Multisensory technologies for embodied and enactive learning of maths

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ABSTRACT

Whereas on the one side multisensory technologies are experiencing a fast grow in many areas, on the other side their introduction in the classroom is still problematic. Nevertheless, the longstanding interest in embodied, enactive, and multisensory experiences as a key factor in the learning process and recent scientific evidence on the role of sensory channels in the early childhood show that multisensory technologies can have a significant role in supporting teaching and learning of complex concepts. In this perspective, this contribution discusses our experience in the initial stages of the EU-H2020-ICT weDRAW project, a technology-enhanced learning project focusing on multisensory technologies for teaching math, namely arithmetic and geometry, to primary school children. We focus, in particular, on the initial design phases of a platform exploiting full-body interaction with, and sonification and visualization of content for teaching concepts such as angles, fractions, and the Cartesian plane.

CCS CONCEPTS

• **Applied computing** → **Computer-assisted instruction**; **Interactive learning environments**;

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KEYWORDS

Technology-enhanced learning, multimodal interactive systems, multisensory technologies, maths.

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1 INTRODUCTION

This contribution focuses on the use of multisensory technologies in the primary school. Whilst, on the one side, these technologies are experiencing a fast grow in many areas (e.g., entertainment, games and exergames, assistive technologies, and so on), due to both technological advances and increased availability of affordable devices (e.g., Kinect, Oculus Rift), on the other side their introduction in the classroom still raises concerns. Nevertheless, the longstanding interest in how learning can be supported by representations engaging multiple modalities and recent scientific evidence on the role of sensory channels in the early childhood show that multisensory technologies can have an important role in supporting teaching and learning of complex concepts, namely maths, in the primary school.

We argue that the intersection between current challenges in pedagogical practices and recent scientific evidence opens novel opportunities for multisensory technologies to bring a significant benefit to the learning process. In this perspective, we report our experience in the initial stages of the weDRAW project[1], an EU-H2020-ICT project focusing on multisensory

[1] http://www.wedraw.eu/

technologies for teaching math (arithmetic and geometry) to primary school children. In particular, we focus on the initial design phases of a platform exploiting full-body interaction with, and sonification and visualization of content for teaching concepts such as angles, fractions, and the Cartesian plane. The platform will serve as a ground to build serious games upon.

2 CONTEXT

The context of the weDRAW project is maths education at primary school. The project aims at developing multisensory technologies exploiting the most suitable sensory modality for teaching a specific concept.

Recent scientific evidence [3][2] suggests indeed that specific sensory modalities can be more suitable than others to convey specific information and hence to teach specific concepts. For example, it was observed that children use the tactile modality to perceive the size of objects whereas the visual signal is used to perceive their orientation. Recent findings further confirmed the theory, showing that children start to integrate multisensory information only after 8-10 years of age, so at the end of the primary school [1].

3 CONTRIBUTION

Whereas many stakeholders consider technology a must for modern technology-mediated pedagogical approaches, adoption of technological solutions for education is often not sufficiently grounded on the actual education practice. The result is that technology is rejected even by students who one would expect being more engaged with it. In our view, multisensory technologies are ideal for effectively supporting a pedagogical approach exploiting the best-suited sensory modality to teach a concept. This represents a great opportunity on the one side for defining novel embodied and enactive pedagogical approaches, and on the other side for making technologies, which are both grounded on a robust scientific evidence and tailored to the actual needs of teachers and students.

We bring to the workshop the experience we matured in the first steps of the weDRAW project, which focused on the analysis of the mathematical concepts to be addressed, of the needs of students and teachers, and of the requirements of multimodal interactive systems that can possibly satisfy such needs. We believe that such experience would help informing discussion about the best practices which should be adopted for a successful introduction of technology in the primary school.

4 LESSONS LEARNED

In the initial stages of the weDRAW project, activities followed major directions: (i) discussion with the pedagogues partners in the project for defining a suitable pedagogical paradigm including multisensory technologies in the teaching and learning practices, (ii) organization of workshops with teachers for individuating the mathematical concepts which can mostly benefit of a technological approach based on multisensory interaction (over 200 math teachers were involved in this activity), (iii) psychophysical experiments to determine which stimuli can be used in the different sensory modalities and which modality is most suitable for a specific concept, and (iv) organization of design sessions involving small teams consisting of teachers, psychologists, pedagogues, and engineers working on possible technological solutions for specific concepts to be taught. This work led to the definition of the use-cases for the project and to initial technological developments which will be tested in the classroom in the next school year.

What we learned is sometimes expected and sometimes surprising. For example, it was surprising for us to see that more than 75% of teachers agreed on the same concepts as the most difficult for children and the most appropriated for a technological intervention. It was instead expected that after an initial enthusiasm teachers in the teams displayed, this somewhat faded out when the constraints technology imposes (e.g., with respect to the number of children at time who can experience an application based on RGBD motion capture devices) emerged. It was surprising, however, to observe the number of ideas and solutions the teams came out with, and this is particularly encouraging for the future of the project. We believe that an in-depth analysis and discussion of the work carried out in these months can provide a kind of guidance for future research in this area.

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REFERENCES

[1] Paul Curzon, Peter W. McOwan, Quintin I. Cutts, and Bell Tim. 2009. Enthusing & inspiring with reusable kinaesthetic activities. *ACM SIGCSE Bulletin* 41, 3 (2009), 94–98.

[2] Monica Gori. 2015. Multisensory integration and calibration in children and adults with and without sensory and motor disabilities. *Multisensory research* 28, 1–2 (2015), 71–99.

[3] Monica Gori, Michela Del Viva, Giulio Sandini, and David C. Burr. 2008. Young children do not integrate visual and haptic form information. *Current Biology* 18, 9 (2008), 694–698.