Augmented Reality as a Social Technology: Visitor Interaction in the Museum

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With the maturing of Virtual Reality technologies over the past several years, virtual experiences have claimed an important position in public education. Museums in particular are now exploring new opportunities to engage their visitors, as they see their role shifting from being places of cultural preservation to providing spaces for participative experiences. After the first wave of digital multimedia exhibits in the 1990s sought to optimize effective communication of information and thus create a stimulating learning museum,[1,2,3] virtual technologies now shift the paradigm to a social participatory museum.[4,5,6] Creative engagement, interaction, and social involvement in the museum are about to transform how historical and cultural knowledge is made available, accessible and relevant to today's societies.[7,8] Thus, many museums are now seeking the "Holy Grail of interactivity"[9] to engage their audiences and to fulfil their role as community spaces.

Fig. 1. *ARticular* iPad app (Image credits: photography adapted from Flickinger, 2012; CC licence)[10].

Today's museum technologies of choice include Virtual Reality (VR) and Augmented Reality (AR) interactive installations and applications. A significant advantage of AR is the affordance to allow users to see the digital content superimposed over the real world without obstructing it entirely and without shielding the user from the spatial and material experiences of their physical surrounding. Unlike immersive Virtual Reality, AR is able to facilitate face-to-face communication between users during their interaction with virtual content. Since museums are public forums, visitor interaction in the museum environment is predominantly social.[11] This is especially relevant for children's discovery centres inside the museum, a popular area for virtual learning technologies, where the age of the children means that they usually visit with adults, such as parents and grandparents. Virtual learning activities can be designed to support social interactions between the children and their accompanying adults, and to provide the opportunity for intergenerational knowledge sharing. Thus, communication of information, no matter how sophisticated and engaging, is no longer the primary focus of museums. Instead, collaboration is the new mantra. This collaboration

can be multi-channel and multi-directional. Aided by virtual technologies, users interact with information and thus collaborate in the presentation, contextualization and even interpretation of knowledge. The museum itself may collaborate with its visitors by facilitating their interactions with exhibits, some of which may be altered by user input.

Most importantly, visitors can interact with each other, making the museum a communal experience.

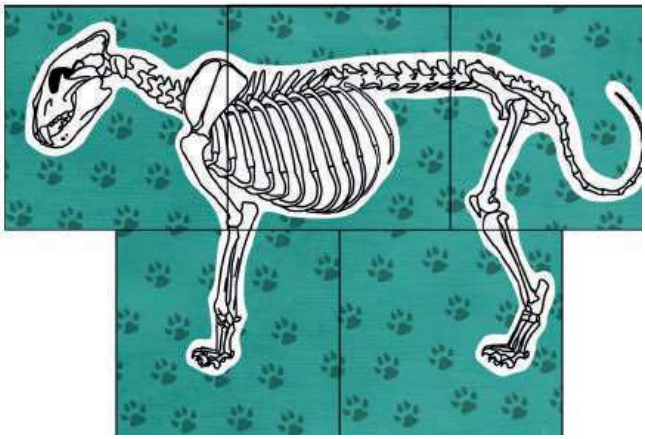

Fig. 2. Skeleton Puzzle (lion) (Image credits: skeleton adapted from Ellenberg, Dittrich, & Baum, 1956; used with permission).[12]

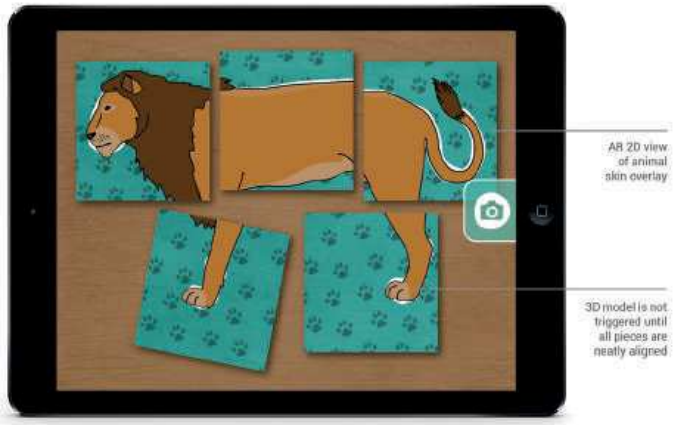

Fig. 3. 2D Skinning (AR overlay) (Image credits: Sophia Spivak)

The social potential of AR has not yet been fully explored. Often, too much emphasis is placed on user interaction with the technological system, be it an app, an interactive game, a virtual artefact or a digital knowledgebase. In contrast, the potential for user interaction that is facilitated by, but concurrently occurs *outside*, the technological system, is much less explored. Because AR can simultaneously engage physical and digital interactivity, multiple users can explore, discover and learn together in real-world experiences. For example, family visitors to a museum can talk with each other about an AR activity *while* interacting with it, whereby the exchange of information and experiences between users happens during the activity, not during intervals or afterwards.

The following example at the Auckland War Memorial Museum explicates the design of an AR learning game that foregrounded the social and motivational affordances of AR. The Weird and Wonderful gallery at the museum already employed a number of virtual activities for young learners, but many of these lacked a capacity for interaction and collaboration. The existing application on marine life, for instance, displayed additional information in AR without further pathways of engagement. What was lacking was a learning experience that allowed for deeper levels of interaction, creativity and collaboration for visitors. A subsequent research project into a suitable AR learning application on natural history, aimed at children aged 4 to 8, produced a set of aesthetic, interactional and pedagogical guidelines that emphasised collaboration and communication between visitors, intergenerational learning where children and adults share their knowledge, multi-sensory stimulation involving sight, hearing, touch and kinaesthesia, a creative component that allowed for open-ended fantasy play and motivational considerations.

The resulting *ARticular* application utilised a gamification approach that assisted with pedagogical and motivational requirements. The facilitation of intrinsic motivation, where a visitor would undertake an activity "for its own sake, for the enjoyment it provides, the learning it permits, or the feeling of accom-

plishment it evokes[13]", was realised through an interactive AR puzzle game about animal anatomy, inspired by classical board games, mix-and-match mobile games, and jigsaw puzzles. The puzzle itself allowed for active participation beyond observation, and encouraged cooperative play with other visitors. Puzzle play requires problem-solving at a conceptual level, and this is where younger and older kids, and children and adults could work together.

Fig. 4. AR 3D model and animation (Image credits: 3D image by De Espona Infographica, 2012; used with permission).[14]

The game play of *ARticular* involved two interaction modes: tangible interaction and device-based interaction. Tangible interaction related to the physical building blocks of the puzzle, which contained sections of animal skeleton structures. The skeleton images were transformed by the AR application into virtual objects, which occurred at two levels: first, 2D images overlaid the relevant skeleton sections with muscles, flesh and skin, and second, 3D animations produced a lifelike representation of the respective animal. One goal of the game was to fully reconstruct an animal skeleton by assembling the puzzle blocks in the correct topography. If the match was successful, the separate virtual 2D images were replaced by a 3D animated model showing the animal moving. At this stage, access to further interactive features and content on the specific animal was provided. The virtual 3D object thus functioned as a gateway to multi-layered information on the animal, which could be explored collaboratively by children and accompanying adults. The game was constructed in a way that each task ("construct" mode) would lead to the possibility of further exploration ("create" mode), and this is where interaction between visitors was particularly encouraged. For example, the feature to assemble "weird and wonderful" fantasy creatures from diverse sets of skeletons excited children and adults alike and opened up AR access to unexpected, strange and novel "fun facts" on imaginary animals.

It was important to set up the play and display area of *ARticular* in a way that supported visitors' communication with each other. Of the three most common AR display positioning approaches, head-mounted display (HMD), handheld, and spatial/projection,[15] two were unsuitable to the communal requirement of the game. HMD tends to limit AR display to an individual player and as such foils a collaborative space. A study by Billinghurst, Kato, Kiyokawa, Belcher and Poupyrev (2002)[16] found that "using a HMD to show AR content made users feel distanced from their collaborator and severely reduced their perceptual clues."[17] AR projection, in contrast, creates too much space between player and the responsive AR display and thus separates the task space from the communication space in collaborative AR activities.[18] In such settings, players would need to constantly shift focus between the screen, the game board and each other, decreasing their awareness of each other's communication cues that are normally present in a face-to-face setting. A handheld device solution proved the more suitable AR display method. *ARticular* utilised a standard Apple iPad that was mounted on a movable stand in order to allow players to use both hands for assembling

the physical puzzle blocks while they could also operate the iPad screen as and when needed. The mounted iPad tablet effectively presented an interactive tabletop solution that incorporated both the physical workspace with the puzzle blocks and the touchscreen for displaying and manipulating virtual content. The free access to the tabletop setup and close proximity between task space and the players' communication space optimised the face-to-face interaction within user groups. A study conducted at the Harvard Museum of Natural History[19] suggested that interactive touchscreen tabletop games have a high potential for museum learning and collaboration, because they are able to "cue social practices of game play that spark collaboration."[20] In order to enable learning beyond the museum visit, *ARticular* is also available as an app that users can download onto their smartphone or tablet and launch the game there. Aided by virtual technologies such as AR, visitors can take the museum with them out into the world and into their communities.

Fig. 5. "Weird and wonderful" fantasy creatures with AR 2D overlay (Image credits: Sophia Spivak)

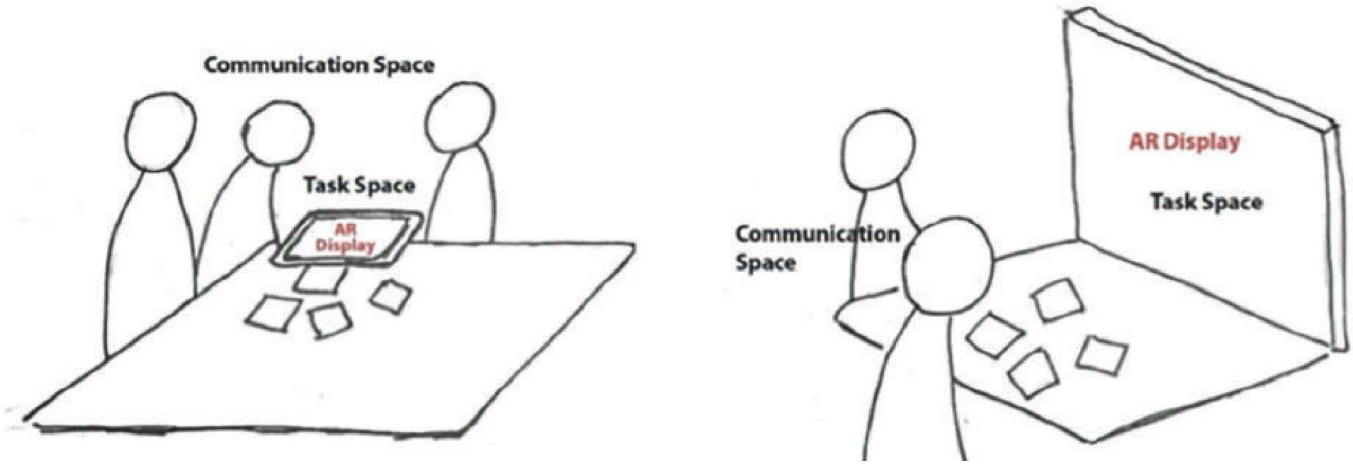

Fig. 6. Shared tabletop (left) vs. AR projection (right) (Image credits: Sophia Spivak)

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