher different words	-	-	-
Radio program	links to present war strategies	- historical events - way of communication during the war	in-built shelves of the shelter	shared auditory experience	-	-	- original radio program broadcasted during the war
Infirmary	identity of injured person on the stretcher	original use of infirmary during a bomb attack	- trajectory of the transport -rounded finish of the walls to facilitate transport	- transport stretcher - make space in corridor to transport stretcher	- the performing students become doctors - other students' civilians in the shelter	synchronization of movements to maintain projected image	performing similar physical action that people in the past
Construction of the shelter	-	typical way of building in Barcelona	-	eight students worked together to construct the arch	students become civilians that constructed the shelter	prompts of physical bricks to construct arch	performing similar physical action that people in the past
Children's drawings about the war	-pictorial elements to represent war	close the guided visit with a reflection upon the role of war in our society	pointing on details in the drawings	shared observation of the drawings	-	stabilize image and search for projection surface to facilitate observing details in the picture	comparison of children's perceptions of the war in two different countries

5.4.3.2 Changes in the understanding of socio-cultural values

Our analysis of students' understanding of socio-cultural values in relation to the historical context focused on the three categories *human dignity, solidarity, and pluralism.* We compared students' worldviews between the two conditions (WaS and TGV), before and after the visit. The outcomes were based on findings extracted from open-ended questionnaires, observations during the *Pictionary Technique* and the collage activity.

A) Students' worldviews before the visit

Human dignity

The results based on the open-ended questionnaires showed that the students described emotions and situations that sharply conflicted with the socio-cultural value *human dignity* (Figure 44). They described expressions (WaS: 27; TGV: 34) that were related to the notion of fear. Some students mentioned specific situations that are attributed to this emotion such as mortal danger, experiencing bomb attacks, losing relatives and friends, experiencing pain, being a refugee and not being able to continue with everyday practices (e.g. shopping and playing football). The students described situations related to sadness (WaS: 6; TGV: 5), i.e. the conflict situation, destroyed towns, the fact that the even former friends were fighting against each other and about the geographical distance between family members. The students described situations related to nervousness (WaS: 8; TGV: 8). Some children imagined this emotion in situations when the civilians heard noises of fights, bombs, and explosions during the war, the need to handle weapons and the uncertainty in civilians' daily lives. Other expressions (WaS: 5; TGV: 12) were related to loneliness, hunger and the will to live. An overview of the differences between the two conditions is illustrated in Figure 44.

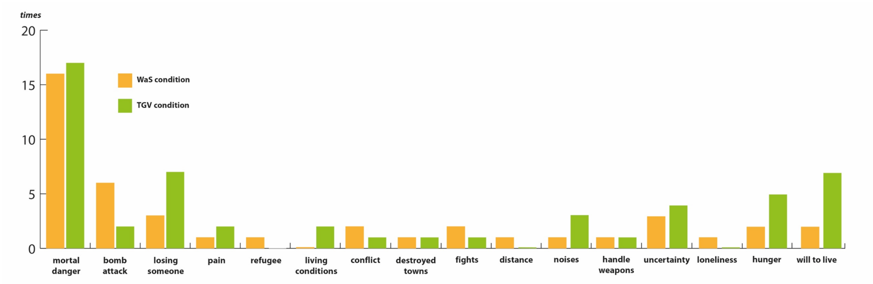

Figure 44. Overview of situations and emotions that children described in relation to their idea of the concept of war.

Additionally, our observations during the *Pictionary Technique* revealed the children in both conditions expressed these negative feelings also on a multimodal level, i.e. we analysed students' body language while performing the activity and the facial expressions that the students used for figures in the drawings. The findings depicted that the students used facial expressions, both through mimic and in their drawings, illustrating feelings such as fear and sadness to express the emotional perspective towards concepts such as *soldier*, *war* and *refugee* (Figures 45.1 and 45.2). In contrast, the term *collective trauma* was rejected because the children did not exactly know its meaning. Finally, the group discussions indicated that even before the visit of the shelter the students could imagine and empathize with civilians during the Spanish Civil War. However, they were not aware of the long-term effects for the war survivors and its relevance for the Spanish society today.

Figure 45. A student represented a soldier with a sad facial expression in the (1) WaS condition and (2) TGV condition.

Solidarity
The results based on the open-ended questionnaires showed that the students described different situations (WaS: 7; TGV: 5) of civilians during the Spanish Civil War that were related to the concept of solidarity, i.e. sharing the same interests, helping mutually in critical situations, curing injured people, supporting other's escape, sharing supplies and constructing a shelter. An overview of the differences between the two conditions is illustrated in Figure 46.

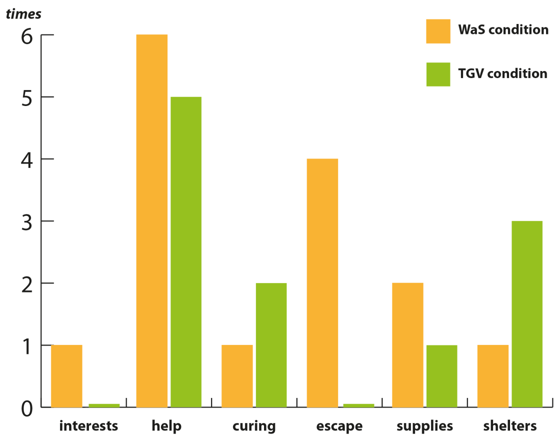

Figure 46. Overview of the situations that children in relation to the concept of 'solidarity' in the two conditions

During the *Pictionary Technique*, a student in the WaS condition who drew *citizen association* attributed the term to the idea of "help" between neighbours. A boy drew a bomb attack on a house and neighbours rushing to help and putting out a fire (Figure 47.1). Students in the TGV rejected the term during the activity because they considered it too difficult to draw. However, during the group discussion, the students explained that the term referred to a meeting of people from the same neighbourhood aimed to make decisions together.

As a representation of the term *individualism*, a boy in the WaS condition drew one person wearing a cap and holding a gun. The figure confronted a group of three other people piled up as a human tower. The first person was drawn significantly larger than the other figures (Figure 47.2). This finding points towards the representation of power relations between different figures and illustrates the child's sensations of courage and cohesion when acting collaboratively in a group. On the other hand, it depicts that the child struggled to put the term into the historical and political context. In the TGV condition, the term was rejected because the students considered it too difficult to draw.

Pluralism

The analysis of the open-ended questionnaire did not depict any aspects of children's worldviews on the socio-cultural value *pluralism*. Our results of the *Pictionary Technique* showed that the students correctly understood and represented the term *protest*. In both conditions, the students showed the term by several people carrying banners (Figure 47.3).

Instead, the findings for the term *coup* pointed towards misconceptions of students in the WaS condition in relation to this value. The student who drew the term represented a person in front of a tank (Figure 47.4). Further discussions between the girl and the researcher revealed that the drawing represented the famous iconic image of the "Unknown Protester". The original photograph was taken on 5th June 1989 when the Chinese military suppressed the Tiananmen Square protests in Beijing. The "Unknown Protester" temporarily stopped the advance of a column of tanks (Saul, 2014). The Chinese dictator regime considered this situation as a coup. However, in the Spanish society, most people would compare it to the 15-M movements in 2011 when students protested and demanded political and economic changes in the country. In our study, the girl who drew the iconic image had an Asian background and her understanding about politic issues was probably primed by her social environment. In contrast, her peers did not associate the drawing with the iconic image and guessed terms related to the idea of "attack" and "war". These findings highlight that the students had difficulties grasping the concept of pluralism as the existence and tolerance of different beliefs and opinions within the same society. In the TGV condition, the term was rejected during the activity because the students considered it too difficult to draw. However, in the group discussion, one girl explained the term the meant that as a group of people deciding to empower the ruling government using violence.

The terms *dictatorship*, *exile*, *repression* and *passive defence* that were related to the value pluralism were rejected in both conditions during the game and group discussion.

Figure 47. Student represented the terms (1) citizen association, (2) individualism, (3) protest and (4) coup.

To sum up, the students in both conditions had a similar previous knowledge on the educational context and shared similar socio-cultural values than the students in the WaS condition. We could only reveal meaningful differences in their understanding of the terms *individualism* and *coup*. An overview of the outcomes is briefly presented in Table 15.

Table 15. Overview of difference in students' worldviews of the socio-cultural values human dignity, solidarity, and pluralism in the condition WaS and TGV before the visit

	WaS condition	**TGV condition**
Human Dignity	The students mentioned emotions that sharply conflicted with the value: *fear* (27 times); *sadnes*s (6 times); *loneliness (1 time), hunger (2 times) and courage (2 times).* In the *Pictionary Technique,* the terms *soldier, war and refugee* were associated with the emotions sadness and fear. The term *collective trauma* was rejected.	The students mentioned emotions that sharply conflicted with the value: *fear* (34 times); *sadness* (5 times); *hunger* (5 times) and *courage* (7 times). In the *Pictionary Technique*, the terms *soldier, war and refugee* were associated with the emotions sadness and fear. The term *collective trauma* was rejected.
Solidarity	The students described 7 situations related to this value. The term *citizen association* was associated with the notion of help between neighbours. **The term *individualism* was associated as a disadvantage in contrast to acting collaboratively in a group (sensations of courage and cohesion).**	The students described 5 situations related to this value. The term *citizen association* was described as a meeting of people from the same neighbourhood aimed to take decisions together. **The term *individualism* was rejected.**
Pluralism	The students represented the term *protest* through people with banners. **The term *coup* revealed socio-cultural differences within the class in relation to the notion of the right of protest.** The terms *dictatorship, exile, repression,* and *passive defence* were rejected.	The students represented the term *protest* through people with banners. **A student explained the term coup as the act of people that decide to empower the ruling government using violence.** The terms *dictatorship, exile, repression,* and *passive defence* were rejected.

B) Students' worldviews after the visit

Human Dignity

The findings of the open-ended questionnaire showed that the students (WaS: 11; TGV: 8) reported that they felt sad and compassion with the civilians because they suffered during the war. Three of these students in the WaS condition made further conclusions on the situation. The first child stressed that nobody (outside Spain) came to rescue the civilians. Another student concluded that in this war even family and friends fought against each other. He also explained that the city of Barcelona had been the testbed for the Italian air force. The third mentioned children that were affected by the war. Instead in the TGV condition, three students specifically referred to the accident in the children's room of the shelter in which two siblings were injured during a bomb attack. One student mentioned injured and dead people in general. Another child concluded after the visit that the shelter was an uncomfortable space to live as a refugee. These outcomes depict that the students in the WaS condition reflected upon higher level issues of the Spanish Civil War. Instead, the observations of the students in the TGV condition stayed very close to aspects that they had been told during the visit.

The analysis of the collage activity showed that students in the WaS condition used more photos (WaS: 4, photos: P4, P7, P9, P11; TGV: 2, photos: P2, P4) to express the meaning of the term 'collective trauma' and described more aspects in the semi-structured interviews (WaS: 7; TGV 3). In the interview, the students in the WaS condition mentioned four aspects that could have traumatized the civilians: (1) not being able to finish a shelter before the bomb attack begins; (2) the need to escape (3) dead people and the possibility of dying themselves and (4) the need to fight. The students in the TGV condition described three aspects. Two of them (situation 2 and 3) were the same as in the WaS condition. In addition, the students stressed how the effects of a bomb attack in the city traumatized the civilians.

Solidarity

Our findings in the open-ended questionnaire showed that the students described situations of civilians during the Spanish Civil War that were related to the concept of solidarity, i.e. they reported that (1) bomb attacks were specific situations when civilians needed help (WaS: 4), they highlighted that that (2) injured people were supported by other civilians (WaS: 7; TGV: 11), (3) they described constructing a shelter as a collaborative activity between the civilians (WaS: 10; TGV: 13) and (4) the students highlighted that men went to the frontlines to fight (TGV: 1).

In the collage activity (Figure 48), students in the WaS condition used more photos (WaS: 9, photos: P1, P2, P4, P7, P10, P11, P12, P13, P15; TGV: 1, photo: P12) to express the meaning of the term 'citizen association' and described more aspects in the semi-structured interviews (WaS: 6; TGV 2). In the interview, the students in the WaS condition mentioned six aspects to describe this term. Two aspects were related to concrete actions: (1) construct shelters and (2) helping injured people. Four aspects highlighted the meaning that they associated with the term: (1) teamwork, (2) power, (3) willingness and (4) compassion. The students in the TGV condition described two situations that were the same (situation 1 and 2) in the WaS condition. These outcomes illustrate that students in the WaS condition were more capable of grasping the essential qualities of the socio-cultural value 'solidarity'.

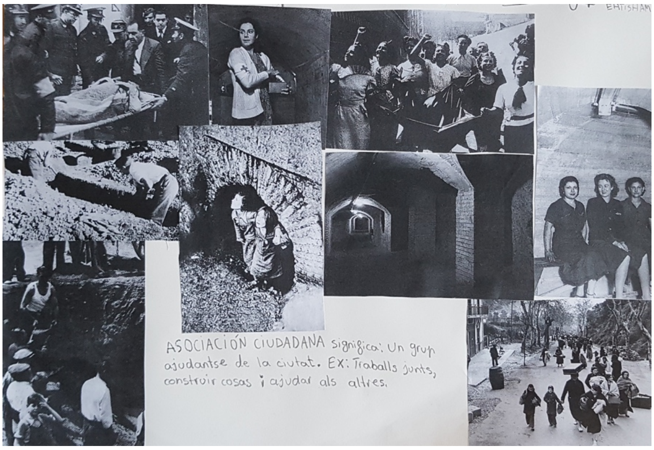

Figure 48. Collage of the WaS group who represented the term "Citizen Association".

Pluralism

Our findings in the open-ended questionnaire showed that the students (WaS: 2; TGV: 1) reflected upon the shelter as a form of passive defence. The two children in the WaS condition reported that they were glad that the people had found a possibility to save themselves.

In the collage activity, students in the WaS condition used more photos (WaS: 6, photos: P2, P4, P10, P7, P12, P15); TGV: 3, photos: P2, P13, P10) to express the meaning of the term *passive defence* and described more aspects in the semi-structured interviews WaS: 4; TGV 2).

In the interview, the students in the WaS condition mentioned four aspects that describe the meaning of the term: (1) defend themselves without weapons; (2) hiding in a shelter; (3) manifestations and (4) escaping with others. In addition, one child mentioned that currently, many people participated in manifestations. He was referring to the current events in Barcelona in relation to the request of independence of Catalonia. The students in the TGV condition described two situations that were the same (situation 1 and 2) than in the WaS condition. These outcomes point towards the possibility that the students in the WaS made connections between historical events and present political situations in Barcelona.

Summarizing the differences of children's conceptual changes between the two conditions (Table 16) showed that the students who participated in the VH experience used more photos and described more aspects in the semi-structured interviews to express the meaning of the three socio-cultural values. This finding may indicate that the VH experience allowed the students to acquire a wider range of aspects in relation to the traditional guided visit. Specifically, we concluded that these students deepened their reflections upon the severity of civilian's situations during the war in relation to more higher level issues than the students in the TGV condition. One finding may also point towards the potential of the VH experience to foster student's capacity to make connections between past and present political events. Finally, in both conditions, the students extended their comprehension of the terms citizen association and passive defence with respect to their knowledge before the visit. However, students in the WaS condition also attributed the term *citizen association* to meaningful qualities of the value of solidarity.

Table 16. Overview of children's conceptual changes on the socio-cultural values human dignity, solidarity and pluralism after the guided visit in the WaS and TGV condition

	WaS condition	**TGV condition**
Human Dignity	The students used four photos (P4, P7, P9, P11) to express the meaning of the term *collective trauma* and described seven aspects in the semi-structured interviews. The students deepened their reflections upon the severity of civilian's situations during the war in four higher level issues: • Nobody (outside Spain) came to rescue the civilians. • This war had been against their own people.	The students used two photos (P2, P4) to express the meaning of the term *collective trauma* and described three aspects in the semi-structured interviews. The student's reflections upon civilian's situation during the war stayed very close to aspects that the guide had been explained during the visit. They extended their reflections only on one higher level issue:

	WaS condition	TGV condition
	• Barcelona had also been the testbed for the Italian air force. • Children had also been victims of the war.	• Children had also been victims of the war.
Solidarity	The students used nine photos (P1, P2, P4, P7, P10, P11, P12, P13, P15) to express the meaning of the term *citizen association* and described six aspects in the semi-structured interviews. The students could describe some essential qualities of the value 'solidarity'. • teamwork • power as a group • willingness • compassion	The students used one photo (P12) to express the meaning of the term *citizen association* and described two aspects in the semi-structured interviews.
Pluralism	The students used six photos (P2, P4, P10, P7, P12, P15) to express the meaning of the term *passive defence* and described four aspects in the semi-structured interviews. • One student makes connections between the term passive defence and manifestations in relation to current political events in Barcelona.	The students used three photos (P2, P13, P10) to express the meaning of the term *passive defence* and described two aspects in the semi-structured interviews.

5.4.4 Discussion

In this study, we evaluated students' user experience of an educational VH experience based on a functional WaS prototype. We also compared its benefits to foster the comprehension on socio-cultural values in opposite to students who participated only in a traditional guided visit. Our findings showed that the students tended to feel more involved during the WaS activities than during the traditional guided visit. The WaS activities had promoted a wide variety of verbal and non-verbal interactions between the students such as group discussions, collaborative performance, perspective-taking, role-play, etc. These activities allowed the students to experience the educational content in a playful way and directed their attention to different aspects of the historical context. We will now discuss the limitations observed in this study and outline ideas for future design iteration of the VH experience.

Designing for socio-cultural values

From an educational perspective, the VH experience helped the students imagine how civilians experienced the war in the shelter and make connections between the physical space and the educational context. Specifically, activities that involved auditory information proved to stimulate in-depth reflections on these two aspects. These learning processes enhanced students' capabilities (1) to reflect upon higher level issues that conflicted sharply with the value *human dignity*, (2) to grasp some of the essential qualities of the socio-cultural value *solidarity* and (3) to connect historical events with present political situations in Barcelona. However, our study showed that there is still a need to enhance students' comprehension on other concepts related to the value *pluralism* such as coup, dictatorship, exile, and repression. Future work could include activities that allow the students to reflect upon these concepts and understand their meaning in the educational context. For instance, in the previous study (Section 5.3), the students had proposed a game that dealt with the conflict between Republicans and people that were in favour of the dictator Franco. This idea could give designers inspiration for activities related to political aspects around the Spanish Civil War.

Orchestrate different types of user experiences

Interestingly, some of the limitations that we observed during the interaction with the prototype revealed potential features for the design. On the one hand, during the activity 'construction of the shelter', the children could project only fragments of a large-scale image of a virtual arch. This limitation was caused by the given resolution of the projector. However, this feature could specifically be used as a metaphor for the notion of a "Magical Lantern". In other words, this feature could create the sensation of exploring the space with a physical spotlight and illuminate interesting details in the shelter that complement the explanations of the guided visit. On the other hand, in the activity 'children's drawings about the war', the students had to search for smooth surfaces to provide a good visibility of the projected images. This feature showed to evoke a sensation of physical effort in the children. It could be used for activities aimed to transmit this sensation and allow students to better empathize with civilians' actions during the war. Consequently, both features could be very useful to orchestrate different types of user experiences with the VH experience.

Future improvements of the prototype

However, due to the small sample size of the evaluation study, we argue that the results provide only a snapshot of the ways in which children could benefit from an educational experience based on the WaS interaction paradigm. Further research is needed to confirm our observations and explore the full potential of the WaS system with a more advanced prototype. We are currently developing a new system that recognizes physical characteristics in the space and augments site-specific locations with audiovisual contents. For instance, this feature could allow us to include the activity of the shrapnel after the simulation of the bomb attack (Section 5.3). This activity aims to encourage the students to explore the expansion of the shrapnel on the wall of the shelter. In further research, we envision also to capture user interactions with the projected images and trigger context-specific digital feedback. For instance, in the 'radio' activity, the users could interact with digital buttons of the device and change to different radio programs.

5.4.5 Conclusions

Overall, this project contributes to the body of advanced interfaces by presenting and evaluating an educational experience based on the WaS interaction paradigm for primary school children in the context of CH. Our studies indicate a first set of benefits of using digital augmentations and collaborative activities based on embodied exploration. On the one hand, it allowed children to explore the physical environment in meaningful ways and to construct meaning by discovering new layers of the educational experience. Also, the enactment of specific situations allowed the students to more directly experience historical content during the visit that required emotional engagement, critical thinking, collaborative learning and the comprehension of socio-cultural values. In future studies, we will explore further potentials of this approach with an advanced prototype.

5.5 Co-Design Techniques to research children's worldviews

In the project *Refugi 307*, we explored a set of co-design techniques to elicit children's worldviews and understanding to research requirements for the design of the VH experience and user experience of the prototype (Table 17). Most of these techniques are commonly used in the Child-Computer Interaction community. However, we made some adaptions to adjust their procedure to the context and needs of our project.

Table 17. Overview of co-design techniques used in the different design stages of the project Refugi 307

Design Stage	**Technique**	**Goal**
Requirements	Open-ended questionnaire	Research children's interests in relation to the educational context
	Semi-Structured Interviews	Research teachers and museum staff ideas to redesign the guided visit
	Dwelling Space	Understand children's interests in relation to the educational context and impact of

Design Stage	Technique	Goal
		being situated in the shelter
	Map Activity	Research what the children remember the most from the guided visit
	Storyboarding	Research children's interests and personal values in relation to the historical context, and how they contextualized it in their present time.
	Brainstorming	Collecting ideas to re-design the guided visit
	Low-tech prototyping	Translate these ideas in an interactive experience
	Bodystorming	Explore the designed ideas
	Group Presentation	Reflect collaboratively upon children's proposals
1st Design Iteration	Reflective Drawing	Elicit and understand the children's impressions and reflections upon the activities
	Semi-Structured Interviews	Understand representations in children's drawings, research the guide's impressions and reflections upon the activities
	Brainstorming	Reflect upon improvements for the prototype
Co-Design Workshop	Bodystorming	Exploring possibilities for collaborative activities during the guided visit
	Reflective Drawing	Elicit and understand the children's impressions and reflections upon the activities
	Semi-Structured Interviews	Understand representations in children's drawings, research the guide's and museum curators' impressions and reflections upon the activities
	Brainstorming	Reflect upon improvements for the prototype
2nd Design Iteration	Open-ended questionnaire	Research children's individual worldviews on socio-cultural values
	Pictionary	Research children's common worldviews on socio-cultural values
	Reflective Drawing	Elicit and understand the children's impressions and reflections upon the activities
	Collage	Elicit and understand children's common

Design Stage	Technique	Goal
		worldviews on socio-cultural values
	Semi-Structured Interviews	Understand representations in children's drawings and collages

In this Section, I reflect on three techniques, titled *Dwelling Space Technique*, *Pictionary Technique,* and *Reflective Drawing Technique,* to outline their possibilities in the design of Full-Body Interaction and non-formal learning contexts. For the analysis of the techniques, the same approach was used as presented in Chapter 4.1, i.e. first we identified the play practice that each technique evoked according to Karoff's (2015) view on play. We clustered then the data of the descriptive transcriptions and manual contributions for each technique (Table 19) into the *Embodied Design Thinking* (EDT) qualities.

5.5.1 Dwelling Space Technique

The technique is based on the principles of the KidReporter method (Bekker et al., 2003) that proposes a playful activity for children in which they investigate a specific topic by pretending to be a journalist of a newspaper team. In our project, each group received a map of the shelter and was asked to choose the place that had caught their attention the most. The students were then instructed to imagine that they were recording a report on the *Refugi 307* for a local TV channel. Each child was randomly assigned to a different role and asked to act as a reporter, a cameraman or an interviewee. They were encouraged to go to their mutual place of interest in the shelter and record a short video of approximately two minutes about why their group chose that place and what made it the most interesting part of the shelter to them. In a consecutive workshop session, we conducted with the same students a redesign activity of the guided visit in which we analysed how their physical presence in the shelter had influenced their proposals. For this analysis, we took into account brainstorming ideas written on paper sheets and group interviews conducted by one researcher. These findings were finally compared with a control group with students that participated in almost the same procedure of the activity, except that they recorded the interviews outside the shelter. The goal was to understand how using the *Dwelling Space Technique* shaped sensory and cognitive implications of students' observations.

Our results showed that the technique promoted a play practice related to the views of 'sliding for devotion' and 'shifting for intensity'[8] (Karoff, 2015) depending on the role that the child was assigned to (check Table 1, Chapter 4.1 as a reminder for these terms). Students in the reporter and cameraman role tended to be very focused on their task and hardly moved within the physical space. Instead, the students in the interviewee role explored the spatial qualities of the shelter through their body, i.e. they touched holes in which originally a stretcher was attached, knocked on the wall to demonstrate how it was made and moved actively around to show different aspects in the physical shelter. These actions gave them an intense feeling of presence and motivated them to look for wide range of sensorial clues to support their explanation. Due to the time limitation of the video clip, some of the children moved fast, sometimes unpredictable, from different places within the same space to show these sensorial clues.

Comparing children's behaviour in the two conditions showed that the children who used the *Dwelling Space Technique* seemed to be more engaged with the learning topic. Our conclusions are based on children's behavioural patterns in-situ. The children were very concentrated and thoughtful during the activity. They seemed to be deeply moved while explaining certain events and the difficult living conditions inside the shelter. They gave much detailed information

[8] The main characteristics of the play practice 'sliding for devotion' is related to the actions of following space and following each other in the play rhythm. In contrast, 'shifting for intensity' refers to the actions of expanding space and changing the play rhythm now and then. The full description can be found in Section 4.1.

and showed their empathy through illustrative gestures. In contrast, the children using the technique outside the CH site tended to perceive the activity as a game and were more likely to transform it into a playful dance or theatre performance (compare two different examples of each condition in Table 18).

Analysing children's contributions during the redesign activity revealed how being situated in the physical space during the *Dwelling Space Technique* primed children's interests. The interviews showed that they were particularly interested in how the characteristics of the physical space had an impact on people's experiences in the shelter. For instance, the children mentioned that the rounded finish of the walls around corners facilitated the transport of injured people on stretchers. During the redesign activity, the children proposed possible enactments within the physical space, e.g. using a pickaxe and a shovel to construct new parts of the tunnel and discover hidden aspects in the cultural heritage site. Thus, we decided to include activities in the guided visit based on children's proposals for enactments. We assumed that these activities would allow children to "embody" actions from the past (Flynn, 2013) and better empathize with Spanish war civilians who helped to build the shelter. By performing the same actions as these people, they could perceive the notion of physical effort (Lyons et al., 2012) that civilians made to save their lives and those of others.

Table 18. Overview of co-design techniques used in the different design stages of the project Refugi 307

Inside the shelter	**Outside the shelter**
Reporter: Hi girls, you have chosen the infirmary. Why is this the most interesting location for you? *Girl A:* It is the safest place. This is because it is in the centre of the shelter. (*The girl folds her hands and presses them sturdily together to empathize that the location is safe.)* *Girl A:* It is more protected because they brought here the people that were seriously injured. Do you see these holes? *(She points with one hand onto the holes and then touches one hole with a finger).* Here were the stretchers placed. *Reporter:* What do you think about the idea to construct an infirmary? *Girl B:* Very good, the most injured people could be treated. Here were two tables and here a shelve *(showing the original locations in the space)* and there they stored the medical treatment. *Reporter:* Thank you very much for the interview.	*Cameraman:* Hi, I am E. and now I will present you an interview about the *Refugi 307*. We will interview M. *(girl A comes on stage, waving her hands and laughing)* and A. *(girl B comes on stage, makes a small jump, raising her hands in the air and laughing. Girl A and B hug each other).* And J. *(girl C. enters on stage and the other two shake her hand).* Well, we can start now with the interview. *Reporter:* What did you like about the *Refugi 307*? *Girl A:* The infirmary. *Reporter:* Why? *Girl A:* Because it is the location where they brought the most injured people. For me, it was interesting that a man could find a way to bring their family to a safe place *(she puts one hand on the chest to express her emotions.)* *Girl B*: I like the echo that you could hear when you knocked against the wall. *(The girl enacted a knocking gesture.)*

We observed that the children who had the opportunity to explore the shelter a second time seemed to have obtained a better understanding about the main purpose of the shelter which was to protect the civil population against bombing attacks. These observations were grounded on children's contributions during the co-design workshop. These children tended to report on more situations or emotions related to the notion of protection. In contrast, the children in the other condition mainly recalled emotions related to fears or uncomfortable situations in the shelter.

Moreover, the children who did not use the physical space as a reference seemed to have a stronger focus on more general personal experiences of people during the Spanish Civil War. One of the children's desires was to personally meet a war survivor. Other children were astonished about people's living conditions during the war. Another interesting finding was that in their proposals these children referred only to events that had been explained in the introduction session of the guided tour. This session took place before the children entered the shelter. They mentioned general events, only indirectly linked to the learning topic and based on contemporary issues in our society such as the use of nuclear bombs.

In general, we observed that the role-play activity created an atmosphere in which the students felt more comfortable to give their opinion with relatively little influence from authority figures, such as guides, teachers or opinionated classmates. In a sense, they did not feel self-conscious about providing their opinion, nor were they afraid of what others might think (Bekker et al., 2003). On the other hand, the activity motivated the children because they had the opportunity to revisit the shelter and explore one specific space in detail. The fact that the students were asked to look around the shelter and record a video clip of the aspects that they were really interested in, helped them think about why they had actually chosen the location and thus their decision-making process of which explanation to give. Finally, the activity helped to overcome different levels of children in expressing themselves verbally because they could include visual clues and body language. This allowed the researchers to assess children's contributions on a multimodal level.

Limitation of the technique

We argue that the technique could be more effective if the redesign activity would be conducted on-site. This procedure would allow the children to explore different aspects of their proposals motivated by their own interests and leave them more time for discovering new aspects of the learning content at their own pace. In the presented study, the researchers become "children's agents" by observing their interpretations and listening to their design proposals around the educational context. However, the definition of the concrete activities for the interactive experience was only made by the adults in the design team. This procedure takes the risk that children's preferences could come into conflict with the pedagogical goals (Scaife and Rogers, 1998). Thus, the goals may be misinterpreted or even neglected.

5.5.2 Pictionary Technique

We proposed the *Pictionary Technique* as a playful strategy to elicit and understand children's worldviews of conceptual learning goals such as socio-cultural values. This elicitation technique involves children in an activity based on the mechanics of the board game called Pictionary™. In previous research, it has been used as an assessment tool to define semantic models and perceptual properties of word referents (Kievit-Kylar and Jones, 2011). Goodman (2003) investigated how the technique could enhance the role of instructors to understand learners. In our research, we broaden previous research by following a multimodal approach (Kress, 2010) which focuses on the analysis of the multiple resources that children employ during the activity (e.g. oral expressions, drawings, and body language).

In our project, we used the *Pictionary Technique* to research children's worldviews on socio-cultural values on the Spanish Civil War. Our goal was to evaluate how familiar children were with concepts such as solidarity, passive defence, neighbourhood association, individualism, exile, etc. and explore how they represented them. Our technique followed a three-step procedure. First, the researchers selected a set of terms and concepts related to the addressed learning goals and wrote them down on post-it notes that were stored in a box. Second, during the activity, one child at a time was asked to randomly pick one of the notes and to represent the term on it through drawings on a large whiteboard. If the child did not know the term s/he could discard it and pick a new one. The rest of children had one minute to guess the term. Third, to finalize the activity, researchers and children together revised and discussed the discarded terms.

Our results showed that the technique promoted a play practice related to the views of 'sliding for devotion' and 'displaying for tension'[9] (Karoff, 2015) i.e. the students were very focused on their task. All movements concentrate on the drawing activity. Within the group were little discussions on the game rules because authority figures gave clear instructions and intervened in case they were not respected. On the other hand, time pressure and the fact that one student was performing in front of his class evoked a sensation of tension and competition. The play rhythm started slowly but speeded up according to the remaining game time. The time-based structure avoided that the children got lost in representing details and helped them focus only on expressing the main signification of the term.

The technique allowed us to grasp children's shared worldviews and understanding of the educational context. It also depicted differences between the students who actively participated in the activity. The drawings also revealed children's emotional perspective considering facial expressions and size, postures and proportion of the represented people to other pictorial elements (Oğuz, 2010).

[9] The main characteristics of the play practice is 'sliding for devotion' related to the actions of following space and following each other in the play rhythm. In contrast, 'displaying for tension' refers to the actions of staging space and the rhythm of swinging according to one's own style. The full description can be found in Section 4.1.

Limitations of the technique

The *Pictionary Technique* has shown to be effective in revealing children's previous knowledge, underlying values, and worldviews in educational contexts. However, this technique is mainly suitable to address conceptual learning goals. Hence, it is limited or even unsuitable to address other educational goals (e.g. procedural learning) that do not strongly rely on the understanding of concepts. Furthermore, the employment of this elicitation technique has an impact on the power relationships between children and adults in the design team. In the *Pictionary Technique*, the researchers observe children's interpretations around the educational context during activity. However, the definition of the educational goals for the interactive experience was only made by the adults in the design team. This procedure takes the risk that children's preferences could come into conflict with the pedagogical goals (Scaife and Rogers, 1998) and, thus, be misinterpreted or even neglected.

5.5.3 Reflective Drawing Technique

The technique is based on an activity in which children are asked to draw themselves during the interactive experience. Subsequently, the researchers interviewed them about their user experience and the different elements represented in the drawings. The aim of the activity is to elicit children's feedback on the educational experience and on using the prototype (Nicol and Hornecker, 2012). Previous research has shown that drawings elicit a large amount of accurate information due to its benefit that no previous training is required (MacPhail and Kinchin, 2004). Drawings are particularly easy to produce by children at all ages and overcome children's verbal difficulties to express their opinion and describe certain situations (Sylla et al., 2009; Xu et al., 2009). In our research, we used this technique to understand children's preferences for different activities and their user experience with a prototype.

Our results showed that the technique promoted a play practice related to the view of 'sliding for devotion'[10] (Karoff, 2015) i.e. during the activity, the students interacted very little verbally with each other. Each child remained still on her/his seat and worked very focused on the drawing task. The drawing allowed the students to mentally recall the experience and to highlight different aspects from their perspective. They uncovered not only usability issues of the prototype, complementing them with individual interviews revealed children's opinions and sensations during the user experience. The drawings were used as the starting point for the interview and allowed us to focus on what was important to the child and to gain their trust in talking about something personal to them (Nicol and Hornecker, 2012). This approach flattened the power relations between children and researcher because the child was allowed to express their personal opinion on the user experience and felt proud of explaining something that s/he had created. During the interview, we also drew children's attention to specific pictorial elements to ask what they represented. This procedure revealed content that children imagined, e.g. for auditory material, or how they made connections between contents of different activities.

On the other hand, an in-depth analysis of the drawings allowed us to uncover aspects that children had not verbally expressed. For instance, the proportion between the representation of the physical space in comparison with people, helped us to understand how much being situated in the physical space influenced students' experience. Analysing the facial expressions of the represented people, their body posture, their body size in comparison with the rest of the composition and the number of people represented provided us with information about children's emotional perspective during the interactive experience and socio-cultural values within the group (Farokhi and Hashemi, 2011; Oğuz, 2010).

[10] The main characteristics of the play rhythm 'sliding for devotion' is related to the actions of following space and following each other in the play rhythm. The full description can be found in Section 4.1.

Limitations of the technique

We have observed that in some cases the children tended to copy each other's drawings (Section 5.4.3), i.e. the students in the same group represented the same activity and even chose a similar composition. In this case, the drawing can inform us about the social dynamics within a class. The drawing may still be used as an entry point for the interview. However, it may not provide sufficient insight into children's user experience and other elicitation tools should be considered to address these shortcomings.

Table 19. Summary of the data analysis using the Embodied Design Thinking qualities

EDT qualities	**Dwelling Space**	**Pictionary**	**Reflective Drawing**
Play practice	(1) reporter and cameraman: 'sliding for devotion' - focused on the task - hardly moved within the space (2) interviewee: 'shifting for intensity' - bodily exploration of spatial qualities - actively looking for a wide range of sensorial clues to support their explanations - due to time limitation, fast movements between different places within the same space	'sliding for devotion' and 'displaying for tension' - focused on the drawing task - time pressure and being on stage evoked a sensation of tension - play rhythm started slowly but speeded up according to the remaining game time	'sliding for devotion' - focus on drawing task - interacted very little, verbally or otherwise
Emergence	children's understanding of the relationship between the physical space and people inhabiting it	elicitation and understanding of children's worldviews on socio-cultural values in relation to the educational context	uncover not only usability issues but also aspects of the user experience and children's opinion

EDT qualities	**Dwelling Space**	**Pictionary**	**Reflective Drawing**
Contingency	possible enactments within the physical space to embody other people's experience	–	understanding impact of the physical space on the experience
Playful Engagement	- role-play made them feel comfortable - motivated them because of the opportunity to revisit the shelter and explore one specific space in detail	- created a playing atmosphere of competition	a creative way of expressing themselves and their opinions
Social Dialogue	no self-consciousness about providing their opinion, nor were they afraid of what others might think	revealed if the children shared a common or opposite view on a specific concept	- revealed socio-cultural influences within the class - drawings were used as a starting point to guide the researcher's questions during the interview
Embodied Memory	video clips captured their in-situ behaviour within the physical space	drawings revealed their emotional perspective and worldviews in relation to the represented term	- drawings allowed them to mentally recall the experience - drawings revealed their emotional perspective and worldviews in relation to the interactive experience
Reflective Imagery	helped them think about why they had chosen the location	- time-based structure avoided getting lost in representing details - helped them to focus only on expressing the main significance of the term	represented relations between different activities
Embodied Awareness	- being situated and experiencing sensorial aspects of the physical space helped them to empathize with other people's felt-experience	representation focus was on the body and on physical actions	representation focus was on facial expressions and body postures
Relationality	- flattened power relations between	drawings allowed to detect power relations	flattened power relations between

EDT qualities	Dwelling Space	Pictionary	Reflective Drawing
	children and researcher - allowed to explore person-environment interactions in-situ	between people represented	children and researcher

5.6 Critical Reflection upon the design process

We carried out a critical analysis focusing on (1) children's roles in the design of the VH experience and (2) by which decisions they were influenced. Therefore, we first researched how children's participation was influenced by adults' assumptions on childhood (Section 5.6.1). Second, we analysed how the different ideas for the WaS activities emerged and how they transformed during the design iterations (Section 5.6.2). Finally, we take this project as a showcase to point towards opportunities to improve the collaboration within a design team and to promote the notion of *symbiotic agreement* between the design partners (Section 5.6.3).

5.6.1 Orchestrating experts' assumptions and children's values in the design of Virtual Heritage experiences

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The contemporary conception of childhood often describes children as independent agents with their own opinions and knowledge (Iversen and Dindler, 2013; Schaper et al., 2014). However, there are different discourses that underpin the understanding of childhood. Grounded on this premise, museums and cultural heritage sites have an increasing interest in adapting their educational programs to novel learning approaches that allow children to autonomously explore learning contents (Allen, 2004). In the Child-Computer-Interaction community, these different notions influence the way the community designs for and with children. Thus, children have been acknowledged as valuable stakeholders to inform and participate in museum design practice for technology-oriented exhibitions (Dindler et al., 2010; Roussou and Ave, 2007; Taxén, 2004).

Regardless of the contemporary perspectives on the notion of childhood, adult stakeholders hold different assumptions about children's agency and their role in the design process. These assumptions may be influenced by stakeholders' personal perspective on the learning topic, cultural influences, teaching methodologies, or ideologies. Due to children's limited role and agency in some of these perspectives, their voices are still too often absent in the design practice of technology-oriented museum exhibitions (Dindler et al., 2010). This can be critical because, while visiting a CH site, for instance, children's experiences and perspectives may not be necessarily aligned with the expectations of content professionals (Smith, 2012). However, children not only have a right to be heard and their views taken into account (Mayall, 2001), but their contributions may also give valuable insights on their interests and understanding of the CH content and the interactive learning experiences.

In the design of interactive technologies for children, these frictions have been increasingly discussed in the community. Dindler and Iversen (2014) point out that designers and other participating stakeholders should reflect upon the values and lenses that they bring into the design process. The authors argue for the need for achieving a *symbiotic agreement* among the viewpoints and objectives of stakeholders. The purpose of this study is to extend this theoretical framework by proposing strategies that facilitate designers and researchers to balance power relations among stakeholders. In this section, I focus on the different assumptions made about children's roles and how they have influenced the design process.

5.6.1.1 Data collection and analysis

For this study, our data collection was obtained through notes and audio recordings that we took during three project meetings with a museum expert, an educational expert and three members of our design research team. The team from the museum was specialized in cultural heritage and educational museum activities. Our design team contributed with an interdisciplinary background in design, engineering and cognitive media technologies. Furthermore, we audio recorded individual semi-structured interviews with three guides and four teachers from three different local schools that visited the *Refugi 307* with their class. We also video recorded verbal expressions and behaviours of a total of 40 children (girls = 18; boys = 22; mean age = 10.78 years old) during two guided visits and three co-design sessions. Finally, we included documents related to reflections upon our final results in our data archive. Altogether, the data archive of the study comprises 277 files that were included in the analysis (see Table 20).

Table 20. Overview of the study data archive

Field of data	Type of data source	Number of documents
Meeting with museum experts and design team	Audio recordings	2
	Annotations (from 2 researchers)	4
		Total 6
Interview with tour guides	Audio recordings	3
	Annotations (from 2 researchers)	6
		Total 9
Interview with teachers from three different schools	Audio recordings	2
	Annotations (from 2 researchers)	3
	Written response via e-mail	1
		Total 6

Field of data	Type of data source	Number of documents
Data collection from guided tour	Video recordings Annotations (4 researchers) Semi-structured questionnaires with the children	2 4 40 Total 46
Data collection from three co-design sessions	Video recordings (video per group and activity) Annotations (3 researchers) "Map Activity" activity sheets Storyboards Brainstorming notes	56 9 10 40 10 Total 125
Results and related documents	Summaries of the findings Master's thesis on the project Conference paper	6 1 1 Total 8

Two researchers reviewed the overall material and performed an analysis focusing on participants' behaviour and extracted explicit statements related to their assumptions. This procedure was derived from an interdisciplinary approach based on Critical Discourse Analysis (CDA) (van Dijk, 1993). Scholars (Iivari et al., 2015) in the field of human-computer interaction have employed the evaluation method to analyse power relations and domination in socio-political contexts, e.g. between different "actors" in the design process. These structures are commonly expressed through statements (e.g. in form of language, drawings or technological artefacts (Spiel et al., 2016)). In our study, we focused on the oral and written contributions of the stakeholders. Our analysis started with carefully reading the data archive described above. Potential statements were extracted using NVivo11 software and synthesized into one document. To facilitate the comparison of viewpoints, we kept the statements of each stakeholder group (museum experts, teachers, designers, and children) in a separate column. We reviewed the data and coded the statements according to repeated concepts that reflected the stakeholders' ideologies. We detected the repeated concepts as follows: (1) stakeholders' cultural values related to childhood (solidarity, respect, empathy, identity, enjoyment, ignorance, incompetence and influenceability), and (2) their expectations of the children's role and agency in the design of the VH experience (empowerment, co-creators, active participation, informants, guided learning, collaborative learning, educator-controlled learning). Two researchers then discussed and compared the produced discourses which were based on the stakeholder's ideologies and attitudes expressed in the statements.

Finally, we wished to reveal a general outline of differences in the discourses of the stakeholders relating to childhood and children's roles in the design process. To do so, we categorized the outcomes according to a theoretical framework that represents a discursive construction of the concept of childhood. This framework was originally proposed by James, Jenks, and Prout (1998) through which they identified the following categories: the evil child, the innocent child, the immanent child, the naturally-developing child, and the unconscious child. This framework was further developed by Skovbjerg and Bekker (Skovbjerg et al., 2016), who adapted it as a card tool to work with values on children's roles in design. In the following section, we report a summary of our findings.

5.6.1.2 Results

Tables 21 to 24 show a selection of data collected on the assumptions expressed by the different stakeholders. We have numbered each statement to facilitate the discussion around multiple perspectives of the same aspect.

Childhood, children's cultural values, and agency

In our study, we observed that the stakeholders of this project had different perspectives on how they perceived children today and which cultural values they attributed to them. To summarize our findings, we grouped these perspectives according to the following concepts: a) The natural-developing child, b) The unconscious child, c) The immanent child and d) the children's own perspectives. The first three concepts used were derived from Skovbjerg and Bekker's card tool, called CHIld PerspectiveS In Design (CHIPS). These cards were presented during the workshop titled "Being Explicit about Underlying Values, Assumptions and Views when Designing for Children", held at the International Conference on Interaction Design and Children in 2016 (Skovbjerg et al., 2016).

a) The natural-developing child

Our findings indicated that the assumptions of museum educators and teachers about childhood were strongly encompassed in the natural-developing child motif (Ackermann, 2004). This category is based on the Piagetian Developmental Theory which suggests that a child's cognitive development is biologically rooted. Consequently, children's capabilities are judged according to predefined age expectations. Adults are supposed to guide and control children's learning activities. This view also implies the need to assess, grade and rank children's achievements against other peers and the "norm" (James et al., 1998).

In our study, museum educators and teachers shared the notion of the natural-developing child view. Our results were supported by the stakeholders' statements as follows. One main goal of history education is to foster children's competence in understanding and reflecting upon historical events and their consequences (21.1a). In alignment with these goals, we identified assumptions on children's capacity for reflection upon aspects related to empathy (5 statements), solidarity (3 statements) and identity (2 statements). However, teachers and educators expressed that to develop these capabilities, children need to be supported by guided and collaborative learning activities (11 statements). For instance, in their opinion, children at that age (10-12 years old) are capable of understanding historical contexts and adopting others' perspectives by illustrating examples of children at their age (Table 1.b). At school, the students undertook preparatory activities to help them connect historical events with their own identity (1c). Teachers and educators regarded children's empowerment (1 statement) and active participation (2 statements) as being important for their development (1d). Nevertheless, they considered that teachers are superior to a child (4 statements), that they have control over the learning approach and the children's participation in the activities (1e). Therefore, children's participation during a typical guided visit took place by answering previously prepared questions prompted by the guide, which were elaborated together with the teacher (1f).

Table 21. Selection of statements related to the stakeholders' assumptions towards the notion of 'The natural-developing child'

Role of actor	Statements	Source
Educational Expert (museum)	(1a) (Our aim is) to foster the children's ability to understand that we must not fall back into these (historical) conflicts.	Interview with museum experts and designers
Teacher	(1b) It is interesting that they learn during the guided visit about the age children were when they went to war and about their responsibilities.	Interview answers sent via e-mail
Teacher	(1c) Apart from the traditional methods, the students do an exercise based on a genealogical family album and they research for information about their grand- and great grandparents.	Interview after the guided visit to the shelter
Teacher	(1d) In class, we talk about the visit and what we are going to see. We leave the children time to explain what they know and do not know about the context. But only as an oral activity and with those who choose to participate.	Interview after the guided visit to the shelter
Teacher	(1e) If we make groups for the recording activity inside (the shelter), they must be supervised. If not they would misbehave and damage the installations.	Interview answers sent via e-mail
Teacher	(1f) (Together with the guide) we prepared questions to see if the students discovered them.	Interview after the guided visit to the shelter

b) The unconscious child

The perspective of the unconscious child is derived from Freud's theory of personality. In this sense, childhood is considered the root of adulthood, a time of needs, demands and unconscious instincts that will eventually form the adult's personality and capabilities. The role of the educator is to shape children's behaviour and guide them in the right direction. However, children's learning activities should be a balance of both discipline and enjoyment to achieve positive learning responses.

We observed that curators and guides shared the same assumptions on children's tendency towards ignorance (3 statements) about historical and social contexts, the inability to understand and complete certain tasks (2 statements), and their influenceability (2 statements) through their environment. For instance, they assumed that children are not aware of the privilege of living in a developed country with a number of social benefits (Table 22.2a). In their opinion, children's personal values are shaped by their family and school environment (2b). Thus, the experts stressed the important role and power of the educator (3 statements) to guide children in the "right" direction (2c). Hence, the learning contents of the guided visit have been defined in the context of the school curriculum and obeying individual teachers' needs and interests (2d). They believed their mission is to teach children that our state of welfare is a fragile condition, and to transmit that errors from historical events from the past should not be repeated (2e). Therefore, they highlighted the importance of transmitting values concerning aspects related to solidarity (3 statements), respect (4 statements), and empathy (5 statements) through educational activities. For instance, our findings showed that curators and guides believed that children often have problems to show empathy for other people's sorrow. They especially noted a lack of empathy when digital media (such as videos) are involved (2f).

Table 22. Selection of statements related to the stakeholders' assumptions towards the notion of 'The unconscious child'

Role of actor	Statements	Source
Curator	(2a) Sometimes the children forget about the fact that here we had a war.	Interview with museum experts and designers
Guide	(2b) When I asked the children where they would go if there was a war in Barcelona, they answered: "to the summer house of our family in France". With other schools with low-income families, these questions usually help them reflect upon people's situations in the past.	Interview with museum experts and designers
Curator	(2c) The narrative of the guided visit, and the work that the educator does, are very powerful.	Interview with museum experts and designers
Curator	(2d) Researcher: How are learning contents for guided visits usually defined? Curator: The learning contexts are based on the contents of the school curriculum. Before the visit, we usually speak to the responsible teacher and then adapt the contents accordingly. Researcher: Have you ever involved children in the planning of the contents of a guided visit? Curator: No, that is like asking children what they want to eat. We would not get any useful answer.	Interview with museum experts and designers
Curator	(2e) What you can give the children is understanding (…) so that they appreciate how lucky they are not to have experienced (the war).	Interview with museum experts and designers

Role of actor	Statements	Source
Guide	(2f) It makes me really sad when in the video (in the shelter) the children watch how a woman falls and they burst out laughing. This occurs sometimes at the end of the guided visit, when they should have learned something. But children struggle with empathy today. The images on the screen have lost a lot in impact with all that they watch today on television.	Interview with museum experts, tour guides and designers

c) The immanent child

Our design team only partially shared the views on children expressed by the other stakeholders. Our values are mainly grounded on the immanent child perspective that understands children from an idealistic view as a "tabula rasa" requiring an adequate environment and guidance for their appropriate development. This view of children also highlights the importance of considering children's needs and interests to promote their learning. Child development is shaped through regulation and socialization.

The results highlighted that our research team tends to start a design process by researching children's needs and is particularly interested in the learning context. We believe that learning contents should be motivated by children's own interests (Table 23.3a) because they can provide an important entry point for children to learn about new contents (Malinverni et al., 2016b). During the design process, we focused our analysis on understanding the core meanings and misconceptions that the children had towards the learning contents. This approach has been seen to be highly effective to define guidelines for the development and improvement of Full-Body Interaction prototypes (Schaper et al., 2014). Thus, we provided the children with a set of design techniques to elicit their reflections about the visit and the learning context. We supposed that these techniques would help them to express their opinions and ideas (empowerment: 3 statements) in an appropriate way. In general, we assumed that, if sufficiently supported, children are capable of making valuable contributions to co-creating content (1 statement) and informing (5 statements) the design of the VH experience (3b, 3c). Building on our analysis, we concluded that the children were capable of grasping values related to solidarity (1 statement), respect (2 statements), and empathy (2 statements). However, we proposed enhancing children's understanding of abstract concepts that embrace these values, e.g. aspects related to changes in society, different standpoints regarding historical events, and the long-term effects of the civil war. Moreover, we regarded the educator as a facilitator who guides the contents and the ways children learn (2 statements). For instance, in this project we aim to design a VH experience that will take place during the guided visit. We proposed participatory activities (3 statements) that could encourage children to discover contents on their own, e.g. make sense of historical aspects in context with the physical space of the shelter through their situatedness and embodied exploration (3d). We thought that not only guided learning but participatory collaborative experiences (Malinverni and Pares, 2015) (1 statement) can give children the possibility to explore and learn about certain topics from different perspectives (3e).

Table 23. Selection of statements related to the stakeholders' assumptions towards the notion of 'The immanent child'

Role of actor	Statements	Source
Designer	(3a) The first step will be to evaluate the children's previous knowledge and their attitudes towards the space. Building on the outcome, we analyse the requirements for the prototype.	Meeting with museum experts and designers
Designer	3b) The children's contributions guide us in relation to aspects we would not have thought of. This greatly enriches our work.	Meeting with museum experts and designers
Designer	(3c) … this is because it has not been explained to them. When I was young,	Meeting with museum experts and

Role of actor	Statements	Source
	sometimes they explained a lot of things to me, but there were others who did not explain anything (about the Spanish Civil War to their children).	designers
Designer	(3d) Our observations confirmed that the guided visit already had a great educational potential to introduce the learning topic to the children. However, we saw several opportunities to complement it through a VH experience (…) by taking advantage of the children's situatedness and combining this experience with the augmentation of "invisible" aspects of the environment. On the other hand, the promotion of specific interactions in the physical space could support the children's meaning making process of the learning contents.	Conference Paper
Designer	(3e) … it stimulates user collaboration in actions that help to reveal layers of the experience that would not have been discovered on their own.	Conference Paper

d) The children's own perspectives

In our study, we also analysed statements expressed by the children related to their interests, understanding, values, and to how they perceived their own agency during the workshop. We observed that the children always adopted a very participative (21 statements) and inquisitive attitude (Table 24.4a). Moreover, they were easily bored by activities that required passive participation only, e.g. listening to the guide (4b). In the re-design activity and during the interviews they pointed out that the visit should include more "fun activities" (enjoyment: 5 statements), e.g. a treasure hunt or a bomb attack drill. They were particularly interested in topics that were concerned with empathy (17 statements) and solidarity (14 statements) such as aspects related to the well-being of family members, animals and other children (4c). These are values they can connect and compare to previous experiences in their own lives. Being in the physical space and experiencing certain characteristics of the shelter helped them to understand other people's feelings in the past (4d). In contrast, they had difficulty to empathize with situations that were very different from their "comfortable" living conditions (4e). On the other hand, the children explicitly expressed how they wanted to be treated the same way as adults (empowerment: 2 statements) by being confronted with reality (4f, 4g). In contrast, when we asked the children to "re-design" the guided visit, most of them mentioned that they liked the visit as it was or proposed only small modifications (incompetence: 3 statements) such as using photos to illustrate explanations. One child pointed out that they could not think of any new ideas because they had no previous experience in this task (4h).

Table 24. Selection of statements related to the children's own perspectives

Role of actor	Statements	Source
Museum Expert	(4a) Primary school children are so participative that we do not know where to cut children's questions. It is good that they engaged and have an interest.	Meeting with museum experts and designers
Designer	(4b) After a few minutes of the guided visit, the children get distracted, start playing with their peers or look around the shelter.	Observation during guided visit
Child	(4c) One day in 1937, a father and a mother died in the war and their daughter was left all alone.	Storyboard
Child	(4d) The infirmary because if you must heal so many injured children with such a small amount of material, perform surgeries… that is very difficult.	Dwelling Space Activity
Child	(4e) Guide: One day without food, you'd eat a plate of fish bones. Children: But not things we don't like to eat!	Guided Tour

Role of actor	Statements	Source
Child	(4f) It's good that they tell us this because we need to know it but it is very sad.	Interview during co-design workshop
Child	(4g) … because this way they do not treat us like children and simply tell how things are.	Interview during co-design workshop
Child	(4h) Because the guy who did it (the tour guide) has more experiences in guided visits than us.	Interview during co-design workshop

5.6.2 Emergence and Transformation of the design ideas

To research how designers' viewpoints on childhood shaped the collaboration and children's participation in this project, we conducted a retroperspective analysis on the design process of the WaS activities. We revised all material used during the design process (in-situ actions, co-design workshop outcomes and definition of prototype activities) and extracted first designers' contributions (children, teachers, museum, interaction designers) in each design stage. This data was then again analysed focusing for each WaS activity on four aspects: *(1) How did the idea emerge? (2) Who proposed the concrete idea? (3) How did the ideas transform during the design iterations? (4) Were there any frictions between designers' opinions on the design ideas?*

5.6.2.2 Results

For the analysis, we considered nine WaS activities, namely: *a) bomb attack, b) behavioural rule sign, c) benches, (d) power generator, e) infirmary, f) construction of the shelter, g) testimonials, h) radio program and i) children's drawings about the war.*

Our findings (summarized in Table 25) showed that 6 out of 9 ideas for the WaS activities were built on observations of children's interests and behaviours during the guided visit and co-design workshops. Only two activities were inspired by student's proposals in the redesign activity in the first study. Four ideas were motivated by concrete educational goals that the museum explained during our first project meeting. Two ideas were based on our observations of the guide's explanations during the visit and possibilities to complement the educational experience using the WaS.

Six of the implemented ideas were proposed by our team, four by the museum and one by the teachers. The evaluation of four activities already achieved a common satisfaction in the first iteration. Two activities were improved to increase students' participation and collaborative behaviour. One activity was based on the museum's previous experience during traditional guided visits and our observations on the potential of auditory material in previous activities. Two activities were excluded because they had either a low potential to promote interactions between the students or we could not access adequate audiovisual material to improve the user experience.

We observed for two activities frictions between the museum and interaction design team. The first differences in opinion was related to children's capability of comprehension on the augmented content. The second divergence was related to the appropriateness and need of using the technological approach at a specific location in the shelter. We will now describe these aspects for each WaS activity in more detail.

Table 25. Overview of the ideation process of the WaS activities

Activity	**Emergence of idea**				**Initiative for idea**			**Transformation**	**Frictions between designers**
	Educational goal	*Guide's explanation*	*Observing children*	*Children's design idea*	*Museum*	*Teachers*	*Interaction designers*	-	-
Bomb attack	X		X	X			X	Increased participation by including a collaborative exploration activity	Differences in opinion on children's capability of comprehension between guide and interaction designers
Behavioural rule sign			X				X	-	-
Benches	X		X		X			Activity excluded due to its low interaction possibilities	-
Power Generator		X					X	-	-
Infirmary	X		X				X	-	-
Construction of the shelter		X		X	X		X	Increased participation by including a collaborative hands-on activity	-
Testimonies			X		X	X		Activity was excluded due to the lack of appropriate audiovisual material.	Differences in opinion on the appropriateness of digital augmentation in a location of the shelter

Radio documentary					X			Activity was a consequence of the benefits of auditory material in other activities.	-
Children's drawings about the war	X		X				X	-	-

a) Bomb attack

The idea of the activity 'bomb attack' was motivated by the museum experts' educational goal to foster students' understanding of the concept *collective trauma* and their long-term effects for the Spanish population. In accordance with this goal, the students proposed performing a drill of the bomb alert and simulating the experience of entering the shelter (redesign activity, Section 5.1.2). On the other hand, they showed curiosity to see a shrapnel of an original bomb (map activity, Section 5.1.2). Thus, we decided to design an activity that would help the students to empathize with civilians' sensations during bomb attacks in the shelter. We proposed the museum to connect this idea with the guide's explanation about the specific physical characteristics of the shelter. During the visit, the guide had drawn students' attention to the walls that were constructed in a zig-zag shape to prevent the entering of explosive waves caused by a bomb.

In the first iteration of the WaS prototype, the guide projected during her explanation an animation of a bomb attack. The activity pointed towards the benefits of transmitting emotions related to fear and sadness related to the civilians (*Reflective Drawing Technique*, Section 5.5.3). However, our observations of students' in-situ interactions showed that the students had difficulties seeing the animation because it was first projected on the floor and then expanded to the walls of the shelter. On the other hand, the activity did not promote any interactions between the students. Instead, they watched the animation as passive observers.

To avoid these shortcomings, we decided to project the animation of the bomb attack on the ceiling of the shelter to allow a better visibility for all students. On the other hand, we proposed including an exercise in which the students would explore the fragmentation and expansion of the shrapnel in the tunnel.

The outcomes showed that the children experienced the activity similar to an authentic bomb attack and it prompted group discussions (Co-design study, Session 5.3.3). In contrast, the second part of the activity did not evoke a natural interaction due to limitations of the prototype fidelity. Consequently, the students did not grasp the relation between the physical space and the augmented content. Furthermore, the guide recommended excluding the entire activity and using only sound effects of a bomb attack. She also highlighted that the students may have difficulties making connections between the augmented content that showed a scenario outside and its consequences in the shelter. Instead, our team argued for the educational value of the activity building on the feedback from the students. Thus, in the second design iteration, we decided to maintain the activity. We excluded only the exploration of the shrapnel and improved the audiovisual effects of the activity.

b) Behavioural rule sign

The idea of the activity 'behavioural rule sign' was motivated by children's interest to see the original wall signs on behavioural rules (map activity, Section 5.1.2). We proposed using the VH experience to draw children's awareness to specific features in the shelter and augmented objects missing from their original locations. Our observations during in-situ interactions during the first and the second iteration showed that the activity promoted collective reading of the sign and a participative attitude of the students. Both the students and the guide expressed that they had enjoyed the activity (interviews, Section 5.2.3 and 5.3.3).

c) Benches

The idea of the activity 'bomb attack' was also motivated by the museum experts' educational goal to foster students' understanding of the concept of *collective trauma.* In addition, we had observed that the students were lacking comprehension of the consequences of the war for the Spanish population. For instance, during the storyboard activity (Section 5.1.2), many children described stories that had a happy ending. Thus, the museum proposed projecting authentic audiovisual material about shelters during the bomb attacks. However, during the first design iteration, we observed that the activity did not evoke any interactions between the students (Section 5.2.3). Thus, the activity was excluded from the VH experience.

d) Power generator

The idea of the activity 'power generator' was also motivated by our idea to draw children's awareness to specific features in the shelter and augmented objects missing from their original locations. During the contextual inquiry study, we had observed that the guide explained the missing generator in the original location of the shelter (Section 5.1.2). Our observations of in-situ interactions showed that the students tried to interact with the displayed content by enacting that he would turn off the switch of a power generator (Section 5.1.2). Both the students and the guide expressed their interests for the activity in the interviews after the visit (Section 5.1.2). However, the activity was excluded from the second design due to our time restrictions of the guided visit.

e) Infirmary

The idea for the activity 'infirmary' was motivated by the museum's educational goal to strengthen student's feelings of solidarity and empathy with the people who had during the suffered the war. To address this goal, we proposed activities that would allow the children to role-play similar physical actions as the civilians during the war. On the other hand, we aimed to focus on social awareness and collaborative actions to transmit the notion of solidarity. During the contextual inquiry study, we observed that the students were particularly interested in aspects around the infirmary of the shelter. In addition, they showed curiosity for the rounded finish of the walls around corners to facilitate the transport of inquired people. Two children during the guided visit even role-played to pull up an injured person from the ground in the infirmary.

Building on these observations we proposed an activity that encouraged two children to project one piece each of a larger image that together represent a stretcher. They had to move their images in synchronized a fashion to take an injured person safely to the infirmary. The activity promoted several reflections about civilians' effort to transport injured people and the severity of the bomb attack (Section 5.2.3). The evaluation of the two design iterations showed the potential of the activity to promote a participative and collaborative attitude within the entire group (Section 5.4.3.1). Particularly, the guide expressed that she had observed how the students took on the responsibility of being in charge of the activity and showed a good performance.

f) Construction of the shelter

The initial idea of the activity 'construction of the shelter' was motivated by our observations that the differences in the way the shelter was built were linked to historical events (contextual inquiry study, Section 5.1.2). The museum proposed projecting a slide-show of selected images that would show the different phases of building. Our observations of the first iteration in-situ showed that the activity, similar as in activity 'benches', did not promote any participative attitude between the students (Section 5.2.3).

For the second design iteration, we decided to focus more strongly on the collaborative aspect of the building process. This goal also addressed the main purpose of the guided visit that was to transmit to children the benefits of collaboration and the implications of being part of a community. On the other hand, the shelter itself was a symbol and reflection of social values because people of all ages contributed to its construction. Thus, we proposed a hands-on activity aimed to collaboratively construct a virtual arch of the shelter. This idea was also inspired by children's proposals for an activity in which visitors needed to dig up a destroyed part of the shelter (redesign activity, Session 5.1.2). Our observations pointed towards the potential of the activity to promote a participative attitude between the students and sensations to the notion of physical effort (Section 5.4.3.2).

g*) Testimonies*

The idea of the activity 'testimonies' was based on the recommendations of the museum and several teachers to use original testimonials for educational activities (Section 5.1.2 and 5.3.3). Our goal was to increase student's collaborative experience and capability of perspective-taking. On the other hand, it addressed the desire of the students to learn more about the life of the civilians. For this purpose, we decided to link the activity to a wall in the shelter that contained traces of civilians' pickaxe marks. The educational experts from the museum and the schools also recommended that we use material that would allow the students to relate to their own identity. Therefore, we recorded the testimonies selected by the guide with children's voices.

Our findings showed that the activity had an emotional impact on the children (Section 5.3.3). However, it also depicted shortcomings in relation to the quality of the recordings and the lack of visual material. On the other hand, the guide stressed that the wall with the pickaxe marks worked very well by itself and did not need any technological support to generate meaning. Thus, we decided to exclude the activity and explore the use of auditory material in another context.

h) Radio program

The idea of activity 'radio program' emerged during our last meeting with the museum (Section 5.3.3). The curator proposed including an activity in which the students would listen to a radio program originally broadcasted during the war. She highlighted her experiences from previous guided visits that made use of auditory information to foster emotions and create a shared group experience. Our findings showed a high potential of augmented content focusing on auditory information to stimulate children's imagination and make connections between the educational content of the guided visit (Section 5.4.3.1).

i) Children's drawings about the war

The idea of the activity 'children's drawings about the war' was motivated by the museum's educational goal to by the museum's educational goal to strengthen student's transfer between historical events and contemporary conflicts today. On the other hand, during the contextual inquiry study, we observed that the guide explained the contents of children's drawings from 1937 (Section 5.1.2).

Building on these requirements, we proposed the museum to project a comparison of two children's drawings to reflect upon the war from different perspectives. Our findings depicted how the drawings had a high emotional impact on the children (Section 5.2.3). On the other hand, the guide particularly highlighted its possibilities to end the guided visit with an activity that stimulated further reflection about the civil war and similar events happening around the world today (Section 5.4.3.1).

5.6.3 Towards a symbiotic agreement between co-designers

We compared the assumptions of the co-designers regarding the notion of childhood and children's roles in our project. Our findings showed that the aforementioned views on childhood strongly influenced the underlying assumptions of adult stakeholders, as well as their expectations of children's designer skills and roles in the design process. Further analysis of the emergence and transformation of the design ideas depicted that these views had an impact on the collaboration between the co-designers and children's participation within the project in general. We will now reflect upon each of these aspects in detail and propose strategies for future projects to strengthen children's role as co-designers.

Collaboration co-designers

During the first design stage, to orchestrate all stakeholders' needs and expectations, we tacitly agreed to treat children from a standpoint that combined the unconscious and immanent child perspective; i.e. we listened to their opinions but their participation and the selection of their final contributions were overseen by adult experts. The museum experts and our design team had the greatest divergence of opinion. Curators and museum educators were used to hierarchical models in which the educator had control over children's participation and the learning content. They assumed that children were not capable of expressing their interests or of making valuable contributions to the design process. In a sense, they believed that children should only "learn from us" whereas our design team also assumed that we could "learn from children". The museum's design practices for guided visits and learning materials were grounded on a top-down model based on content-driven strategies (Pares and Pares, 2001). Instead, our design team considered the analysis of children's interests and behaviour as the starting point for the design process (design-based research strategy (Wang and Hannafin, 2005)). As a consequence, in the beginnings, the museum experts pointed out that they had difficulties to imagine the educational goals of our learning experience. These shortcomings, on the one hand, had an impact on the flow of the design process. On the other hand, it limited our possibilities to give the children a voice in the modification of the learning contents of the guided visit. At the same time, during the co-design workshops, the children themselves reported that they had difficulties to think of improvements and novel proposals due to their lack of "professional" knowledge or training in designing guided visits. This seems to show that some views on children's roles are very deeply rooted even in the children themselves.

Our analysis of the emergence of the design ideas for the VH experience depicted that, particularly in the first design iteration, most of the ideas were proposed by the interaction designers. Only during the improvement phase, the museum team became more engaged and made valuable contributions that allowed us to explore different ways of students' engagement. This tendency in the beginning of the project was caused by the museum's cautious attitude towards our collaboration. They were not familiar with the technological approach and had difficulties to imagine how their traditional guided visit could benefit from it.

To find some common ground in the design of the VH experience, we proposed strategies that were based on the notion of *symbiotic agreement* (Dindler and Iversen, 2014) aimed at balancing each stakeholder's professional knowledge, values, and power relations. This ability requires designers and researchers to facilitate negotiations through open dialogue between different viewpoints and objectives among stakeholders. These negotiations may concern expectations and assumptions on each co-designer's participation, the values they contribute to the design process, collective learning goals and technical solutions of the learning experience, and so on. Often, values and roles are continuously evolving and being redefined during the design process. Among other aspects, the approach directs decision-making processes about how goals and expectations should be communicated between stakeholders, but also determines the choice of elicitation and evaluation methods used during co-design workshops. Throughout the project, we involved the museum experts in the evaluation of our findings by highlighting examples of children's contributions, demos of the prototype and collaborative brainstorming for the improvements of the design iterations. This procedure allowed them to bring their own experience and expertise to bear in the design of the WaS activities (e.g. using auditory material in the 'radio program' activity). In relation to this aspect, the curator explained in the last feedback meeting:

> "We think that the (traditional) visit works very well because the only what they see is an empty space and it is an emblematic experience. However, we have observed that images can be introduced during the explanation and this can support the (educational) experience."

The guide added to this statement:

> "I think that the exercises that have been added through the technology open a respectful window with the physical space and the discourse. And we used mainly material based on the authentic documentation. (…) I consider the VH experience very adaptable. That means, one day we could use only three exercises and another day five."

Our collaboration strategy helped us to find a common agreement on different views on the definition and refinements of the design ideas. For instance, the museum team expressed that the wall with traces of pickaxe marks would generate meaning on its own and did not need any support through the WaS activities. Although the interaction designers still saw a potential in this location to promote reflections upon differences in the civilian's experiences during the war, we commonly agreed on excluding the activity. On the other hand, for the 'bomb attack' activity, the guide recommended to exclude it because she considered the generated experience too abstract for the children. However, during the meeting, we highlighted again children's interesting reflections upon the activity. Finally, we commonly agreed on maintaining the activity and enhancing the audiovisual content.

Design strategies to strengthen children's role as co-designers

Despite this positive development of our collaboration, we felt that the museum's views on children's role had hardly changed through the design process. The analysis of the emergence and transformation of the design ideas for the VH experiences showed that our views had influenced children's participation in the design process. The students were not directly involved in the decision-making process of the WaS activities. Only two ideas were inspired by children's proposals from the first redesign activity (Section 5.3.2). Most ideas of the VH experience were built on observations during in-situ interactions in the shelter and co-design workshops. Despite, our differences in the views on children's roles in the design, we decided to adopt a co-design approach that went further than traditional Informant Design approaches (Scaife and Rogers, 1998). We particularly focused on researching and providing the children with adequate tools to elicit and express their interests, worldviews, and opinions during the design. This design strategy allowed us to leverage their expertise as a child user and indirectly involve their 'voice' in the design process. In a sense, we 'became their agents' to collect their valuable inputs to design engaging and playful WaS activities from their perspectives. Their participation also uncovered aspects that were essential and representative for primary school children in general and allowed us to provide a meaningful learning experience for a wider audience.

Based on our findings, in future design stages, we envision stimulating an open dialogue among the participants to negotiate a shared vision on childhood and children's skills of the VH experience. One strategy could be to involve museum experts actively in the design sessions with children. On the one hand, this could give museum experts the opportunity to observe children's participation and to better value their contributions as potential design partners. On the other, it would permit museum experts to observe how designers introduce the historical context, instruct, and employ design techniques. Thus, museum experts' involvement in the design sessions would offer the possibility of giving feedback and recommendations for improvements on the design activities. This procedure could also allow greater involvement of museum experts in the evaluation of the outcomes of the design sessions. In this way, all stakeholders learn mutually from others' expertise and create a more homogeneous view for their collaboration as co-designers.

Furthermore, it would be beneficial to provide design techniques that facilitate mutual reflection between the participants. For instance, Halskov and Dalsgaard (2007) proposed using concept posters to guide the emergence of design ideas. Smith et al. (2011) showed how this technique was also a successful strategy to establish a collective vision in a design workshop between teenagers and adult stakeholders. We propose using this design technique not only to negotiate design ideas but also to openly discuss emerging values and assumptions derived from outcomes of a critical analysis of individual viewpoints.

Moreover, in our workshops, we mainly focused on understanding the children's interests and knowledge around the learning topic and the emergence of design ideas. However, we did not interview them directly about their own involvement and experience during the workshops. In future studies, it would be beneficial also to focus on this aspect. On the one hand, it may motivate children to participate in the design process because they feel that their opinions are as valued as those given by adult co-designers. Moreover, views of childhood in society can influence children's perception of their own agency and political power (Smith, 2012). In this sense, the use of an inadequate technique may foster the possibility that power relations between children and adult facilitators influence children's contributions (Iversen and Smith, 2012) and their own perceptions of their capabilities in the design activities.

On the other hand, interviewing children about their participation could help reveal deficiencies in using certain techniques and procedures in the study. For instance, we observed that children had difficulties to design from "scratch" (Schaper and Pares, 2016). We assumed that children's previous experience with the guided visit and the elicitation techniques provided during the co-design workshops would be sufficient to inspire their imagination. Despite our expectations, children's contributions revealed only a general desire for more participative activities during the visit. In this context, recent studies argue that researchers often report that children were unable to make some contributions, as opposed to reporting that the design methods used might have been inadequate to elicit the required insights. Iversen and Dindler (Iversen and Dindler, 2013) suggest that researchers working with children need to make a greater effort to adapt techniques to children's capabilities and to explore new methods that help them to reflect upon the task and to express their ideas. In our research context, we believe that the instruction to re-design the guided visit was probably too openly formulated. Thus, in future design stages, we will use techniques that help children to better reflect upon the visit and potential design ideas, such as providing additional visual references of the shelter, revisiting the cultural heritage site to brainstorm ideas and exploring those with different media in-situ. Particularly, techniques based on student-centered learning approaches (Ackermann, 2004; Rogoff, 1998) could help children construct meaning through new knowledge obtained during the guided visit, prior experience in their personal lives and connecting these aspects with potential design concepts (Rogoff, 1998).

6 FUBImethod: Co-Design Strategies to engage Children within Intergenerational Teams in Full-Body Interaction

Building on the projects presented in this thesis, I propose a structured Full-Body Interaction co-design method: the FUBImethod. The step-wise procedure of this method has been elaborated within our research team in collaboration with Prof. Dr. Ole Sejer Iversen from the University of Aarhus. The main goal of the method is to help interaction designers in Full-Body Interaction to guide intergenerational teams and their design sessions with a number of techniques to foster embodied awareness and making the body be the focus and protagonist during the design. With this method, we particularly aim to engage children in co-design processes and benefit from their natural playfulness and expertise in movement. Most people lose their natural playfulness in adulthood due to daily routines, obligations and the awareness of socio-cultural norms. These developmental changes cause some adults to feel uncomfortable during tasks that involve play and the performance of unusual movements (Hickey-Moody et al., 2016). Moreover, adults have often difficulties to reimagine their motivations for certain childhood experiences (Yip et al., 2017), specifically those which include body sensations. In a sense, we conclude that childhood is a special life period in which children seem to have a stronger connection to their bodies than an adult. Consequently, these skills and knowledge make them experts not only in the design of embodied interaction, but specifically for embodied technologies and experiences that are designed for them as users. Therefore, we give high priority to providing tools that make children understand how their bodies mediate their experience of the world, and hence how they can propose computer-based activities in which the body plays a meaningful role. On the other hand, this method offers strategies to strengthen children's perspectives in the design process and achieves a common agreement in the design goals and design choices within the rest of the design team.

6.1 FUBIMethod

The Full-Body Interaction co-design method, which we titled the FUBImethod, proposes a set of clearly defined steps to help interaction designers in guiding intergenerational teams with children to understand the role of the body in a Full-Body Interaction experience. The method is situated between the Informant Design and Participatory Design model. In other words, the design team decides when the involvement of each stakeholder is appropriate depending on the needs of the specific project (Scaife et al., 1997). There are numerous ways to include stakeholders as informants into the design process. Usually, the role as an informant implies using observation methods of the stakeholders' actions and listening to their feedback during the design activities. Our method differs from the original Informant Design approach by focusing on stakeholders' expertise (Dindler and Iversen, 2014) that they can bring into the design process and on a mutual learning approach between adults and children. On the one side, children benefit from adults' expertise in design, knowledge on the design context (e.g. topics related to natural science, cultural heritage, arts, etc.) and somatic practices (physical theatre, yoga, Feldenkrais, etc.). On the other side, the method builds on the notion of children's skilfulness (Iversen and Dindler, 2013) in Full-Body Interaction design, i.e. young designers can contribute with a different perspective of using the body (i.e. playfulness and the nature of movement). Furthermore, we particularly concentrate on providing adequate design techniques that allow children to fully participate in the design process (Iversen and Dindler, 2013). This participation can imply both an indirect involvement through observations of children's behaviours or a direct involvement through design activities aimed to define design proposals and evaluate prototypes.

Within the presentation of this method, we illustrate the use of a number of techniques aimed to evoked embodied awareness and to train co-designers in strategies to design for Full-Body Interaction. We understand a method according to Walsh's et al. (2013) definition as a collection of techniques used in conjunction with a larger design philosophy. For the development and definition of our approach, Mathiassen's work (1998) on "theories and method for system development" has provided us with useful guidelines to structure the theoretical framework of the FUBImethod. From Mathiassen's perspective, a method is limited to a specific *application area*. In our research, we focus on the exploration of the potential of Full-Body interactive experiences for children. Furthermore, Mathiassen stresses that a design method defines also a general *perspective* on a *phenomenon* as well as an underlying theory of system development. Our research is focused on the one hand, on the need to include children in interaction design, and is based on assumptions of embodied cognition theories. According to Mathiassen, this perspective frames the *principles of organization* that characterize a co-design process and which *tools* and *techniques* the design team decides to employ.

Building on Mathiassen's perspective, the FUBIMethod is organized in six design stages as follows: *(1) Defining a Common Ground, (2) Defining Context and Goal Appropriateness (3) Awakening Embodied Awareness, (4) Translating Embodied Experience, (5) Prototyping Embodied Experience and (6) Understanding Embodied Experience* (Figure 49).

Figure 49: Overview of the six design stages of the FUBImethod

For a broader understanding of the *principles of organization* employed in our approach, it is important to formulate our shared view on co-designers' roles and participation. We consider the *design team* as a network composed of the different stakeholders that participate in the design process of a project. The members that form this network may vary according to the project goals and involve different types of topic experts, practitioners and end users. However, each of them contributes with their own knowledge and expertise. This approach allows the design team members, on the one hand, to mutually learn from each other. On the other hand, it converts them all into co-designers participating at project stages in which their contributions are required and appropriate.

I will now illustrate how the FUBIMethod may be employed using the outcomes of a number of examples design techniques used in this dissertation.

6.2 Defining a common ground for participation

6.2.1 What is this design stage about?

This design stage aims to establish the participation within the network of the design team. Therefore, each member needs to reflect upon their own lenses for personal interests, values and commitment level in the project. It is important to note that this stage is the foundation of co-design projects in general and not only relevant in the design for Full-Body Interaction. The final goal is to achieve *symbiotic agreement* (Dindler and Iversen, 2014), i.e. relationships based on mutual accords between the design members where symbiosis is understood as a state "in which every protagonist is interested in the success of the other for its own reasons" (Edwards, 2010). In this dissertation, I particularly focus on emerging values that concern the agreement on children's roles and participation throughout the design process.

6.2.2 Why is this design stage important?

Muller and Druin (2010) describe co-design as a third space that helps bridging knowledge and practices between researchers, developers, and end-users. Thus, the concept of *symbiotic agreement* can help balance each stakeholder's professional knowledge and reach a consensus on values and power relations within the design team. This approach can bring the participants in the position of mutual learning, negotiation of assumptions and shared construction of the design. Furthermore, it increases commitment and ownership of the evolving knowledge and design within the team. In design projects with children, these aspects are relevant because they help to engage them in the design activities and leverage their expertise that they can bring into the design. According to Makhaeva et al. (2016), this project stage can also be reflected in the concept of a *Handlungsspielraum*, the creative space in which the design team collaborates, given structures and freedoms in the design process are explored. Thus, the *Handlungsspielraum* defines the role of each design team member and which research methods are employed.

6.2.3 How has this design stage been employed in practice?

In this design stage, our research team proposes using approaches that allow researching (1) designers' values and assumptions on children's roles in the design process and (2) employing strategies that facilitate an open dialogue on the values of children's participation. The first aspect requires designers to use methods that permit a critical reflection upon the design process. In this dissertation, I used Critical Discourse Analysis (van Dijk, 1993) to compare stakeholders' expectations during the beginnings of the project *Refugi 307* (Section 5.6). Furthermore, I contrasted the different points of view of designers, museum experts, guides, teachers, and children using the card tool called CHIld PerspectiveS In Design (CHIPS) (Skovbjerg et al., 2016). The card tool was based on a theoretical framework that represents a discursive construction of the concept of childhood (James et al., 1998) to work with values on children's roles in design (see for more details about this framework Section 5.6). This analysis was performed by our research team due to our expertise in the evaluation methods used.

Our findings showed that the underlying assumptions of adult stakeholders, as well as their expectations of children's designer skills and roles in the design process were strongly influenced by different concepts of views on childhood. More specifically, we detected mayor differences between the expectations of the museum and our research team. In a sense, the museum experts believed that children should only "learn from us" whereas our research team also assumed that we could "learn from children". The museum's design practices for guided visits and learning materials were grounded on a top-down model based on content-driven strategies. Instead, our design team considered the analysis of children's interests and behaviour as the starting point for the design process.

Subsequently, our research team guided the agreement process and defined strategies aimed to facilitate negotiations through open dialogue between different viewpoints and objectives among the design members. On the one hand, we proposed involving museum experts in future design sessions with the children. We assumed that this procedure could give museum experts the opportunity to observe children's participation and to better value their contributions as potential design partners. On the other hand, we proposed interviewing them directly about their own involvement and experience during the workshops. This procedure may motivate children to participate in the design process because they feel that their opinions are as valued as those given by adult designer. Due to the time constraints of the project *Refugi 307*, we were not able to explore the usefulness of these two strategies in practice. But we believe that they could bring an improvement to strengthen children's role as co-designers in future design stages.

Building on our experiences in this project, we recommend employing evaluation methods based on Critical Discourse Analysis to detect frictions in designers' assumptions on values and roles throughout the project. It is also important to note that values and roles are continuously evolving and being redefined during the design process. The approach directs, among other aspects, decision-making processes on how goals and expectations should be communicated between stakeholders, but also determines the choice of elicitation and evaluation methods used during co-design workshops.

6.3 Defining context and goal appropriateness

6.3.1 What is this design stage about?

The goal of this design stage is twofold. First, the design team needs to define an educational context and contents that are aligned with children's knowledge, interests, understanding and socio-cultural values. A second design challenge concerns the need to question the goal appropriateness (Malinverni and Pares, 2017) of the employed medium, i.e. if Full-Body Interaction is the best design solution to support the defined design or learning goals (Malinverni and Pares, 2014). This notion builds on the contribution of media theory (McLuhan, 1964) and multimodal social semiotics (Van Leeuwen, 2004). According to McLuhan (1964) all media are active metaphors which have the power to translate and transform experiences into new forms. As a consequence, each medium constitutes itself as a message (Levinson, 1993) since it conveys specific meanings and shape perceptions through its features. These features delineate a panorama where each medium can be more or less appropriate to convey specific meanings or support specific experiences. In our context, this implies that researchers should carefully understand the specificities of Full-Body Interaction in order to define the goals and experiences that can be better supported by this medium.

6.3.2 Why is this design stage important?

In this stage, the design team evaluates if the project goals are appropriate for children as a target group. This first step is essential for the design process because it allows, for instance, identifying knowledge gaps of children that can be addressed as learning goals. Furthermore, it can inform the design team about potential concepts that can bridge the gap between what children already know and novel knowledge, i.e. children's previous knowledge can be used as an entry path for the comprehension of novel learning contents (Rogoff, 1998). For this reason, children's participation is required to research their perspective on the educational context and contents. The outcomes of this evaluation determine if a project continues or if changes on the focus of the design goals are necessary. Moreover, in this step, co-designers examine if the concept of Full-Body Interaction is the best way to convey the design contents or if a different medium may be more adequate.

6.3.3 How has this design stage been employed in practice?

In this design stage, our research team proposes using design techniques that allow researching (1) children's worldviews on the learning context and (2) what the concept of Full-Body Interaction can add to the educational experience. In this dissertation, I presented the *Dwelling Space Technique* (Section 5.5) within the project *Refugi 307* to address these two goals. The technique was based on a group activity that consisted of recording a report on the *Refugi 307* in the same shelter for a local TV channel. Subsequently, the technique included a re-design activity of the guided visit during which the students could reflect upon their experience within the site-specific location. The use of the *Dwelling Space Technique* allowed us, on the one hand, to understand children's worldviews in relation to the Spanish Civil War. On the other hand, we could observe how the children became bodily engaged with a specific physical space and which opportunities the shelter could offer to engage children in Full-Body interactive activities.

Our results revealed how being situated in the physical space during the *Dwelling Space Technique* primed children's interests. This finding was based on expressions assessed during children's performance in-situ and contributions (interviews, drawings, etc.) for the redesign activity. Both depicted that the students were particularly interested in the characteristics of the shelter that showed traces of actions from civilians during the war. For instance, they mentioned that the rounded finish of the walls around corners facilitated the transport of injured people on stretchers. During the redesign activity, the children proposed possible enactments within the physical space, e.g. using a pickaxe and a shovel to construct new parts of the tunnel and discover hidden aspects in the cultural heritage site. Thus, we decided to include activities in the guided visit based on children's proposals for enactments. We assumed that these activities would allow children to "embody" actions from the past (Flynn, 2013) and better empathize with Spanish war civilians who helped to build the shelter.

Building on our experiences in this project, we recommend employing design techniques in the first design stages that allow researching both children's worldviews on the educational context and the appropriateness of the interaction concept that designers envision. In this project, the definition of the context was led by the museum experts and research team. Nevertheless, depending on the project requirements, it is also likely that children are involved in the decision-making process of this aspect. For instance, in the project *Magical Movements* (Chapter 4.3), the children undertook the leading role in defining the narrative and characters of the interactive experience. The project specifically focused on children's perspectives on Shakespeare's theatre play *A Midsummer Night's dream*. Giving them the role of the protagonists in the design, also required to strengthen their role as co-design partners in decision-making activities.

6.4 Awakening embodied awareness to understand the Full-Body Interaction features

6.4.1 What is this design stage about?

The goal of this design stage is to introduce the members of the design team to the fundamental qualities of Full-Body Interaction and to understand the features of the embodied child experience. Therefore, we propose to organize workshop sessions that involve embodied exercises aimed to make designers aware of sensations related to their own body and to communicate them to other members of the team. In our research, we focus on embodied techniques that allow engaging both adults and children in the design activities and promote a mutual learning approach between them. Additionally, we recommend deepening this felt-experience by facilitating exercises that promote awareness about how the body relates to spatial and social aspects between people and the environment. The final goal of this design stage is to achieve that all designers of the team understand these embodied qualities as tools to generate meaning around the project context and train them in different ways to "bodystorm" design ideas.

6.4.2 Why is this design stage important?

Due to the imprinting effect of our Cartesian Western culture (Kelan, 2010), people tend not to be trained to intentionally use their body as an expressive medium. As a consequence, while bodystorming approaches have shown to be particularly fruitful with trained practitioners such as dancers or performers (Loke, Robertson and Sydney, 2013), they may prove challenging to the general population. On the other hand, particularly in the design of technologies for younger users, adults may benefit from children's perspective on the body and natural playfulness. Therefore, we focus in our research on embodied techniques that allow engaging both adults and children in the design activities and promote a mutual learning approach between them.

6.4.3 How has this design stage been employed in practice?

In this design stage, our research team proposes using embodied design techniques that allow (1) designers to become bodily engaged to explore the properties of Full-Body Interaction and (2) leveraging children's perspective on the body. In this dissertation, I presented the *Situated Performance Technique* within the project *Magical Movements* (Chapter 4.3.2, Session 4). The technique is a bodystorming activity based on the physical theatre exercise "the machine of rhythms" (Boal, 1992). We started with one child performing simple, repetitive movements of their choice, related to the space and idea chosen by their team. The other children joined in the exercise one after the other with a complementary movement. In this exercise, we particularly encouraged the children to explore their physical actions in different locations and to incorporate the space which surrounded their bodies in their proposals.

Our results showed that the technique allowed the children to explore sensations of movement variations. By slowing down the movement pace, it became clearer to them how various parts of the body interacted in the process of moving. The movement repetitions helped the children to keep the focus on the sensorial experience in relation to the situated environment to compare sensations that they had imagined before their performance. Enacting the physical actions in different locations help them to explore questions of person-space interactions (e.g. timing, coordinating and synchronizing body actions) and led to understanding related to the capacity and constraints of the body actions. Performing these actions with their own bodies also allowed them to explore and become aware of the effects of inter-relating movements between the different actors from an internal point of view. Furthermore, the children paid attention to the movement to other actors sharing the same action space. Finally, this technique was useful to train the children in using their body as an expressive medium and to understand features that are relevant in Full-Body Interaction design.

Building on our experiences in this project, we recommend employing playful design techniques that engage children in bodystorming activities and allow them to reflect upon their body sensations and relationships between proxemics. Our results were mainly based on researchers' observations during the activity. In future projects, it would be advisable that adult designers also experience the same body exercises to obtain a better understanding of the felt-experience. One possibility would be that the children instruct the adults in the exploration of movements that they find relevant to experience specific properties related to embodied awareness and proxemics. In this procedure, it would be also important to stimulate conversations between all designers about the different sensations that they experience during the exercises.

6.5 Translating embodied experience into co-design ideas

6.5.1 What is this design stage about?

The aim of this design stage is to instruct the intergenerational design team in how they can use their felt-experience and knowledge in embodied awareness to define concrete design ideas for an interactive prototype. On the other hand, it aims to overcome legacy bias caused by users' experience with traditional WIMP and touchscreen interfaces (Ringel Morris et al., 2014). These deficiencies have often been reported using gesture elicitation techniques for the design of Full-Body interactive technologies (Hoff et al., 2016; Ringel Morris et al., 2014; Schaper et al., 2014). In these contexts, users may tend to propose gestures that mainly emulate simple touch or mouse-based interaction and do not incorporate the potential of Full-Body interfaces.

6.5.2 Why is this design stage important?

In the previous stage, designers are trained in embodied awareness. This notion entails non-verbal knowledge about embodiment and how sensations evoked through movement can mediate an experience. In this step, we propose using techniques that allow translating this knowledge into tangible design ideas, i.e. this translation permits to transform a feeling, sensation or idea into "a product" that can be experimented by others, evaluated and redefined. Furthermore, we claim that in this design stage, children can particularly contribute to design ideation due to their playful way of approaching and expressing ideas. More importantly, they are the actual experts in understanding the child experience that is designed for them as a target group.

6.5.3 How has this design stage been employed in practice?

In this design stage, we propose employing techniques that use (1) the felt-experience to think of concrete interaction design ideas, (2) focus on situatedness (i.e. use the body in space to make meaning) and (3) promote the reflection upon social relationships (i.e. use proxemics in the space with others to make meaning). In this dissertation, I presented the *Puppet-Based Design Technique* within the project *EcoSystem* (Section 4.2). The goal of the presented study was to propose interaction design ideas that would enhance children's understanding of the reciprocal relationships of the game elements (e.g. the amount of air-pollution in relation to actions of recycling vs. waste incineration).

Inspired by previous work on embodied design techniques for children (Section 3.2) that focused on their playfulness, we decided to take advantage of children's specific play patterns and behaviours. Most children are familiar with puppet play. We assumed that using puppets as design instruments for physical actions would allow, and additionally motivate, children to actively participate in the design process. Furthermore, we believed that this approach could allow children to express their ideas at different levels, e.g. through verbal articulation and through play.

Our results showed that the children constantly switched between two modes, using the puppets and then performing their interaction design ideas with their bodies. This continuity of shifting from one mode to the other mainly occurred when the children aimed to bodily explore their own ideas or those proposed by their peers. This repetitive play rhythm seemed to allow the children to focus on what matters in the design task and to think of different solutions for physical actions. Furthermore, the technique allowed the children to express an idea through multimodal resources, verbally through doll play and bodily while they were enacting their ideas.

Building on our experiences in this project, we recommend employing playful design techniques that generate a balance between "getting immersed in a situation" and "stepping back" from it in order to construct knowledge and learn (Ackermann, 2004). This procedure has shown to allow the children to focus on both the ideation of new ideas that are suitable for Full-Body Interaction and the felt-experience of these body actions. The use of puppets may not be adequate for older children and adult designers. Thus, the design team needs to provide techniques that evoke similar behaviour of immersion and reflection on the embodied experience. In future projects, it would be advisable using techniques that allow designers to explore ways in which the notion of situatedness and social relations play a role in the ideation of the interactive experience.

6.6 Prototyping the embodied experience

6.6.1 What is this design stage about?

The goal of this design stage is to enable the designers to simulate a functional prototype of the interactive experience. Therefore, the design team needs to be provided with techniques including low-tech and mid-tech prototyping materials that can be easily manipulated. Furthermore, these techniques should allow redefining design ideas and test simulations of real-time mechanics of the interactive experience. Prototyping is a common practice in co-design (Lim et al., 2008). Many of the participatory approaches are used for understanding user needs and for exploring design ideas (Druin, 1999; Muller and Druin, 2010) that have been brainstormed and elaborated in previous design stages. In the fields of HCI, software engineering and design prototypes often have been considered tools for evaluation of design failures or success. Hence, prototypes are used not for providing concrete solutions but for discovering problems and for exploring design alternatives. In this context, Lim et al. (2008) highlighted that a primary strength of a prototype is its incompleteness that makes it possible to focus and investigate specific qualities without building a copy of the final design. The same authors argued that the nature of the prototype works as a "filter" which allows one to focus on particular aspects within an imagined or possible design space. According to them, the best prototype is one that makes possibilities and limitations of a design visible and measurable.

6.6.2 Why is this design stage important?

In Full-Body Interaction, we are confronted with two additional challenges. In the design for Full-Body interactive experiences, co-designers face difficulties when having to imagine aspects at a human scale rather than on a screen. These aspects involve dealing with ideas related to the design of large-scale interactive spaces, body enactment and gesticulation, merging physical and virtual space, etc. Thus, prototyping techniques employed in this field must allow to specifically explore these design features. On the other hand, most prototyping tools are developed for screen-based interaction (e.g. software for wireframing such as Sketch, Balsamiq or Mockingbot). Thus, designers in the field of Full-Body Interaction need to invent and explore approaches that enable them to create adequate prototypes.

6.6.3 How has this design stage been employed in practice?

In this design stage, our research team proposes using prototype techniques that (1) can be easily manipulated and test simulations of real-time mechanics of the interactive experience; (2) allow designers to explore body actions at a human scale and (3) filter specific qualities of the prototype to discover problems and for exploring design alternatives. In this dissertation, I used the *Wizard of Oz Prototyping Technique* (Markopoulos et al., 2008) within the project *Magical Movements* (Section 4.3.2, Session 8). The content of the prototype was based on children ideas for the interactive experience that they had expressed in previous workshops. The research team selected the main ideas. We presented first a proposal for the prototype as a written description and visual concepts for the game characters. Based on children's feedback, these ideas were transformed into an interactive presentation with short video clips of consecutive scenarios that were executed by a researcher according to children's interactions. The presentation was projected on a large vertical screen to allow the children to interact with the game elements at a human scale. The 'filter' of the analysis was to understand if the prototype would evoke the same interaction design ideas that the co-design team had defined as body actions and if the children would naturally perform them. This approach was grounded on research on guessability methodology as a means of deriving child-defined gestures (Connell et al., 2013). Guessability studies usually involve a Wizard-of-Oz approach (Markopoulos et al., 2008) in which gestures are elicited from non-technical users. To do so, the effect of a gesture is first illustrated by an unseen technical 'wizard' manipulating the system. The users are then asked to perform its corresponding feedback (Wobbrock et al., 2009). Interactive experiences usually provide "natural" or "intuitive" interaction when they offer users ways to "uncover, explore and develop the meaning of the use of the technology as it is incorporated into practice" (Dourish, 2001). In our analysis, we employed a multimodal approach focusing on children's verbal utterance, facial expressions, gestures, and body postures during the interaction with the prototype (Kress, 2010).

Our results showed that most of the proposed body actions were naturally used and similar to children's proposals during the co-design workshop sessions. In addition, the analysis revealed that the children performed alternative actions that were unexpected by the design team. Finally, it also highlighted some usability issues in relation to the synchronization of the animations and game mechanics with real-time actions and visual effects.

Building on our experiences in this project, we recommend employing prototyping techniques in Full-Body Interaction that foster a critical analysis of the design ideas at a real human scale. This technique has also shown to be particularly useful to confirm and refine initial ideas for physical actions by comparing the designers' proposals with children's intuitive interaction in an existing prototype. Future approaches should involve the children already in the creating process of the prototype. This procedure would give them the opportunity to explore together with the rest of the design team different alternatives for the design and allow them to bodystorm first proposals for physical actions with low-fidelity materials.

6.7 Understanding the embodied experience with the prototype

6.7.1 What is this design stage about?

The goal of this design stage is to understand how children create bridges between the embodied experience and knowledge construction while interacting with a functional Full-Body interactive experience. Therefore, we propose to provide the design team with a set of elicitation techniques to research how children build their understanding from an embodied experience during and after children's interaction with the functional prototype. The design team needs to focus, on the one hand, on researching meaning-making during the experience. On the other hand, in this design stage is also important to verify if the physical actions that were implemented in the prototype are natural and intuitive for the children.

6.7.2 Why is this design stage important?

The comprehension of the interactive experience from the children's perspective is the basis for the evaluation and refinement of the prototype. It allows designers to put themselves in the place of the children, understand their worldviews and reasons for certain behaviours during the experience. Considering children's perspectives on worldviews that are related to their way of playing and certain educational contexts also increase their motivation for the engagement with the embodied experience.

6.7.3 How has this design stage been employed in practice?

In this design stage, our research team proposes using elicitation techniques that allow (1) designers to understand children's worldviews and (2) triangulate the outcomes using different techniques to confirm designers interpretations of children's behaviours with a prototype. In this dissertation, I presented the *Reflective Drawing Technique* within the project *Refugi 307* (Section 5.5.3). This technique is derived from previous work of Nicol and Hornecker (2012) who used drawings to elicit children's feedback on interactive museum experiences. We adapted the technique to our project requirements. In our study, the technique is based on a task in which children are asked to draw the educational activity during the Virtual Heritage experience that they found most interesting. After completing the task, the researchers interviewed them about their user experience with the prototype and the different pictorial elements represented in the drawings. To analyse the outcomes of this technique, we used a mixed approach that combined content analysis and multimodal analysis.

Our results showed that the drawing activity allowed the students to mentally recall the experience and to highlight different aspects from their perspective. They uncovered not only usability issues of the prototype. Complementing the analysis of the drawings with individual interviews revealed children's opinions and sensations during the user experience, the influence of others, the impact of the physical space and the digital augmentation. Furthermore, the drawings were used as a starting point for the interview. On the other hand, the drawings and children's body language during the interviews also revealed aspects of the user experience and their emotional perspective towards the educational context that children had not verbally expressed.

Building on our experiences in this project, we recommend employing elicitation techniques that are adapted to children's skills and motivate them to express their experience with the prototype. However, in this project, only the researchers had been involved in the interpretation stage of the data from the techniques used. The outcomes have not been verified again with the children. Consequently, this procedure limited children's decision-making power within the design team because the researchers decided what mattered for the experience and selected relevant results for the design refinements.

6.8 Discussion

In this chapter, I have presented a set of representative design techniques for each design stage of the FUBImethod. Their employment was based on the goal to leverage children's participation in an intergenerational design team and capacitate co-designers to develop Full-Body interactive experiences that are adequate and consistent with the specificities of embodied interaction. The method provides a means to benefit from children's expertise in Full-Body movement and natural playfulness. Furthermore, it offers step-wise guidelines for using research methods to guide an iterative process for making adequate design choices and refinements.

To discuss the specific properties of the FUBImethod and to highlight how the method differentiates to other approaches in the HCI community, I used the classification method FACIT (Framework for Analysis and Creation of Intergenerational Techniques) PD approach (Walsh et al., 2013). This framework aims to guide the description of co-design techniques and provides specific values that are relevant to intergenerational design teams. Specifically, the framework focuses on three main aspects: the design partners, the design goal and the design technique.

I used the FACIT framework as follows. First, I used four dimensions of this framework to highlight the benefits of the FUBImethod. The dimensions (1) *design space* and (2) *maturity of design* refer to the design goals of each technique, (3) *portability* and (4) *physical interaction* concern qualities related to the technique itself. For this description, I added one more dimension related to the (5) *required material* during each design stage (e.g. low- and high tech materials, the fidelity of technology used). Second, I used the two of the dimensions (6) *partner experience* and (7) *need for accommodation* describe the relationship between the technique and intergenerational participants. Building on this framework, I will now describe the specific properties and advantages of each design stage (Table 26) and reflect upon children's experience as co-design partners using the FUBImethod (Table 27).

6.8.1 Benefits of the FUBImethod

The first two design stages *defining a common ground* and *defining goal and context appropriateness* are both essential for the co-design process and form the foundation of the design project. The research methods employed are generalizable for other application areas in HCI, such as computer-based, application design or tangible technologies. They require the use of traditional low-tech material for group activities (e.g. whiteboards, pen and paper, post-it notes, etc.). Most of the proposed techniques do not require any specific locations for their employment. Although, we also propose techniques for the second design stage that aim to stimulate context awareness and, therefore, are recommendable to conduct in locations related to the design context. For instance, the *Dwelling Space Technique* is based on an interview activity in a site-specific location to gain insights into aspects that children find interesting and engaging in the environment. The technique allows researchers to understand children's worldviews, interpretations, cultural values and preferences towards the proposed context. The technique also helps us to evaluate if Full-Body Interaction as a medium could bring an added value to the educational experience.

The next two design stages *awakening embodied awareness* and *translating embodied experience* are specific for the design of embodied interaction. In both design stages, we propose techniques based on bodystorming, performance and gesture-elicitation to stimulate sensations related to proprioception, space awareness and proxemics. The goal of these design stages is to train the design team in using their felt-experience to define features for Full-Body Interaction design proposals. Thus, the main "material" used in those design stages are the own body. The techniques used can be conducted in general workshop rooms or specific locations that are connected to the design context. The aim is to direct designers' attention to relevant sensorimotor and spatial qualities that need to be taken into account for the design and inspire design ideas.

The last two design stages *prototyping the embodied experience* and *evaluating the embodied experience* are again generalizable for other application areas working with children. Nevertheless, they also address specific challenges in Full-Body Interaction such as prototyping and the evaluation of user interaction at a human-scale. Furthermore, our focus on multimodal analysis to research user contributions embraces the very nature of embodiment. The prototyping techniques proposed require bodily activity of the tester and the use of low- and high-tech material to simulate interaction and real-time mechanics of the Full-Body interactive experiences. To make suitable conclusions for design refinements, the prototypes should be explored in locations simulating the real-world environment or directly in-situ.

The last three design stages form part of the iterative design process and assessment cycle of the FUBImethod, i.e. by considering design and assessment as inseparable instances, mutually reinforcing and informing each other, this structure allows us to constantly evaluate the suitability and feasibility of the design ideas in accordance with children's felt-experience and worldviews (Malinverni et al., 2016b). For instance, detecting aspects that do not transmit the desired design goals require the design partners to move back to previous design stages, such as prototyping and bodystorming, to refine the final embodied experience.

To sum up, the FUBImethod is not exclusively an approach developed for the application in design projects related to embodiment. Several design stages are essential for a successful collaboration between design partners in co-design processes and research methods are generalizable for a wide range of design spaces, e.g. bodystorming for ideation and multimodal analysis to research user contributions communicated through different resources. Furthermore, we believe that also other research fields can benefit from focusing stronger on design aspects which require children's skills and expertise. They are not only experts on play and worldviews for experiences designed for young users. Children may also provide insights into other contexts due to their playful way of approaching the world.

Table 26. Overview of the properties of the FUBImethod

Design Stage	**Maturity of Design** *For which design stage are the research methods used suitable?*	**Research Methods** *Which design techniques and evaluation method are required?*		**Required Materials** *What kind of materials are required for the techniques used? (low-tech, high-tech, technologies)*	**Physical Interaction** *What kind of materials are required for the techniques used? (low-tech, high-tech, technologies)*	**Portability** *To which degree does the research method need to be employed in a specific location?*
		Elicitation	**Evaluation**			
Defining a common ground	Foundation of a co-design process	Interviews, open-ended questionnaires, group discussions	Critical Discourse Analysis	Low-tech materials (white boards, pen and paper, post-it notes, etc.)	Group discussions can take place in workshop rooms e.g. with moveable tables	No specific location required
Defining context and goal appropriateness	Early design stage	Assessment tools for conceptual learning goals: Open-ended questionnaires, interviews, collages, conceptual maps Elicitation techniques: collage, drawings, Pictionary Technique, Dwelling Space technique, Signifying Space Technique	Multimodal Analysis	Low-tech materials (white boards, pen and paper, post-it notes, etc.); high-tech material (photo and video cameras, printer, etc.)	Traditional assessment tools take place in workshop rooms e.g. with moveable tables; playful activities such as the techniques Dwelling Space and Signifying Space require physical movement around a specific location	Traditional assessment tools and reflective activities do not require any specific locations; other playful techniques such as Dwelling Space and Signifying Space are recommendable to use in locations related to the design context
Awakening Embodied Awareness	Early design stage	Bodystorming, somatic practices (e.g. Feldenkrais), dance performance, theatre exercises (e.g. techniques Situated Performance, Body Shadows)	Multimodal Analysis	Low-tech material can be used as props to stimulate body sensations related to felt-experience, space and proxemics	Require active body movement of the practitioners	Techniques can be employed in locations related to the design context or decontextualize d depending on the focus of each technique

Translating embodied experience	Iterative design stage	Interaction design ideation techniques and gesture elicitation: Bodystorming, Puppet-Based Design, Group Environment, Body Shadows	Multimodal Analysis; Reflective tools to make design choices e.g. conceptual Posters (Halskov and Dalsgaard, 2007), Reflective Design Document (Halskov and Dalsgaard, 2012)	Own body, low-tech materials as props for bodystorming and role-play, construction of small-scale prototypes and puppets	Require active body movement of the practitioners	For inspirational purposes, we recommend conducting the activities in locations related to the design context
Prototyping embodied experience	Iterative design stage	Paper prototyping, small-scale prototyping, Wizard-of Oz prototyping	Multimodal Analysis	Low- and mid-tech material to build a functional prototype	Require active movements to manipulate material and bodystorm design ideas	For inspirational purposes, we recommend conducting the activities in locations related to the design context
Evaluating embodied experience	Iterative design stage	Elicitation techniques: Reflective Drawing, collage, Assessment tools: semi-structured interviews and questionnaire, Affective Slider (Betella et al., 2013), Self-Assessment Manikin (Bradley and Lang, 1994), Smilyeometer (J. Read et al., 2002),	Multimodal Analysis; Content Analysis	Mid-tech material to build a functional prototype	Require active movement to explore the prototype	The evaluation needs to take place in the location in which the final experience will be employed

6.8.2 Child partner experience

Co-design is a poly-voiced perspective embracing complex and often blurred constellations of users, contexts, and purposes (Halskov and Hansen 2015). Specifically, when working with children. Equal partnerships are difficult to manage because adults tend to set agendas, choose research projects and organize the design activities (Yip et al., 2017). The FUBImethod claims to involve children as partners in the design of Full-Body interactive experiences by focusing on their expertise in felt-experience and capabilities in playfulness. Therefore, we explored several embodied design techniques that specifically focus on child users. Thus, most of them are very intuitive for children but still require an adult to set up the activity and facilitate the sessions. We argue that the design team should give more credit to children's specific expertise in felt-experience and explore novel strategies on how they can teach this knowledge also to adults and collaboratively elaborate the procedure for design sessions.

In the projects presented in this study, one main drawback of the FUBImethod is that the designers and researchers often only observed and evaluated children's contributions. As a consequence, the adults did not actively take part in the felt-experience activities nor the children in the evaluation of the design. One reason for this shortcoming is that the proposed techniques (e.g. Puppet-Based Design technique) were adapted to children's skills and capabilities, i.e. an adult may use them in a different way that does not reveal any insights about children's felt-experience or even adults may reject their use because puppet play is a child activity. On the other hand, the outcomes (written contributions, drawings, video recordings, etc.) are formats that were difficult to simplify for participatory evaluation with the children. Novel approaches need to make an effort to integrate both intergenerational design techniques (Walsh et al., 2013) and participatory evaluation methods (Moser, 2012; Spiel et al., 2017) in this framework.

Table 27. Overview of the aspects related to the experience of the co-designers using the FUBImethod and possible application of design spaces.

Design Stage	**Partner Experience** *Who provides the expertise?*	**Need for accommodation** *In which degree needs the research methods to be adapted to designers' skills and cognitive ability?*	**Design Space** *How specific is the design problem and technology approach defined?*
Defining a common ground	Researcher (analysis)	Need for a high accommodation of the reflective group activities by a trained facilitator; need for playful techniques to involve children in the discussion	Generalizable to a wide range of design spaces
Defining context and goal appropriateness	Researcher (assessment), Designer (design goals), Children (worldviews)	Need for a high accommodation of the reflective group activities by a trained facilitator; need for playful techniques to be adapted to children skills and capabilities	Generalizable to a wide range of design spaces
Awakening Embodied Awareness	Practitioners in somatic and theatre practices (facilitation techniques), Children (felt-experience)	Need for a high accommodation of bodily-based exercises by a professional or previous training in those techniques	Specific for experiences based on embodied interaction
Translating embodied experience	Designers (facilitation techniques), Practitioners in somatic practices (facilitation techniques), Children (felt-experience)	The techniques used are very intuitive and do not need a strong accommodation, however, they need to be adapted to the age and capacity of the designer, i.e. Puppet-Based Design may not be adequate for adults.	Specific for experiences based on embodied interaction
Prototyping embodied experience	Designers (facilitation techniques), Children (felt-experience, worldviews)	Low-fidelity prototypes do not need a strong accommodation. Mix-fidelity approach may require accommodation due to their involvement of technical solutions	Generalizable to a wide range of design spaces
Evaluating embodied experience	Researchers (assessment tools and analysis), Children (felt-experience, worldviews, etc.)	High accommodation for the evaluation of the results	Generalizable to a wide range of design spaces

7 CONCLUSIONS AND FUTURE WORK

In this thesis, I have researched co-design processes of Full-Body interactive learning experiences together with children and experts (teachers, museum curators, pedagogues, etc.). In this context, I have focused on how to better design Full-Body Interaction for children in non-formal learning contexts and, on the other, how to achieve a better involvement of co-designers during the design process to have their voice and vision in the final experiences. Furthermore, I proposed the body as the main protagonist in co-design practices for Full-Body Interaction.

The studies that I have presented provide contributions on a practical, methodological and theoretical level. From a practical perspective, I led the design and development of three applications: projects *EcoSystem* (Chapter 4.2), *Magical Movements* (Chapter 4.3) and *Refugi 307* (Chapter 5). From a methodological level, I explored the potential of several co-design techniques with and for children within these three applications. The exploration of these techniques allowed me to reflect upon the relevance of embodied awareness (Chapter 4.4) and situatedness (Chapter 5) for the design of Full-Body Interaction. From a theoretical viewpoint, I proposed a framework to analyse the potential of embodied co-design techniques for children (Chapter 4.1) and developed a co-design approach to engage children within intergenerational teams in Full-Body Interaction, titled the FUBImethod (Chapter 6). Now I will detail these contributions, highlight limitations and outline possible directions for future work.

7.1 Practical contributions

In the project *EcoSystem,* we co-designed in collaboration with primary school children and topic experts from Fàbrica de Sol, Barcelona a Full-Body Interactive experience. The design was built on the premise that collaborative learning experiences may increase children's comprehension of abstract concepts (Carreras and Pares, 2009; Karadimitriou and Roussou, 2011; Roberts et al., 2014). The prototype showed to complement traditional learning materials in environmental education and offered a new way of collaborative learning in a virtual environment (Malinverni et al., 2016b).

In the project *Magical Movements*, we co-designed in collaboration with students and teachers from the local theatre school *Plàudite – Espai d'Arts Escèniques* a novel approach to integrate a storytelling experience in theatre events. The co-design workshops revealed children's worldviews in relation to Shakespeare's play *A Midsummer Night's Dream* and led to the definition of content, visual and interactions design ideas for a first design iteration of a Full-Body interactive experience. In this project, the central focus of the design was children's perspectives on the context and their skilfulness in the applied design techniques (Iversen and Dindler, 2013; Smith et al., 2011).

In the project *Refugi 307,* we co-designed a Virtual Heritage experience in collaboration with an interdisciplinary and intergenerational design team to complement the educational experience of the guided visit in a Spanish bomb shelter. For the definition of the requirements and improvements of the prototype iterations, we worked closely together with the Barcelona History Museum (MUHBA). In the design process students and several teachers from two local primary schools also participated. This project provided the first real case to apply a novel interaction paradigm called the World-as Support, which represents a pioneering approach in the field of cultural heritage (see Chapter 5). The prototype allowed us to implement and evaluate the educational potential of Full-Body interactive activities based on several theories related to embodied learning. The findings confirmed the benefits for hands-on activities in a learning environment (Dewey, 1968; Kolb, 1984; Piaget, 1955), exploration of a site-specific location through sensorimotor experiences and movement (Goldin-Meadow, 2011; Kontra et al., 2012), collaborative learning (Vygotsky, 1980), perspective-taking (Ackermann, 1996) and environment awareness (de Certeau, 1988; Langer, 2000). In addition, some of the evaluated WaS activities were built on the concept of physical exercise as a metaphor for the notion of effort proposed by Lyons (2012). Our outcomes confirm this idea and point towards opportunities in cultural heritage to foster students' empathy with people from the civil war. On the other hand, activities based on this concept allowed students to "embody" certain actions that these people performed in the past (Flynn, 2013). In future work, our research team foresees improving the technological approach of the WaS prototype to allow users to employ a wider range of movements and specific physical actions that could improve their understanding on high-level aspects such as socio-cultural values related to the educational context.

Finally, our mission in this project was to adequately empower children in the design process so that they could influence the design of the Virtual Heritage experience. Therefore, I explored the feasibility and relevance for our project of the concept of *symbiotic agreement* proposed by Dindler and Iversen (2014). Focusing on this concept allowed us to detect some frictions between the values and assumptions on childhood and children's participation in the design project. Inspired by this concept, I proposed different strategies to improve the collaborative work between the design partners. However, the pre-defined learning goals, conservation, and security policies in relation to use of the shelter and the availability of the participants during the design process limited us in our *Handlungsspielraum* (Makhaeva et al., 2016) to involve the children as co-designers in the project. One main drawback of this procedure was that only the adult co-designers were involved in the evaluation of children's contributions. One reason for this shortcoming was that the outcomes (written contributions, drawings, video recordings, etc.) consisted of formats that were difficult to simplify for participatory evaluation with the children. I see opportunities to overcome this issue in researching novel approaches that make an effort to integrate both intergenerational design techniques (Walsh et al., 2013) and participatory evaluation methods (Moser, 2012; Spiel et al., 2017).

7.2 Methodological contributions

In this thesis, I explored the involvement of children as partners in the design of Full-Body interactive experiences by focusing on their expertise in their felt-experience and researching the impact of children's embodied awareness during the design process. Therefore, I have defined seven embodied co-design techniques (*Bodystorming, Pupped-Based Design, Signifying Space, Small-Scale Prototyping, Situated Performance, Body Shadows, and Group Environment*, see for more details Section 4.2 and 4.3) that specifically focused on child users.

The projects *EcoSystem* and *Magical Movements* offered me a testbed to explore these embodied co-design techniques. First, I used the context of the project *EcoSystem* to conduct a comparative study of two co-design techniques, *Bodystorming* and *Puppet-Based Design.* Our observations of children using the techniques paved a first entry path to research playful strategies proposed by Hemmert et al. (2010), Giaccardi et al. (2012), Lerdahl et al. (2002) and Iacucci et al. (2000). Our adaptations of the techniques allowed children to participate in the design of physical actions for a Full-Body interactive experience.

I extended this research in the project *Magical Movements* in which I specifically focused on the notion of embodied awareness and possibilities of including physical theatre practice in co-design techniques for children. Although there has been research for more than a decade on Full-Body Interaction for children, only a few scholars (Connell et al., 2013; Höysniemi et al., 2005; Landry et al., 2012; Malinverni et al., 2016b) have explored the benefits of embodied design methods with this target group. Even less research has specifically focused on the aspect of embodied awareness as a means to understand the features of Full-Body Interaction. This dissertation made a first step in this direction by exploring physical theatre exercises proposed by Boal (1992), Casado (2016) and Reusch (2005) and including them as embodied techniques (*Signifying Space, Small-Scale Prototyping, Situated Performance, Body Shadows, and Group Environment*) in the design process for children. However, these techniques have only been tested in one project. Future work needs to explore these co-design techniques in different contexts to evaluate their naturalness for children that are untrained and unfamiliar with theatrical exercises. Novel approaches may also research possibilities to include adult designers in the use of these techniques and allow them to better empathize with the child user experience.

Furthermore, inspired by current research in embodied elicitation techniques (Wilde et al., 2017), our research team is currently exploring the benefits of including physical objects as props in design stages that involve bodystorming techniques. The inclusion of physical objects may be beneficial to complement the techniques presented in this thesis. Exploring different postures and scenarios with props could help designers better understand the relation between proprioception, space, and proxemics.

7.3 Theoretical contributions

Embodied Design Thinking qualities

I have proposed a framework of nine *Embodied Design Thinking* qualities to analyse the potential of the embodied co-design techniques presented in this thesis. This framework extends current approaches in the Human-Computer Interaction community (Hummels and van Dijk, 2015; Malinverni, 2016; Wilde et al., 2017) by specifically focusing on aspects that are relevant in the design of embodied interaction technologies for child users. In other words, I adopted a phenomenological lens on play practice as a means to understand children's use of a design technique (Karoff, 2015). Furthermore, I focused on the aspect contingency that has been first proposed by Malinverni (2016) as a design quality to reflect upon adequate features for experience based on Full-Body Interaction. I used this idea to evaluate the potential of a design technique to meaningfully augment the sensorimotor experience through digital technology and to couple with the physical space. Future studies need to explore and validate the effectiveness of this framework in other research contexts related to embodied interaction for children.

FUBImethod

I have proposed a preliminary six-stage approach to co-design interactive experiences based on Full-Body Interaction. The FUBImethod aims to specifically engage children in co-design processes and to benefit from their natural playfulness and expertise in movement. This approach allows co-designers to go beyond the surface level of content-driven ideas by raising awareness of the body and space, and by proposing techniques that help the design team to understand and incorporate the specific qualities that constitute Full-Body Interaction. This contribution addresses the main challenges in Full-Body Interaction design outlined in Chapter 3. The goal of the method is also to strengthen the collaboration between all co-designers and provide them with tools to contribute with their expertise to the design. In this regard, children's roles and participation need to be negotiated according to the requirements and constraints of each project. For instance, in the project *Magical Movements*, we particularly focused on children's expertise in movement and interests to represent their perspectives on Shakespeare's play *A Midsummer Night's Dream*. We involved them in the decision-making process and evaluation of the design proposals. Nevertheless, the time constraints of the project and availabilities of the theatre school limited their participation in the final decision-making process of the prototype. In contrast, in the project *Refugi 307*, the museum was mainly involved in the evaluation and decision-making process due to the specific project requirements. However, we specifically used co-design techniques that allowed adult designers to elicit and focus on essential design aspects from the perspective of the child experience.

The FUBImethod is not exclusively an approach developed for the application in design projects related to embodiment. Several design stages are essential for a successful collaboration between design partners in co-design processes and research methods are generalizable for a wide range of design spaces. Nevertheless, the FUBImethod is an initial proposal derived from outcomes from a complex research project consisting of several subprojects. In this thesis, I have not been able to employ all design stages in a single project. Its effectiveness and the flexibility of the proposed design stages still needs to be explored. One possibility to validate the robustness of the FUBImethod could be to undertake a structured analysis by testing this approach against existing methods with different design teams that address the same design task. This procedure would allow us to compare the final experiences in regard to their appropriateness for Full-Body Interaction. In other words, we could observe how well they integrate the specific features of the medium and take advantage of embodied cognition benefits. On the other hand, we would also be able to analyse the design process and obtain a clear view on which aspects of each method fosters the emergence of Full-Body Interaction and meaning-making. One group could even possibly be a control group that does not use any particular method to structure the design process of the team. Based on the findings of this group, we could observe how designers use their intuitive experience and expertise to design for Full-Body Interaction.

Finally, the method could benefit from including research methods that focus on the reflective practice of design ideas and the communication of intermediate-level knowledge (Barendregt et al., 2017) between the design stages. The current procedure shows that researchers and designers tend to have a stronger role in taking design refinements and final decisions. In future work, design teams need to explore and develop new strategies to translate design outcomes of ideation and evaluation sessions into workable formats for reflective tools.

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ANNEX

Participa en el Projecte MOVENT-SE PEL PASSAT al Refugi 307

T'agradaria participar en un procés de disseny i investigació d'un joc interactiu? I descobrir com a través del moviment, la interpretació i la reflexió sobre el passat es pot desenvolupar aquest joc interactiu?

T'agradaria col·laborar amb un equip de recerca universitari i conèixer els seus mètodes de treball?

L'objectiu d'aquest projecte és el disseny i l'avaluació d'una experiència d'aprenentatge per a nens i joves sobre el tema de la defensa passiva durant la guerra civil espanyola. L'experiència es desenvoluparà en col·laboració amb el Refugi 307, un centre d'interpretació històric de la guerra civil presentat pel Museu d'Historia de Barcelona.

Qui som?
El *Laboratori d'Interacció de Cos Sencer (FBIL)* forma part del grup de recerca CMTech (http://cmtech.upf.edu/) que centra la seva recerca en comprendre el comportament humà en la interacció amb el món i amb altres persones a través de tecnologies interactives.

Els nostres objectius giren al voltant de la Interacció de Cos Sencer aplicada al joc, a l'aprenentatge i a les necessitats especials. La Interacció de Cos Sencer és la que permet experiències de joc en què els usuaris es comuniquen i controlen la tecnologia digital a través dels moviments del cos en l'espai. Aquesta recerca es porta a terme des del Disseny d'Interacció i amb la col·laboració dels nens i nenes en el procés de disseny. Les tecnologies utilitzades són anomenades "no intrusives", és a dir, sense cables, comandaments o controls (un exemple podria ser la Kinect per a la consola XBox). En els últims anys, la recerca en processos d'aprenentatge està demostrant que l'activitat física pot aportar beneficis. El moviment i la interacció amb l'entorn ens ajuda a aprendre, i a més, és divertit i motivador. Partint d'aquestes premisses, la nostra recerca se centra en definir, dissenyar i avaluar entorns educatius basats en la Interacció de Cos Sencer com a suport i reforç per a les formes d'aprenentatge habituals.

De què tracta el taller?

Aquest taller forma part del projecte de tesi "Full-Body *Interaction Design strategies and Assessment Methods for Non-formal Learning Experiences in Public Spaces*" de Marie-Monique Schaper, estudiant de doctorat de la Universitat Pompeu Fabra. Aquesta recerca està dirigida pel Dr. Narcís Parés, professor del Departament de Tecnologies de la Informació i les Comunicacions (DTIC) de la mateixa universitat.

Les activitats d'aquest projecte sorgeixen de la idea de crear una experiència interactiva d'aprenentatge d'interacció de cos sencer per a nens que contextualitzi la visita guiada del Refugi 307.

Les nostres propostes no pretenen substituir els mètodes habituals d'ensenyament, sinó que volen complementar el coneixement adquirit i promoure la reflexió dels alumnes sobre la relació d'esdeveniments històrics, el present i en la seva pròpia identitat. Al mateix temps volem ajudar els professors, tutors, monitors, guies, i tot tipus d'experts a millorar la transferència del coneixement i l'experiència durant la visita del Refugi 307.

Això vol dir que respectem els continguts didàctics dels centres educatius i al mateix temps busquem noves possibilitats d'usar tecnologies interactives per aportar un valor afegit als mitjans actualment usats en el Refugi 307.

El nostre objectiu és organitzar un seguit de visites al Refugi 307 i tallers en col·legis on els nens puguin acostar-se al procés de disseny de tecnologia interactiva, a partir dels continguts del currículum escolar i el programa educatiu del MUHBA.

En les primeres sessions es realitzarà una anàlisi de la visita guiada, dels interessos dels alumnes i dels objectius educatius del centre educatiu i del MUHBA. En les següents sessions s'introduirà la temàtica i la metodologia del procés de disseny i els nens aprendran a dissenyar una experiència interactiva des de la concepció inicial fins a la simulació d'un prototip.

En aquest procés els nens involucrats tindran per tant l'ocasió de desenvolupar competències bàsiques vinculades al coneixement del pensament crític implica el desenvolupament de competències claus com la capacitat de qüestionar i raonar sobre la realitat social i històrica. Amb el nostre projecte volem estimular la comprensió de fets històrics de manera més profunda i significativa. Les activitats permetran als alumnes valorar la seva pròpia història personal i la relació amb altres per facilitar la comprensió del passat i del present i la construcció del futur. D'aquesta manera els nens podran col·laborar i aportar el seu punt de vista en el desenvolupament de tecnologies educatives destinades al públic més jove.

Aquesta és una excel·lent oportunitat per col·laborar en un projecte de recerca innovador d'una universitat pública catalana, que té l'objectiu d'ajudar en problemàtiques socials a nivell europeu i al mateix temps aprendre com es fa recerca a la universitat.

Consentiment informat del participant
Per la present es certifica que el participant i els representants legals han estat adequadament informats sobre l'estudi que es realitzarà a les instal·lacions del Refugi 307 i en els centres educatius participants com a part de les activitats dins el projecte de tesi de Marie-Monique Schaper.

- Es poden enregistrar en vídeo o altre suport audiovisual les sessions d'activitats dels participants, tenint en compte que:
- En aquestes imatges les cares dels participants seran distorsionades de forma no reconstruïble per tal de garantir-ne l'anonimat.
- Aquestes imatges i vídeos seran d'ús exclussiu en el context de la recerca.
- La seva difusió en articles o conferències científiques garantiran l'anonimat dels participants.
- La seva difusió en mitjans o actes públics serà tan sols amb vocació de divulgació de la recerca per tal de fer arribar a la societat els avenços científics i en tot cas es garantirà l'anonimat dels participants.
- Tota la informació i resultats que es publiquin sobre aquest experiment seran realitzats en forma de grup i garantint l'anonimat dels individus.
- Els participants (i/o els seus tutors legals) poden no autoritzar la seva difusió marcant la casella adient més avall.

Poden contactar amb nosaltres en el moment que ho desitgin per tal d'aclarir qualsevol dubte tal i com s'indica al final d'aquest document. Tant el participant com el tutor legal del participant han de llegir i contestar les preguntes següents amb atenció: (Cal encerclar la resposta que es consideri correcta).

Ha llegit tota informació que li ha estat facilitada sobre aquest projecte? **SI / NO**

Ha tingut l'oportunitat de preguntar i comentar qüestions sobre el projecte? **SI / NO**

Ha rebut suficient informació sobre aquest projecte? **SI / NO**

En plantejar els seus dubtes, ha rebut respostes satisfactòries a totes les preguntes? **SI / NO**

Ha comprès que vostè és lliure d'abandonar aquest projecte en qualsevol moment i sense donar cap explicació, sense que aquesta decisió pugui ocasionar-li cap perjudici? **SI / NO**

Autoritza l'ús de les imatges i vídeos en les condicions esmentades a dalt? **SI / NO**
Autoritza la participació en el projecte de la persona de qui vostè és responsable? **SI / NO**

Nom i cognom del participant: **Edat:**

E-Mail del tutor legal:

No dubti en consultar allò que consideri oportú, tant abans com després de l'experiment. Pot sol·licitar tota mena d'informació a través del correu: *mariemonique.schaper@upf.edu*

o posar-se directament en contacte amb el Prof. Narcís Parés:
Narcís Parés
Departament de Tecnologies de la Informació i les Comunicacions
Edifici Tànger (Campus de la Comunicació-Poblenou) Tànger, 122-140
08018 Barcelona
93 542 26 31

Declaro que hem estat informats sobre l'estudi.

Signatura del participant: **Signatura del tutor legal:**

Data: Data:
Firma: Firma: