MagicMuseum: Team-based Experiences in Interactive Smart Spaces for Cultural Heritage Education

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ABSTRACT

MagicMuseum is a set of team-based, immersive, full-body activities for Cultural Heritage Education of primary school children. MagicMuseum exploits the interactive and multisensory capability of the Magic Room, an indoor smart space equipped with IoT-enriched components such as floor and wall projections, smart lighting, music and sound, motion and gesture sensors, and smart objects. The paper describes MagicMuseum and briefly reports an exploratory study involving 22 children at a local primary school.

CCS CONCEPTS

• **Human-centered computing → Human computer interaction (HCI)**; • **Applied computing → Collaborative learning**.

KEYWORDS

Cultural Heritage Education, Smart Space

ACM Reference Format:
Simone Ghiazzi, Stefano Riva, Mattia Gianotti, Pietro Crovari, and Franca Garzotto. 2022. MagicMuseum: Team-based Experiences in Interactive Smart Spaces for Cultural Heritage Education . In *Proceedings of the 2022 International Conference on Advanced Visual Interfaces (AVI 2022), June 6–10, 2022, Frascati, Rome, Italy*. ACM, New York, NY, USA, 3 pages. https://doi.org/10.1145/3531073.3534488

1 INTRODUCTION

The basic idea of Cultural Heritage (CH) education is to offer opportunities to better understand our history and culture, learn new concepts and skills, and strengthen our identity as members of a national or transnational community sharing common cultural roots. CH education is one of the pillars of the European Policies in Education [15] which also promote the adoption of CH education initiatives at school since childhood. Interactive technologies offers powerful means to address this vision: they enable educational activities in which learners are exposed to the *virtual* experience of both tangible and intangible cultural heritage, and in a way that is potentially more attractive and engaging than traditional educational tools. Different interaction paradigms are adopted from this purpose [3], ranging from mobile applications to smart objects (i.e., digitally enhanced physical items) typically used for "on-site" (e.g., at museums or archeological parks [1, 3, 12–14, 16]). Our research explores the use of interactive smart spaces (smart spaces for short) for CH education at primary school. A smart space is a IoT-enhanced ambient, in which various kinds of connected sensors and actuators are smoothly integrated in the physical environment or embedded in physical objects, can sense human actions (e.g., body movements, hand gestures, or object manipulation) and generate various multi-sensory effects. Smart spaces have been explored for different educational purposes, e.g., learning of curricular contents [8], school inclusion [6], or development of cognitive and social skills for children with neuro-developmental disorders [6, 7, 10]. There are a few examples of smart spaces in museums, ranging from installations conceived as pure artistic expressions or as a means to promote museum's visitors' creativity (e.g., those created by the Italian group Studio Azzurro [2] or the Japanese group Team Lab [9]), to interactive experiences aimed at facilitating CH interpretative processes [5] and [11] or science understanding [4]. Differently for the above cases, our research explores the use of smart spaces for *whole-class* CH education *at school.*

2 MAGICMUSEUM

MagicMuseum is a set of team-based, immersive, full-body activities for Cultural Heritage education that exploit the interactive and multisensory capability of a smart space called Magic Room, currently installed at two local primary schools. The Magic Room [6] is equipped with various connected components: Frontal projector, zenith projector, audio system, smart lights, Kinect 2, custom smart objects, soap bubble makers, a tablet for caregivers to control interaction flows, and a miniPC that orchestrates the system behavior. The interaction with the smart space use gestures and body movements, or the placement of RFID-tagged smart objects on special smart objects called "recognizers" (equipped with RFID readers). The activities of MagicMuseum involve the exploration of the virtual museum rooms (rendered by immersive 3D room representations projected on the wall and the floor) and multi-player minigames. Users explore a virtual room by moving in the physical ambient, and interacts with virtual exhibits using hand-gestures. Some selected items react by displaying cultural information, while

AVI 2022, June 6–10, 2022, Frascati, Rome, Italy

ACM ISBN 978-1-4503-9719-3/22/06.
https://doi.org/10.1145/3531073.3534488

Figure 1: Children playing with MagicMuseum

others trigger a minigame. A Virtual Guide (Avatar) provides contextualized voice output to offer a CH narrative around exhibits or minigames concepts. Other avatars play as Mimes, asking users to imitate their posture and gestures. Initially, participants are divided into four teams. In each virtual room, each team nominates a representative member who performs the actual interactions while the rest of the team - seated outside the interaction area - give them hints. Exploration tasks are *collaborative*, with the goal of discovering minigames to launch. Minigames involve more articulated interactions with digital and physical contents, through a mix of collaborative and competitive task. In some cases, each team representative plays against another one or against all the others. In other cases two representatives alley to win. The overarching goal is always to provide playful experiences to learn new CH concepts and stimulate reflection on CH issues. At the end of each game, the Virtual Companion tells curiosities about the CH concepts of the game task. From a technological perspective, MagicMuseum is a *cyberphysical application framework* that maximizes development-by-reuse: for each specific CH education domain, virtual rooms and all ingredients of the experience can be created as *instances of a set of patterns* that refer to multimedia contents of the specific domain. This framework-based approach also supports *customizability during play*, enabling caregivers to configure interaction parameters (e.g., players number) to meet the learning requirements of each class. Below are examples of the general logic of some minigames.

Quiz minigame. The goal is to answer multiple-choice questions (presented on floor projections and commented by the Avatar) as fast as possible. Choices are related to CH topics and are projected on the floor. Playing in turn, each team representative consults their mates and move over the area on the floor corresponding to the selected choice.

Hangman Minigame. This is a smart space version of the classic word guessing game. The initial character and a set of blank letters that match a word are projected on the wall, and the player has to guess what these letters are to reveal the hidden word. She/he does the guessing by picking smart cardboard letters from those placed on the ground, and "showing" it to a letter-recognizer smart object. If a letter is correct, that letter is revealed from the projected blank letters. Otherwise, the turn is taken by the next team. .

What-Where Minigame. The 4 teams play in parallel, and each team has its own game area on the wall projection, which shows an image and a question (e.g., a map and the question "Where was Leonardo da Vinci born?"). Using a mid-air gesture, each player must place a visual pointer on their team's image to indicate the answer. Points are given according to the proximity of the team's pointer to the correct answer after 30 seconds.

Crafting Minigame. All teams play in parallel and there are simultaneous pairs of wall/floor projections, one for each team. Each player must select two different elements that can be composed to create a new item (e.g., "water" and "clay" to obtain brown paint). To select an item, the user points it for 3 seconds; new items and related questions are progressively shown as a task is successful.

3 EXPLORATORY STUDY

We performed an exploratory study involving a class of 22 children (8 y.o.) and 3 educators from a local primary school hosting a Magic Room installed in a previous project. Our aim was to measure the effect of MagicMuseum on *short term learning* about a completely new subject. The activities were customized on themes related to Leonardo Da Vinci Museum in Milan. The multimedia contents concerned topics never addressed in the classroom and were co-designed with the teachers. The children's experience with MagicMuseum lasted for 3 hours. We submitted a custom 10 items questionnaire on on Leonardo da Vinci before and after the experience. Overall, pre-testing results report a mean of 3.18 out of 10 (SD = 3.01), while post test scored a mean of 6.04 (SD = 2.04). The improvement was of 2.86 points, meaning that the children acquired new knowledge on Leonardo da Vinci after the experience. We performed a Kolmogorov-Smirnov test on both pre and post score distributions to verify normal distribution of data ($D_{pre}(21) = 0.104$, $p = .05$, $D_{post}(21) = 0.186$, $p = .05$). Since data were normally distributed, we performed a paired-sample t-test for statistical significant difference between the two scores $t(21) = -7.65$ $p= 0.05$.

Altought very preliminary, this study confirms the findings of previous research about the potential of *group* activities in the Magic Room for children's learning [6, 7]. Further work is certainly needed to better understand the specific design factors of Magic Room activities - in terms of multimedia contents and tasks, individual interaction modes, social interaction paradigms and cooperation format - that are more influential on specific learning processes, and should be optimized to maximize the educational benefits.

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