GENIEL: An auto-Generative Intelligent Interface to Empower Learning in a Multi-Sensory Environment

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ABSTRACT

Recent studies demonstrate how personalized and multisensory learning improves students' performances and teachers' work. Each student has different skills, aptitudes and difficulties, and the learning process requires more or less time in relation to both the topic to assimilate and the employed teaching method. Our system, called Magika, is a multi-modal and multi-sensory environment that empowers teachers and aims at providing students with the right learning supports. Magika includes a preliminary phase called "onboarding", aimed at defining their likes and dislikes, and an intelligent engine, "Geniel", capable of discerning and suggesting the most suitable activities to be played, according to the player's profile.

CCS CONCEPTS

• **Social and professional topics → People with disabilities**; *K-12 education*; • **Information systems** → Multimedia and multimodal retrieval.

KEYWORDS

Multi-Sensory Environments, Auto-generative

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1 INTRODUCTION

Providing different educational strategies and an optimal path for learners from divergent backgrounds, and with different learning abilities, is thought to enhance education [1]. Consistently with this belief, Resnick [8] underlines how Frobel, with the invention of "the childhood garden", moves away from a traditional approach, opting for an innovative, multisensory educational model. This model gives children the opportunity to learn by interacting in collaborative spaces with materials and other tangible objects. The potential of technologies that require bodily interaction is also grounded on theoretical approaches that recognize the relationship between physical activities and cognitive processes, and are supported by a growing body of evidence from psychology and neurobiology [9].

1.1 Multi-Sensory Environments

Most multi-sensory approaches take shape in dedicated spaces called "Multi-Sensory Environments" (MSE) - rooms equipped with items that provide gentle stimulations of different senses while offering a nonthreatening, relaxing environment [5]. Researches have already developed different solutions by, such as MEDIATE, MapSense and SensoryPaint. MEDIATE [7] stimulates children through visual, tactile and aural channels and allows them to express themselves through body movements, but does not support interaction with objects. MapSense [3] is an interactive map that uses a touch-sensitive surface, tangibles, olfactory and gustatory stimuli. Finally, SensoryPaint [6] allows users to paint on a large display using physical objects, gesture-based interactions, and interactive audio. Still, both MapSense and Sensory paint do not support full-body movement-based interaction.

2 MAGIKA

Our research is inspired by the mentioned multi-sensory environments and intends to overcome the stated limits, proposing a space where children are involved in new forms of full-body, playful, multi-sensory learning experiences [2]. Magika is an unconventional, IoT enabled, physical space designed in close cooperation with teachers from two primary schools in Cornaredo (Milan), where the first Magika has been set up, and psychologists from L'abilitá Onlus (Milan) and Fraternitá e Amicizia therapeutic centers. The technology underlying Magika consists of an extensible multilayered software and hardware platform that integrates sensors, actuators, lighting systems and output devices, managing their communication and orchestrating their behaviors. This technology transforms an empty room into an immersive space that integrates projections on the walls and on the floor, ambient sound, smart physical objects (textured 3D shapes, stuffed toys, appliances like bubbles makers or fragrance emitters) and smart lights (digitally controlled portable lamps and bulbs). These elements have a coordinated behavior and react to children's manipulation and body movements. The activities consist of recreational and educational games that involve movements and interactions within the space. A succession of activities, significantly juxtaposed in order to follow and conform to the user's development and progression, generates experience. The intelligence of the system is capable of creating ad-hoc experiences and managing them automatically. Nevertheless, teachers can always remotely control children's activities real time through a dedicated interface.

2.1 GENIEL

"Content is king", asserted bites' ancestor in the far 1996, and today we embrace his forward-looking theory more than ever. With the aim of developing a tailor-made experience for each child enjoying Magika, we designed an intelligent system capable of discerning and suggesting the most suitable contents and interactions to be played, according to the user's profile who interacts within the room.

2.1.1 Auto-generativity. The system takes advantage of its intelligence in two different phases of an experience creation, exploiting both times a Knowledge-Based Technique (KBT), which aims at capturing the knowledge of human experts to support decision-making during each activity, designing and setting.
The first KBT employment validates the definition of "auto-generative" interface referred-to: thanks to its rulebased approach, the system automatically extracts contents from the web and generates educational activities, founding its initial knowledge on a dictionary and a set of rules. Starting from the words contained in the dictionary and exploiting a web scraping algorithm, the system searches, retrieves, elaborates information and reorganizes it into a formatted file, returning an easily "queryable" document.
GENIEL reliance on human expertise lies in its games logic: categorized by subjects, a set of mechanical activities have been devised and developed under the guidance of psychologists and teachers, whose expert knowledge is encoded as rules regulating the generation of each game activity. Activity mechanics define the ultimate educational goal of the game to be: for instance, the model of an activity aimed at checking and strengthening child's knowledge about capital cities includes the instructions to examine all the capitals known to the system, to elaborate adequate questions and to verify the fairness of given answers. Different final activities can be created from the same model, according to the topic chosen (e.g. European, American, Worldwide capitals).

2.1.2 Adaptivity. The innovative factor of the automatic process of creation, as well as the second intelligent engine of GENIEL, is the user-adaptation, inflected by the system as the choice of the aptest contents and interaction manner to be presented to each child during the experience. The above-mentioned flow of activities is characterized by the alternation of different interaction paradigms proposed for the answer selection, on one hand, modelled on the line of the Duolingo gamification [4], fully exploiting the multi-sensory potentialities, on the other. We hypothesize that the variety of interactions, together with the involvement of multiple senses in an unconventional education space, can provide an alternative way to engage and motivate students during the learning process. For this reason, speaking language, body position, different gestures and movements are expected as reaction to the challenges proposed and detected by the embedded sensors.
With the aim of generating an history of each player's progresses and weaknesses, personal profiles are outlined starting from the "onboarding" phase and continuously updated during their interactions with Magika: the storage of information as response time to the question, number of attempts, answer nature, movements and sounds detected during the activity, relative to the user interaction with the room, allows the system to draw up a classification of the most and less efficient interaction modalities, in relation to both the specific topic treated and the player. This data collection provides the system with a wide amount of information, allowing crowd analysis and statistics, which supports Magika GENIEL in the modeling and prediction of users' behavior.
Here it is exploited the second KBT, which substitutes cases for rules, focusing on a case-based reasoning approach. Cases are essentially solutions, which have been turned out to be the most appropriate for certain profile during the learning of specific topics, that our system attempts to apply to a new profile. Each case rises a rule every time an analogy is drawn from it, as behind every analogy it exists an implicit rule. We think that bringing the "power of many" to ours, as a collaborative interface, can improve the overall user experience, allowing each user to find the preferred and facilitating way of learning, proposing its commonly successful solutions for profiles with the same weaknesses or difficulties.

3 CONCLUSION

Magika's auto-generative and adaptive intelligent interface and experiences (GENIEL) are a contribution to the growing research on adaptive and multi-modal learning, aimed at empowering teachers' educational role and children's learning outcomes.

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