

# Designing an Interactive Installation for Children in a Museum to Learn Abstract Concepts

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**Abstract:** Most interactive informal learning approaches use different technologies to focus on a specific knowledge domain from school curriculum for children. Others attempt to develop children's skills: social, cognitive, physical, etc. We propose that interaction has also great potential to enhance learning of abstract concepts, such as how science and knowledge are structured, by designing specific user-attitudes in the interactive experience. In this paper we describe the steps followed in the conceptual design and interaction design of an interactive museum installation for children 14 to 18 years old. We explore how to extend informal learning towards learning abstract concepts through interaction.

## Introduction

In the quest for understanding how interaction and interactive applications can provide a learning ground for children, most approaches have been based on school curricula. This means that interaction is used to transmit a very specific content with very specific material support. In contrast, we present a project that explores how interaction can transmit very general abstract concepts.

The use of digital technologies for informal learning in museums, science centres, cultural centres, galleries and other public spaces has shown a massive increase in the past years (Hawkey 2004, Roussou 2000). Based on the notions that more active participation enhances children's learning and that virtual reality presents advantages for education (Wickens 1992) several projects have been developed to provide novel playing and new informal learning activities focusing on children's curriculum, especially on science, math, engineering, creativity and storytelling (Johnson et al. 1998, Salzman et al. 1996, Johnson et al. 1999).

On the other hand, it is quite important to study also interaction "considering how physical actions and user activity can become more an integral part of cognitive activities" (Price & Rogers 2004). Understanding interaction and its properties as a communication medium should help better design motivating learning experiences for children and decide when interaction is useful and justified to use (Druin & Inkpen 2001).

Recently, through mixed and augmented reality environments, different projects bring physicality to interaction and ubiquitous computing and mobile technologies have been widely used to combine users physical movements, gestures, or position with higher order cognitive processes promoting exploring, planning, decision-making, reflecting and reasoning (Price & Rogers 2004, Facer et al. 2004, Halloran et al. 2006). Also, tangible interfaces and tabletop systems are other approaches to bring physical actions into informal learning, through hands-on learning activities (Papert 1980, Resnick et al. 2000, Zuckerman & Resnick 2003).

In comparison to state of the art we present Connexions, a museum installation, based on previous work (Parés et al. 2005), where full-body user actions and attitudes help them understand that science is a network of knowledge where cooperation between scientists is essential for its evolution. This is achieved by:

- Defining actions that enhance a specific user attitude, which supports a desired metaphor that links to the stimuli represented in the interactive experience.
- Understanding “learning as a process of active engagement with experience encouraging a wide range of behaviours, skills, dispositions and actions” (Hawkey 2004).

## Context.

### The Museum

Museums offer a great chance to teach using new pedagogical approaches (Semper 1990, Resnick 2004, Roussou 2000). Taking advantage from this opportunity Connexions was conceived for Barcelona’s Science Museum “CosmoCaixa”. The central strategy underlying museology for CosmoCaixa is based on showing the visitor that all areas in scientific knowledge are related. Therefore experiments, real pieces and living beings are placed in one single large exhibit (3500 m<sup>2</sup>) called the “Room of Matter”. This room is structured in four areas that follow evolution of matter since the beginning of the Universe:

- Inert Matter: e.g. radiation and waves, optics, fluids, uncertainty;
- Living Matter: e.g. genes and genetics, the cell, the first ecosystems;
- Intelligent Matter: e.g. the neuron, perception;
- Civilized Matter: e.g. tools, fire, self-awareness, inventing matter.

CosmoCaixa takes selected objects (e.g. a fossil, a meteorite, a brain, a living fish, etc.) as the excuse from which to guide the visitor into scientific knowledge, as opposed to subdividing the museum into isolated compartments (e.g. mechanics, optics, waves, etc.) as traditional science museums have done in the past. In other words, each object represents a set of scientific domains that are related to it and by interesting the visitor in the object she is then engaged in the concepts behind the object (Fig. 1, museologic approach).

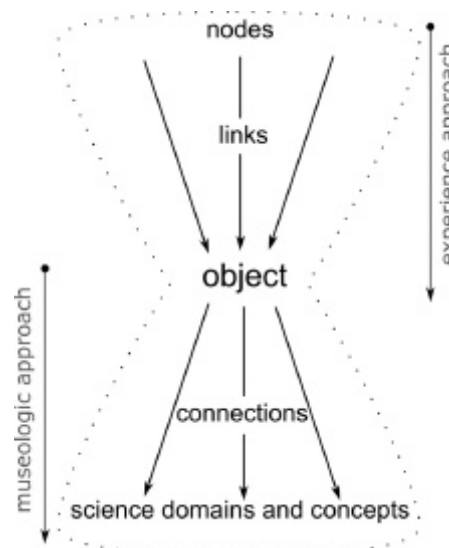


Figure 1: Underlying museology strategy for CosmoCaixa and the related strategy for the interactive experience.

## Framework

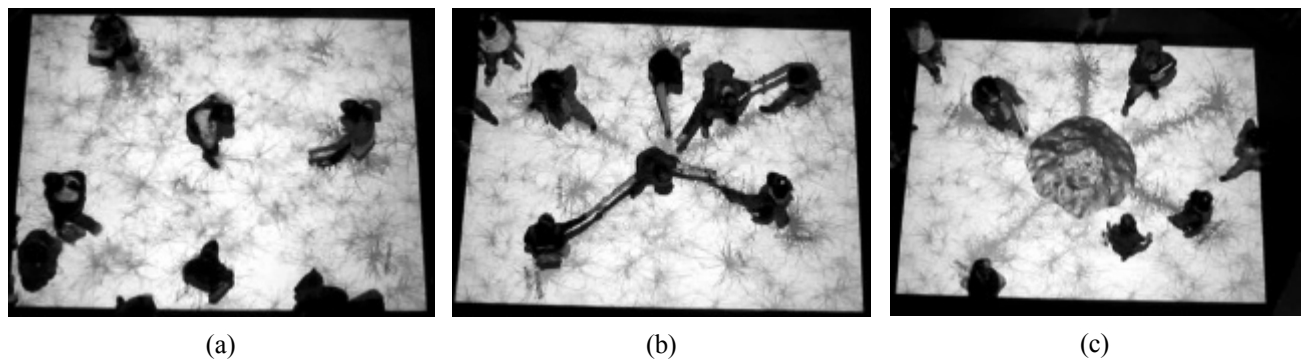
Because we wanted to stress that scientific areas are not isolated compartments, we decided to use the notion of a mesh or network as the leading metaphor. This linked with the museological approach of CosmoCaixa in an inverse direction (Fig. 1, experience approach). In other words, the experience starts from scientific concepts and domains and leads to discovering a related (virtual) object; a virtual object that represents one of those found in the museum.

## Connexions

### Game play

Connexions, is a full body interaction installation for children 14 to 18 years old. A mesh of nodes is projected on the floor surface that acts as a large screen –5m x 3.8m– (Fig. 2a). Between four and nine nodes are highlighted and labelled with a tag –a concept found within the museum displays–. Some of the highlighted nodes are clearly related and reference one specific museum object while remaining nodes are not related to that object. For example, the concepts: “atmosphere”, “fusion”, “turbulence”, “trajectory”, “solar system origin” and “extraterrestrial stone”, refer to a “meteorite” object. These are mixed with two more concepts: “genes” and “floatability”, which have no relation with the meteorite.

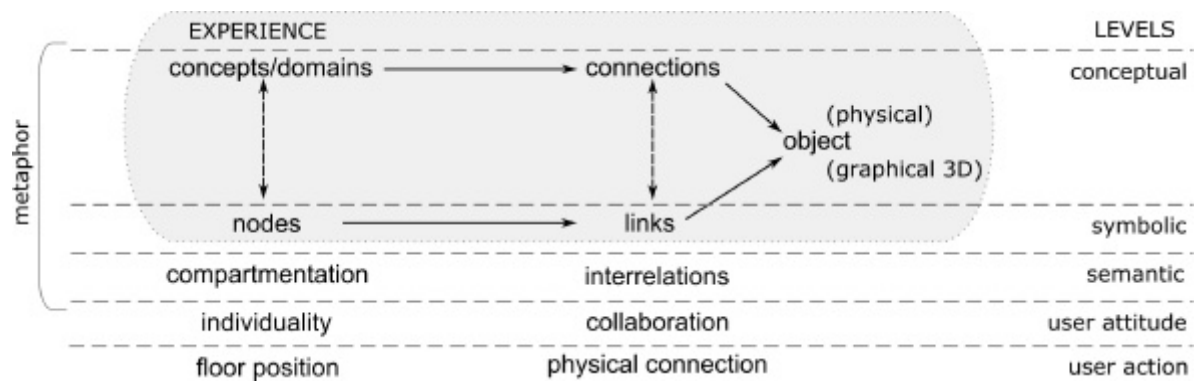
By walking around the space children explore the mesh and may activate the nodes related to the object by standing on them. In such case the nodes are coloured showing that the concept is related to the others and to the “hidden” object (Fig. 2a). The non-related nodes cannot be activated by users. Children may cause activated nodes to grow extending links towards other activated nodes if they extend their bodies along these paths. The goal is that children link all nodes with coloured paths, by physically linking together: holding their hands, extending their legs or arms, touching each other, etc. (Fig. 2b). When all the nodes making reference to the hidden object are linked, a 3D image of the object appears (Fig. 2c). Between 8 and 15 children are necessary to activate and link the nodes and discover the objects. After a while the experience restarts with a different set of nodes, concepts and hidden object.



**Figure 2:** Game play: **(a)** children activate (colour) nodes by standing on them, **(b)** children link activated nodes connecting their bodies, **(c)** an object (here a meteorite) appears when children link all the nodes related to it.

### Meaning generation through interaction

To describe the interaction design followed in the experience we will define a model (Fig. 3). The goal of the experience was to transmit to children the abstract notion of science being a network of knowledge that interconnects concepts and domains.



**Figure 3:** Model describing the relations on which interaction design is supported (see text for details).

### ***Conceptual-Semantic relation***

From the goal above, which constitutes a conceptual level, we established a relation to a semantic level by relating the *concepts and domains* to the meaning of *compartmentation* and relating *connections* (of those concepts and domains) to that of *interrelations* between compartmented items.

### ***Metaphor: Semantic-Symbolic relation***

To transmit the defined meaning to the users we decided to use a metaphor that could aid us in the interaction design and in the visual output design. We defined the metaphor of a mesh or network, relating *compartmentation* with the visual notion of a *node* in the network, and *interrelations* with the visual *links* of the mesh.

### ***Interaction Design: a user attitude for the symbols***

This is the central focus of our research, i.e. to design user attitudes that can support the semantics of the experience. Each user, as an individual, is related to the notion of *nodes* at the symbolic level. Therefore, *individuality* signifies *compartmentation*. Likewise, a collaborative attitude is related to the notion of *links*, which signifies *interrelations*.

### ***User Activity: enhancing user attitude***

To promote users to adopt the described attitudes certain specific actions must be designed. In other words, if a user must fulfil the act of *individuality*, she must move through space inputting her position to the system. On the other hand, to generate a collaborative attitude, users must physically connect with others. These actions are physically conveying the metaphor.

### ***Meaning generation***

To sum up the described levels and the diagram (Fig. 3) the bottom-up steps taken by users in interaction are a set of actions that promote two attitudes, namely: *individuality* and *collaboration*. Through *individuality*, they activate *nodes* (the visual output of the metaphor), which provides the meaning of compartmented science domains. However, through *collaboration*, they make branches grow between nodes until they are all connected, which generates the meaning of *interrelations* between domains. Moreover, this collaboration also directly signifies collaboration between scientists in finding new connections in knowledge and, hence, new discoveries. Therefore, physical full-body interaction generates the desired meaning.

## Results

When the virtual object appears, children can question themselves about the following relations:

- between the object and the concepts in the activated and linked nodes.
- between their activity during interaction and the obtained results.

This are the minimum notions we wish to provide the children that pass through the experience. However, this must be assessed and either proved or refuted. Therefore, we are currently in the process of gathering data through surveys to the groups of children that visit the experience. We will also use control groups of children that will visit the museum but not play with the installation.

Taking into account different assessing frameworks: the one proposed for successful learning games (Malone & Lepper 1987); the criteria of good interactive educational software (Reichert & Hartmann 2004); for assessing learning in museums with an educational experience (Gammon 2001); and the analysis of learning – educational efficacy of virtual reality learning experiences (Roussou et al. 1999)– an ongoing work tailored for them is being done based in quantitative studies and observation.

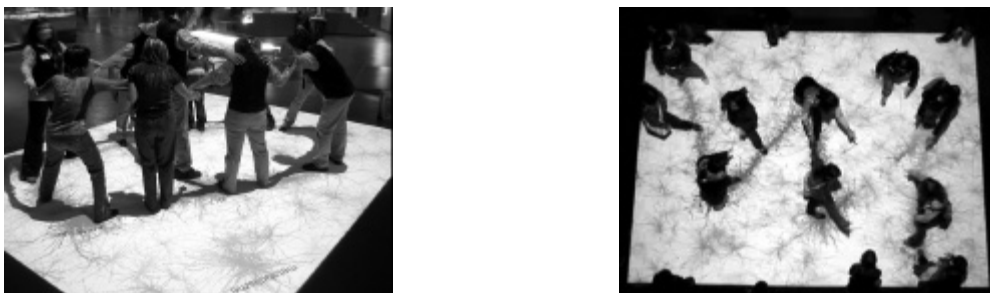
## Conclusions

Several groups of scholars have already played within the installation. We have received some very encouraging feedback from teachers of these school groups and from monitors guiding them through the museum and experience.

We can identify a set of interesting properties and advantages of the designed interaction in this experience:

- Naturalness: This has been achieved by using a camera vision system to detect users and by analysing which game mechanics best fitted the desired user attitude.
- Multiuser: the chosen interaction activity is inherently multiuser.
- Participative: children are required to interact with each other by asking them to collectively analyse how the nodes are activated and linked promoting exploration, discovery and reflection.
- Collaborative: the proposed game mechanics asks children to place themselves with respect to others and connect to others for a common goal (Fig. 4).

And as minor drawback we have to mention the tags attached to nodes defining the game concepts which impose a language understanding constraint.



**Figure 4:** Users collaborating linking together (two views).

Hence, our main conclusion is that when designing interaction that wishes to generate meaning, a good approach is to put the accent on the relationship between the activities and attitudes of users within interaction and the concepts or ideas that are to be transmitted. Users' actions must be placed at the center of the design

and the meaning must be generated by making the users live the concepts through designing accurately their attitudes. This design approach must now be further researched and applied to many other cases to be able to structure it formally and learn more about the potential of interaction, especially in applications for children and playgrounds.

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