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Designing for spatial narration in children's playscapes

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Abstract
Today, digital technology is very much present in the everyday settings children live, learn, and play in. Focusing on supporting children's use of body-movement and senses in narrative play, we offer a theoretical framework and guiding design principles for digitally-enhanced physical play environments. Probing how children construct spatial narrative through interaction with tangible objects, we argue that blended environments which combine digital and physical media may contribute to the versatility of such spatial activity. With reference to an overview of related work in human-computer interaction, we discuss the intermediary capacities of objects, whether they are designed as toys for child-play or not. We identify different forms of interaction that children have with objects, and position blended environments within this classification. Also offering a repertoire of roles children take on in play, we outline four design principles for a prototype of a digitally-enhanced environment that enables children to articulate spatial narrations.

Keywords
Design for play, Interactive narrative, Playscape, Spatial experience.

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1. Introduction

Children intuitively use their environments for play and are generally adept in creating their own materials within it. While inherent features of places and objects may constrain how one engages with them, children use their imagination and intellect to see the environment and the objects in their own way: they utilize signals, construct their own rules and manipulate everyday objects according to the physical scenes they create (Piaget & Inhelder, 1967; Garvey, 1990). For example, they can turn a nook into a hiding place, or step on the pavement for immunity. Children can transform a place and create their own narrative world. A playscape is a space for "magical thinking" (Talbot and Frost, 1989) that children interpret and reinterpret in play. Today, playscapes are changing as digital technology becomes ever more present in the everyday environment children live, learn and play in. From here on, environments that possess digital technologies in support of the physical world are referred to in this text as digitally-enhanced.

In the field of human-computer interaction (HCI), there are several ongoing efforts for creating digitally-enhanced play environments that incorporate the body and space in the interactive experience. Many studies focus on augmenting objects of play with digital features that support spontaneous, imaginative and tangible interaction (Price et al., 2003; Follmer & Ishii, 2012; Van Beukering, 2014). Tangible features may prompt children to be physically active. Some other studies, grounded in the constructivist paradigm, encourage children to be physically active in a spatial context (Back et al., 2016; Shapira et.al, 2016; Boon et al., 2016; Valk et al., 2013). Even though these works do not focus on spatial narration, the novel interactions they offer activate more body movement than with just the fingers and eyes. There are yet other studies that support physical activity by providing digital augmentation through pervasive technologies (Price et.al, 2004; Ryokai et. al, 2011). These invite children to be physically active and explore their physical environment by moving around and looking. Yet, each consists of a unique configuration of activities, material resources, and relationships, as well as the interactions that emerge from these. They are structured, rule-bound, and goal-directed. They follow educational concerns but do not support children's own playful spatial narration.

This paper contributes to the existing body of research exemplified above with a framework of digitally-enhanced settings for small children of 4-8 years to create alternative play scenarios. The premise is to support children's spatial narrations as much as possible in their daily environments such as homes, schools and gardens as well as creating a bridge between children's spatial experience and their construction of meaning with an awareness of the role of their bodies. Our study delineates guidelines for designing environments that blend physical and digital objects for children to control in narrative play. The term narration throughout this study refers to story construction, not only as a process of meaning-making with symbols, but also as place-making via spatial transformation using objects. The theoretical groundwork given below concentrates on objects and their intermediary capacities to instigate narration with bodily movement in space.

We first give an overview of the relevant literature on child development to establish how physical objects can enhance children's spatial narration through bodily experience. Then we deliver four different interaction forms for classifying children's active engagement with their surroundings as well as the constitutive and intermediary role of everyday objects during play. Later, referring to key examples with a particular focus on children-object engagement implicit in spatial interactions, we delineate the terms self, avatar and reflection as different roles in narrative play. In the last section prior to conclusions, we synthesize design principles for digitally-enhanced narrative play scenarios of spatial experience.

2. Background

In developmental theory, children primarily construct knowledge through interacting with the environment and its components (Bruner, 1990; Piaget, 1962; Singer et al., 2006).

Accordingly, the physical environment and objects have key roles in a child's cognitive development and children have their own views of the world. Building on this, Papert's constructionism (1993) advocates that children learn more effectively when they are actively engaged in the making of tangible objects. Different than instructionism with technical methods for an educational agenda, constructionism is concerned with the nature of knowing (Papert & Harel, 1991) and how ideas "form and transform" in hands-on engagement in various contexts and media (Ackermann, 2004).

Research in developmental psychology (Piaget, 1962; Winnicott, 1971) and pretend-play in childhood (Garvey, 1990; Brosterman, 1997) shows that physical objects have a central role in children's exploration of their environment during play. Engagement with objects can support the construction of play narratives with both the real and transformed identities of the object (Fein, 1980). Several studies attest to how children use objects in play. According to Garvey (1990), objects mediate an open-ended place where children can represent their imagination. And Rossie (2001) demonstrates that children transform objects into toys, whether the object is designed specifically for child-play or not. The capacity for play that an object holds is linked to affordance, as coined by first Gibson (1966) then Norman (1988), the key facility of an environment or an object to convey its potential uses. Built-in features and embedded qualities of artifacts are suggestive in the meaning-making process through objects (Ackermann, 2007). Affordance is an essential issue to consider in the design of digitally-enhanced environments and the physical objects contained within. Children's engaged experience in an environment is defined by the materiality and the interactive potential of that environment (Crawford, 2009).

These fundamental relations between objects, space and narration in play are key in the design of digitally-enhanced play environments. It is essential to consider the intermediary role of children's everyday objects for mediating spatial narration.

3. A repertoire of forms of interaction in embodied ecologies

During play, children make use of signs they recognize in their surroundings, creating a dialogue between what is assumed to be and what could be. As they play, meaning and coherence both emerge as a result of their creative process through language and actions (Piaget, 1962).

Children perform various physical actions and interactions while playing. They interact with a small hand-held object in different ways than with a spatial element such as a carpet or a table according to the play scenario and/or the affordances of that object. Play spaces and action patterns display different forms in which children intentionally use and physically transform objects during play. In our analysis of several scenarios reported in the literature, children's interactions with objects show variation in the scale of the spatial experience, and the physical and metaphysical relations between the child and the object during play. We identify four forms of interaction in the physical environment related to body movements and spatial narration:

1. Hand-held form -- hands interacting with objects
2. Inhabited form -- transforming the physical environment that the body is in through narration
3. Abstract form -- narration through giving new meanings to objects
4. Across time and place -- connecting different times and places with digital technologies

In a playscape, all four categories can occur simultaneously. Nonetheless, this conceptual distinction of forms highlights different types of one's active engagement with their environment. In turn, this informs what type of interaction digital technologies may address in designs for spatial narration in children's playscape.

3.1. Hand-held form: Objects to transform

Children are able to transform objects into toys when they play with them. Hand-held form points at a particular kind of relation with objects that can be held and can be transformed physically. In earlier ex-

amples of how hand-held interactions are addressed in the field of child development, kindergarten aids, called the "gifts", were designed to support children in recognizing the common patterns, shapes and forms found in nature (Brosterman, 1997) and the relations between them. The Swiss educator Johann Heinrich Pestalozzi had observed that children learn through their senses and through physical activity. Pestalozzi's hands-on learning methods influenced many educators including Friedrich Froebel whose first kindergartens provided an environment with designated physical objects and physical activity. Maria Montessori extended Froebel's approaches, and she developed a framework in which manipulative materials play a constructive role. Her principles underlying the education of the senses, helped children develop sensory capabilities, control their own learning process and learn through personal exploration (Montessori, 1917). Today's kindergartens still contain diverse collections of manipulative materials such as Pattern Blocks and Lego. These materials support children's "understanding of mathematical concepts such as number, size and shape" (Resnick, 1998). Children learn to set stages and to build props to explore, enact, and ultimately work through many intriguing actions (Ackermann, 2007). The support eventually extends to making sense of and transforming everyday objects. Moreover, the "digital manipulatives", created by Resnick's group at the MIT Media Lab have computer powered traits for dynamic interaction between components and engage children in understanding and creating patterns. Physical artifacts can be digitally augmented to trigger innovative ways of interacting and discovering for children (Ishii et al., 1998) and digital manipulatives are among the best-known toys that incorporate digital technology with hands-on play blocks.

3.2. Inhabited form: Physical environments to adapt

The category of inhabited form addresses the evocative power of the physical environment. Outdoors, children seek adventure and challenge, explore and transform places to create imaginary worlds (Tovey, 2007). They rely first on their self-centered understanding of the world to navigate the environment, and after preschool, they gradually start relying on landmarks (Bechtel & Churchman, 2002). Every space has characteristics that evoke particular mental representations (Tversky et al., 1999) and until landmarks are learnt, physical features of the environment guide how they personalize the relationships with space (Maxwell & Evans, 2002). Comparative studies attest to the different spatial interactions that playgrounds and desks present to children (Bell, 2002). Examples of designs where spatial use of digital technology in the play environment guides bodily movement are Interactive Pathway Project (Seitinger et al., 2006) and The FlowSteps (Valk et al., 2012). In these, children all together engage in multiple play patterns while interacting with a large and mountable object in the environment. However, since these projects offer one shared object, the experience is limited for children's personalized narratives.

3.3. Abstract form: Objects to customize for narration

Narration is a fundamental aspect of meaning construction. The representation of experience in narratives provides a frame for children to interpret their own experiences to one another (Bruner, 1990). The category of abstract form corresponds to the meaning-making process through objects. The child's narrative language is a powerful vehicle that "allows children to designate the meanings of objects, and actions, to assign roles to people" (Engel, 2005). Research on narrative-driven pretend play shows that it requires a decoupling between the signifier and the signified (Piaget, 1962; Perner, 1993). The corollary of this proposition is, making the absent present, giving form to ideas, and bringing ideas to life. When a child uses a stick as a horse in play, s/he knows that it is not really a horse. Once the stick takes part in the child's activities, it begins to reshape her/his original ideas about horses (Ackermann, 2004). Many projects in digitally-enhanced environments that

recognize this "magical" power of objects focus on designing tangible construction kits that enable children to create their own objects. Examples are Topobo (Raffle et al., 2004) and Makerwear (Kazemitabaar et al., 2017). These construction kits typically offer components, such as sensors or actuators, that children can put together or connect to other artifacts to customize them. Another example, MaKey MaKey (Petersen et al., 2015) provides electronics to connect physical input to digital output. One of the popular examples of its use is the banana piano where fruits stand in for piano keys. The kit enables children to build their interactive toys by integrating everyday objects and computer programs. Even though these examples are of a similar scale with the hand-held objects, meaning can be attributed to the surroundings or remote objects as well. The next category achieves that to another extent.

3.4. Interaction across time and place

In addition to the spatial forms of interaction given above, experiences may extend across time and space, such as simultaneous presence in multiple places and varying temporality, as enabled by digital technology. The graphics of a previously created graphic reality, or a remote reality can be projected onto the surfaces of the physical environment. All kinds of surfaces can be augmented by digital display technology as a support for interaction. Commercially available technology such as those of Nintendo Labo, Nintendo Wii, and Microsoft Kinect use artificial visual recognition to detect and incorporate body movement in the virtual and augmented play environments. The natural feel of these interfaces blurs the line between the real and the virtual.

The physical sensing of virtual objects is absent in computer-augmented environments except while holding an implement that extends our sense of self encompassing an object of virtual reality (Shapira, 2016). When a person physically wields reality, his perception of it changes (La'davas, 2002). However, while virtual playgrounds provide children with access to a network and possible contact with the entire world from their personal physical space, they may disconnect children from physically engaging with their immediate surroundings.

These four forms of interaction in the physical environment highlight different modes of body movements relevant to children's spatial narration. Interacting with small objects, inhabited places, customizing the meanings of said objects and spaces, and virtually moving to a scene from the past or the future all provide rich experiences and constitute a vocabulary for initial design ideas. A separate set of categories for how children create narration during play is given below as a second repertoire to cross-link with these forms of interaction.

4. A Repertoire of roles in meaning construction with tangible artifacts

In pretend play, children move from real worlds to imaginary worlds and give new meanings to objects. They distribute character roles and take turns in being the narrator. Between their imagination and the physical environment, they shift from point of view to point of being to reframe the relations between the body and the world, self and other, mind and thought. This is a shift from the visual to the proprioceptive experience (Kerckhove, 2014). While point of view is visually dominant and detached from other sensorial experience, points of being privilege the sensations of the individual over its representations (Kerckhove, 2014). In her model of framing and reframing experience, Ackermann (2004) underlines the importance of a physical shift of position for a child for them to adopt different understandings. An action-perception loop mediates between embodied experiences and meaning making.

Children use narrative structures to invent and reinvent the world (Engel, 2005). In the narrative structures of pretend play, a child transforms what is to what if, for potentially both the meaning and the use of an object (See Figure 1). Children can engage with objects initially in two ways: manipulating description of object's properties or object itself. These engagements are

interrelated with object's affordances and this interrelation triggers the cycle of intentional and physical transformation of objects depending on children's narration. For these transformations, a child moves between different roles. Below, we outline three different modes of narration in play, i.e. self, avatar, and reflection. Our descriptions for each simultaneously offer evidence from eight existing projects that offer venues for these particular roles that children take on in their engagements with objects during spatial narration.

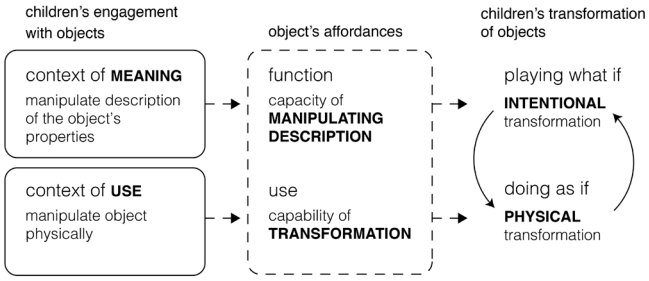

Figure 1. *Narrative structure of pretend play (created by author).*

4.1. Self: Our version of the world/ what is

Through play, the child begins to develop a concept of self. According to Piaget (1962), pretend activity begins with self-representation. For example, when a child pretend sleeps in the context of play, s/he is aware of pretense (Piaget, 1962). Pretend play adds a crucial new dimension to a child's understanding of reality. With expanding symbolic transformation into narrative play, children can differentiate and explore between the real and unreal.

A child has a perspective that gradually develops. Piaget (1972) writes that "the young infant relates everything to his body, as if it were the centre of the universe but a centre that is unaware of itself". An infant's isolated actions such as sucking, looking, and grasping are centred on her own body. When the infant conceives of objects only in terms of her actions on them, she has not yet differentiated the object from her own action on it. Decentration occurs in the infant's first two years after which s/he no longer feels at the centre of the universe but now recognizes herself as part of a world of other objects (Piaget, 1972).

Various designs for interactive narrative environments for children have emphasized the value of the role of objects in cognition. For example, the POGO environment, developed by Decortis and Rizzo (2002), supports the development of children's narrative competence by providing them the opportunity to express themselves through different media channels. The circle of narration starts from the sensorial knowledge of reality and returns to a different version of it through an active transformation of the environment. This environment supports children to express themselves in building a world model. POGO players can capture and manipulate images in various media and combine them in sequential forms to create visual narrations.

4.2. Avatar: Character roles/ what if

In pretend play, children need to view a situation from someone else's point of view. This supports individual's personal and cognitive growth (Piaget 1962; Winnicott, 1971). With character toys children can create interrelationships and plots while practicing their social knowledge (Shantz, 1975). These toys are tangible interfaces that can empower children in constructing personal narratives. A child can talk to her character toys who do not really listen to her. Continuing an "illusion of magical thinking and captive listeners" (Vaucelle, 2010), the child can practice her narrations on imaginary accompanists.

The child may choose to use not only an exterior prop such as a toy but also oneself as a prop (Vaucelle, 2010). In human-computer interaction, this role-playing brings about avatars. Avatars are virtual representations of humans controlled completely by the owner and other agents. An avatar reflects real time behaviour of its human counterpart whereas an agent reflects behaviour according to "a computational algorithm designed to accomplish a specific goal or set of goals" (Bailenson and Blascovich, 2004, p. 64). These environments encourage children to take perspective through narrations.

Several projects build character-based-narrative environments to support children in building their own

narrative pet or character. Three early examples with character-based interactive environments encourage children to construct narrations through characters. In the first with the improvisational puppets (Hayes-Roth & Gent, 1997), children explore different character actions and reactions while manipulating the puppet-characters. Adding emotive facial expressions on the computer screen, Personal Electronic Tellers of Stories (Druin et al., 1999) provide a robotic environment where children name their robotic companion and compile a library of stories. SAGE is another collaborative narrative environment that invites children into a three-way interaction between the child, computer and a stuffed animal (Bers et al., 1998). The stuffed animal becomes the child's listener instead of being the hero of the child's story and holds stories that the child chooses to tell. The children in SAGE can create their own characters and databases of stories, while exploring different notions of self and performing the narrative voices they want or need to hear.

4.3. Reflection: Perspective taking/ what is and what if

During play, children acquire the foundations of self-reflection and abstract thinking to develop complex communication and meta-communication skills (Bateson, 1976). Related to this, metacognition is an awareness of one's own cognitive processes and thinking (Flavell, 1979; Fisher, 1998). Piaget & Inhelder ([1969] 1993) have pointed out that it is possible to engender in children an inner discussion and that later on, this inner discussion starts a kind of reflection.

Metacommunication is fundamental in the development of shared understandings between children as they play together (Bateson, 1976). These shared understandings among co-players are what Bateson calls "play frames" and determine children's actions in a play episode. Play frames are situations when children talk in character about what their characters will do as well as the props they will choose. They are essential for the development of children's self-reflection and the awareness of the rules of communication (Fein, 1980). Children learn to monitor and direct their own progress, asking questions such as "what am I doing now, what else could I be doing instead?"

In narration, voice can be of a narrator, a character, or the author speaking as herself (Cassell & Ryokai, 2001), and can be a tool of reflection as well. There are examples of digital narrative platforms that support voices for individuals or for peer collaboration. Some combine physical objects with digital data. For instance, StoryMat is an augmented digital map that records, stores and recalls children's narrations (Cassell & Ryokai, 2001). It stores not only voices but also the movements of the toys the children play with. It offers a place to experience collaborative narratives regardless of the presence of a co-temporal and co-spatial playmate. Differently, the DiamondTouch table invites children to collaborate over shared digital media (Dietz and Leigh, 2001). And in another example, I/O Brush, children use a paintbrush to gather color, texture, motion information from their surroundings in order to build their visual narrations and share them with their peers digitally (Ryokai et al., 2004).

Overall, the eight projects referred to in the sections above show how an interactive environment that seamlessly supports the self, the avatar and reflection roles dynamically. While POGO and KidsRoom support children to look at their environment more actively and express their way of looking at the world, Improvisational Puppets and Personal Electronic Tellers of Stories and SAGE are designed as platforms for creating character toys for children as their own playmate when narrating. StoryMat and The DiamondTouch Table support collaborative narration and can be also considered as augmented furniture that sustains daily spatial experience. I/O Brush invites children to look at their environment more actively. Blended environments can also offer children intermediary platforms to simultaneously take on different roles and create collaborative spatial narration even when children are at different locations. Narrations that extend across different roles, times and places

constitute a fourth mode.

4.4. Narration beyond time and place

It is already established that children construct stories with characters they identify with and objects that can be held, moved, transformed. Their actions with objects facilitate transitions between thoughts and situations (Turkle & Papert, 1990). In digitally-enhanced environments, these transitions can be to virtual worlds. Referring to some of the examples already mentioned above, a narrative in KidsRoom (Bobick et al., 1999) ties the physical space, the participant's actions, and the different output media together into a coherent experience. A child's own room might stimulate the child's imagination by using images and sounds to transform itself into a fantasy world. As POGO (Fusai et al., 2003) supports different media channels, children can use several interactive tools to compose, edit and perform stories in a virtual world. A simple setting of distributed tools provides a seamless integration of the physical and virtual world through intuitive interaction modalities. This causal link between the physical and the digital enable children to plan what is happening and why, and from this plan precipitate further experiences and interactions.

5. Design principles of digitally-enhanced environment for spatial narration

As articulated in the section above, digitally-enhanced environments can support the reciprocal relation between actions and the environment in children's play by revisiting the role of objects and the actors who manipulate them. Digital interactive technologies can provide unique feedback to children and allow them to be in control of the flow of their play through interventions. The feedback can motivate children to move around in space, pick up and manipulate, or add objects. In line with the categories presented above, we infer below a list of general guides for the design of digitally-enhanced narrative places that sustain bodily and sensorial experiences that support children in constructing their own rules and meaning:

1. Inventing Tools by Manipulating the Object
2. Becoming a Playmate
3. Switching Roles in Collaboration: Planner and Player
4. Being Here and There: traveling across spaces

These follow the categories of children's interaction and roles in narrative play and can be used as guides to integrate the physical environment and the digital environment to the child's playscape narratives.

5.1. Inventing tools by manipulating the object

The first principle is to design an environment to allow children to explore through engagement with objects. Physical engagement with objects can provide intuitive models of interaction where children can develop their own way of expression. Using an object in pretend play, provides children to construct their own spatial narration. While creating their own narratives, children explore their environments (what is) and through their imagination, they also investigate new ways of looking at their environments (what if). Addressing learning through making, Papert's approach shows that the use of external objects helps for self-directed learning that "learners invent for themselves the tools and mediations that best support the exploration of what they most care about" (Ackermann, 2004).

One's physical use of an artifact may turn into a central role in the immersion and engagement activity. If there is also a reaction that transforms the object into a new use or meaning, this role is similar to that in the reflection in action coined by Donald Schön (1983) for designers. In the context of design, action is the trigger of a reflection where following the experience upon the action, the designer switches perspective. Accordingly, a digitally-enhanced environment may enable children to construct their own narratives using physical objects.

5.2. Becoming a playmate

In addition to providing physical objects to interact with in digitally-en-

hanced environments, it is important for children to be able to observe the impressions their moves and engagement with objects create. The idea of triggering reflections provides children to create their narration by interpreting their environment. In doing so, children can experiment character roles and the casual relationship between their action and interaction. Children construct and move within alternative worlds while acting out different roles. Through narration, children develop their own idiosyncratic view of things and also ways of expression (Engel, 2005). Spatial experience may enable children to build their schema, by exploring their reflections among digital and physical environments. Within the context of human-computer interaction, through display surfaces, children manipulate tangible props and observe the augmented scene. They can observe the results of their actions on the augmented scene displayed on a screen. This enables them to perceive and observe the effects of positions by interacting with the system. It may enhance their understanding of the causal links by spatial experiences. Current examples show that augmenting surfaces can act as an interaction modality. Displays are usually used as access layers to common information spaces where children manipulate images through common sets of rules. Digitally-enhanced environments can promote interaction with physical objects and surfaces that children are playmates to or have as playmates.

5.3. Switching roles in collaboration: Planner and player

In the context of play and its relationship to engagement with physical objects and their reflections, the interaction between the children themselves is also essential. This can support children to transform the place that facilitates multiple roles and perspectives to them. During play, children point out things to one another, share their findings, and instruct one another by making up rules. They switch between the roles of the planner who makes up the rules, or the player who performs them. The making up of rules can be through engagement with an object that is also an intermediary for switching one's role from planner to player. Sharing roles, taking turns, and thinking about the activity and the events from another's point of view creates a collaborative environment. Such a collaboration may stimulate the children to externalize their thoughts and share their experiences with others (Price et al., 2003) and such communication between children is likely to enhance their level of engagement, their ways of exploration and ability to reflect on their own experiences. To enable this communicative cycle, digitally-enhanced environments can create semantic links between the use of physical objects and environments where different roles can occur. Physical activity with objects helps to associate new meanings in the physical environment.

5.4. Being here and there

Being actively engaged with the physical and digital environment, whether it is when interacting with another child, an object, or the space, can enhance children's understanding of their actions. Our movements constitute a continuous interaction between our bodies and the environment while the structures governing our sensory faculties characterize our tactile and visual exploration of it (O'Regan and Noë, 2001). While, in tactile exploration, a part of the body touches an object partially or fully, visual exploration reverts to some previous tactile knowledge of the sensed object alongside of the visual attributes.

Physical interaction with objects can trigger new visual explorations and reflections and these capacities are often utilized in play. For instance, objects can be presumed to be bridges or doors for players to move from a physical environment to a digital environment. Digitally-enhanced environments can specify the degree to which the designated object enables travel among environments.

6. Conclusion: Future of playscapes

Addressing the potential of digitally-enhanced environments for children's narrative worlds in pretend play, we identify key features that frame ways to introduce spatial narrative into

playscapes. In the intersection of the fields of design research, child development, and HCI, we present a framework for designing environments for children to co-construct narratives, engage in active exploration and reflect on narrative experiences.

The overview presented here is trifold. Firstly, we categorized the different forms of interaction observed in relevant examples of digitally-enhanced narrative environments for children. The criteria were the distinction of physical and metaphysical scales of the interaction. These categories are the basis for exploring spatial features necessary for children to infuse imaginative play into their everyday places of inhabitation. Secondly, we delineated the narrating behaviors of children in playscapes, based on patterns of full-body engagements with object/space in educational psychology literature and in recent HCI practice. When coupled with the various forms of interaction, these yield to the potential features, both digital and physical, of playscapes. Thirdly, we established four basic design principles for digitally-enhanced playscapes that encompass the categories of interaction and the repertoire of roles towards promoting children's bodily interactions with everyday objects.

By concentrating on narration-heavy pretend play, we expand children's spatial experience in digitally-enhanced environments to encompass active engagements with objects. The framework with categories of interaction and repertoire of roles embodies a unifying approach to designing an environment that sustains the values of bodily and sensorial experiences of playing children. It can also be seen as a formulation of criteria of the essential qualities for spatially enabling narration in play. What is identified as design principles refers to the set of desired affordances for the environment to be designed. It embodies the kinds of experiences for which to reconfigure the physical and digital worlds as well as the sensory and symbolic modalities of interaction.

In order to bridge embodied experience and the construction of meaning, an awareness of the role of the body

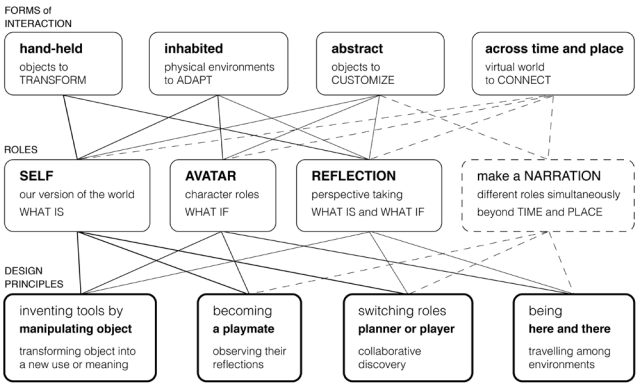

Figure 2. *The links between forms of interaction and narrative behaviours to reveal design principles of digitally-enhanced environment for spatial narration in children's playscapes (created by author).*

and spatial narration in a child's experience is an essential groundwork. Next steps include investigating techniques for creating models of pedagogical planning while undertaking the design of a prototype. Employing an iterative process of designing new environments, implementing prototypes, and conducting empirical studies can further articulate the parameters of narrative-centered playscapes. In ongoing related work, we specifically develop a digitally-enhanced physical play environment that articulates narrations in action with visuals. The premise is to enable children to establish dialogues between fact and fancy, as well as between the eye and the body as they see the results of their thoughtful actions with objects-in-the-world. Thus, we are motivated to use surfaces for display to provide children's own images synchronously to enable the reciprocal connection between the digital and physical environments. By moving around and adding objects to the physical space, children can fictionalize the meaning of that space and compose their own narration embedded in that physical playscape with feedback from a digital environment. The dynamic cycle of action, observation and reflection in the active interface of thus transformed components of an architectural space can continuously create variations that enrichen children's spatial experience and narrative.

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