CONNECT: Designing the Classroom of Tomorrow by using Advanced Technologies to connect formal and informal learning environments

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Abstract. *The main objective of the CONNECT project is to develop an innovative pedagogical framework that attempts to blend formal and informal learning, proposing an educational reform to science teaching. The project will create a network of museums, science centres and schools across Europe, to develop, apply and evaluate learning schemes by pointing to a future hybrid classroom that builds on the strengths of formal and informal strategies. The proposed approach will impact upon the fields of instructional technology, educational systems design and museum education. It will explore the integration of physical and computational media for the design of interactive learning environments to support learning about complex scientific phenomena. The project will be implemented on an advanced learning environment, the Virtual Science Thematic Park, developed upon emerging technology that will allow for ubiquitous access to educational and scientific resources. The CONNECT project will evolve through a systematic, multi-step assessment process involving the collection and interpretation of data. The current paper presents the project's framework, the initial ideas and the future plans of the consortium.*

Keywords. Formal/Informal Learning, Contextual Learning, Instructional Technology, Augmented Reality

1. Introduction

During the last decade some attempts have been made to evaluate the impact of efforts and investments made in Science and Technology Education worldwide, for example the Third International Mathematics and Science Study (TIMMS, 1994) and the Programme for International Student Assessment (PISA, 2000). These two large scale studies have explored the achievement and the attitudes towards Science and Technology (S&T) of the students' population in many countries of the world. The main findings of these studies are that the average achievement of the students' population is relatively low in most of the Southern European countries. Additionally while the vast number of students hold positive attitudes towards S&T at the early schooling stages (70-80% of the 4^{th} graders in all countries), this situation is considerably moderated at the latest stages (8^{th} grade). These findings suggest that the educational systems need to shift from the traditional paradigm of the teacher-directed learning and the dissemination of knowledge to the learner-centered curricula that promote the development of lifelong learners who can think critically, solve problems and work collaboratively (King, 1996). Sfard (1998) argues that learning becomes a process of discovery and participation based on self-motivation (informal learning) rather than on more passive acquaintance with facts and rules (formal learning). The importance of visualisation and of hands-on experiences as vital components to the learning process has also been stressed (Bransford et al. 1999).

From the beginning of the nineties there has been a considerable growth and development of the research on learning in science museums. Changes in accepted paradigms and definitions of learning have resulted in studies that point to the considerable richness of learning that have the potential to emerge from experiences in informal settings. There was widespread acceptance of the cognitive, affective and social value of experiences in museums and similar institutions (Rennie & McClafferty, 1996), and Falk and Dierking (1992) had drawn attention to the physical, social and personal contexts in which learning occurs.

Exploring the integration of informal learning experiences within the formal school curriculum could make an important contribution to the field of science education by helping students to develop critical capacity and deeper understanding of the concepts underlying scientific investigation. It will further provide students with first-hand experience of the ways that technology can both serve and inspire scientific investigation. This will later affect their career choices and will provide a scientifically qualified workforce (Falk, 1999). It will furthermore significantly enhance the learning of science for diverse and heterogeneous populations of future citizens, promoting the public understanding of science and the development of lifelong learners who can think critically, solve problems and work collaboratively (King, 1996).

2. The CONNECT Project

The CONNECT project [17] is a step towards an ambitious comprehensive educational reform, pointing to a future hybrid classroom that builds on the strengths of formal and informal strategies. It is an innovative approach that crosscuts the boundaries between schools, museums, research centers and science thematic parks and involves students and teachers in extended episodes of playful learning.

The CONNECT project is a joint initiative of pedagogical, cognitive science and technological experts, museum educators and psychologists, that research the possibilities of using advanced technologies for educational purposes. The CONNECT project develops an active learning environment the Virtual Science Thematic Park that functions in two distinct and equally important, from a pedagogical point of view, modes: the museum mode and the school mode.

The Virtual Science Thematic Park allows for ubiquitous access to educational and scientific resources and will incorporate all the innovative use of technology for educational purposes. The partnership aims at providing students with a variety of learning methods that will incorporate experimental, theoretical and multidisciplinary skills that will eventually enable them to become independent learners. The suggested educational scenarios include field trips (virtual and conventional visits to science museums and parks) that are tangential to the curriculum, pre- and post-visit curricular activities (including the use of internet resources), 'minds-on' experiments and models of different kinds into everyday coursework heavily involving 'real' remotely controlled experiments in the "student-friendly" and engaging environment of a thematic park or a remote observatory.

The working hypothesis of the CONNECT project is that the amendment of the traditional scientific methodology for experimentation with visualization applications and model building tools will help students and learners in general to articulate their mental models, to make better predictions and to reflect more effectively. The CONNECT project will take advantage of the fact that students enjoy visits to museums tremendously and that the resulting increased interest and enjoyment of science activities constitute extremely valuable learning outcomes that persist over time (Ayres & Melear, 1998). The CONNECT project will provide students with observations and experiments that have the potential of showing to them that some of their beliefs can be wrong; will create the circumstances where alternative beliefs and explanations could be externalized and expressed and design activities that give students enough time to restructure their prior conceptions.

2.1 Pedagogical innovation of the CONNECT project

The CONNECT project is developing a new science learning scheme by introducing a technologically advanced approach for teaching and learning and by connecting a wide range of learning environments (school, home, science museums, research centers, science thematic parks exhibitions) and bridging the theoretical and applied aspects of every day personal activities.

In order to learn science in meaningful ways students need to see connections to familiar problems relevant and important in their daily lives. Additionally, situated learning fosters the ability to transfer acquired knowledge to a variety of different situations. Situated learning is an essential component of acquiring the ability for self-organised and self-regulated learning. The schools of the CONNECT project will provide opportunities for the development of a competence to learn and an ability to be an autonomous learner in the future. This includes the development of meta-cognitive learning competences like e.g. elaboration strategies or learning strategies and their application and usefulness. The learning processes are embedded in communicative situations where teaching science offers good conditions for fostering communication and cooperation in students' experimental practices. For the content orientation the planned teaching topics are based on a broad field of knowledge and applications. The teaching sequences are built up in a way that student knowledge can increase and link, in other words be “constructed” by them.

The educational material and the adopted instructional strategies are tailored to the abilities and aptitudes of different types of learners. The development of the educational scenarios aims at providing materials and instruction that gives reality and concreteness to scientific concepts (Hofstein & Walberg 1994).

In the light of the above the “basic scenario principles” of the CONNECT project can be summarized as follows:

(a) Personalization: The learning tasks need to be related to the interests and background of a wide variety of different learners and facilitators and to built upon these individual differences, tapping into intrinsic motivation and providing opportunities for choice and control.

(b) Interactivity: The tasks should be “learner-centered” and should provide learners with opportunities to engage actively in the experience.

(c) Collaboration: Learning is often enhanced by collaborative efforts. The tasks should promote such collaborative learning, through opportunities for collective work on problems or challenges.

(d) Self-regulation: Teachers should help students to plan and monitor their learning, to set their own learning goals and to correct their errors.

(e) Authenticity. The learning tasks should be as real-world and authentic as possible.

(f) Learning Strategies: When possible, the learning tasks should employ effective learning strategies, e.g., the use of advanced organizers, the use of dynamic explanations, making explicit connections between visible and invisible phenomenon, making explicit connections between linked-phenomena which take place on different scales (micro vs. macro), etc.

Another important aspect of the CONNECT project is the promotion of ubiquitous access for students and teachers that will be able to access to the Virtual Science Thematic Park; to visit the exhibits and the experiments; the research laboratories and the advanced scientific instruments. Thereby science education will act as the mediator among people in different countries reducing at the same time prejudices and stereotypes and increasing social cohesion. The direct interaction with science or the doing of science reflect a fundamental pedagogy of the museum to provide learners with personal and direct experiences which can build upon in their own ways. Students will experience the phenomena presented in their own terms, freely choosing what to attend to and interact with, depending on their prior knowledge, interest and expertise. It is important also to note that in the science museums and science centres the exhibits and the related phenomena are embedded in rich real world contexts where visitors can see and directly experience the real world’s connections of these phenomena.

Finally, a virtual learning community of learners, students, teachers, museum educators and researchers who are involved in the project has been created and will have the possibility to communicate and to collaborate via the CONNECT system.

2.2. Scenarios of Use

The Virtual Science Thematic Park requires the use of augmented reality tools which visually explain with the help of virtual objects projected onto the real setting the physical phenomenon manifested by an experiment inside the museum. By this way many “invisible” parameters in physical phenomena (e.g. forces, fields, waves, charges) will be visualised and presented in the eyes of the students augmented on the real experiments. Haptic feedback could add to the experience of complex physical phenomena. An example is the representation of Lorentz force in space. Other scenarios include, giving life to static exhibits by animating parts of it (e.g. the cloud creation in the water cycle, meteorological movements, tectonic plates movements, sea currents, the propagation of sound waves, etc.) or performing on-line astronomical observations (Sun movement, planets and stars, solar and lunar eclipses, etc.) with the use of a robotic telescope. Furthermore, wearable systems will provide an additional wealth of information, linked to dedicated databases.

The add-on of the augmented exhibit, compared to a conventional exhibit, is that the students wearing the CONNECT system have at their disposal additional wealth of information. The real exhibits are mixed in their optical view with the 3-D visual objects and representations that the system is producing and embedding into this augmented world through their glasses. In this way all the important parameters of the experiment, all the abstract symbols, which are normally represented in drawings after the experiment, can be visualised. This interactive hands-on experience is recorded on the students' wearable computer for later use. The next day at school (post visit procedure) the students are sharing their personal experience of the visit to the museum with their fellow classmates by projecting it onto a video screen. The fellow students will be able to make a virtual visit to the museum and follow a different tour or make different choices to the same tour through the Virtual Science Thematic Park. Various collaborative activities (discussion forums, mini-projects, writing reports etc) follow the visit in order to provide students with the necessary time and the appropriate tasks to better understand the new information

3. Expected Impact

The goal of the CONNECT project is to redefine the conceptual framework of education, by designing learning environments and implementing pilot experiences that use state-of-the-art digital technologies. Such environments would encourage reflection and collaboration and draw their pedagogical value from the cross-over between education and entertainment.

The CONNECT approach will impact upon the fields of instructional technology, educational systems design and museum education.

- In the field of instructional technology, our research will examine alternative instructional systems that attempt to blend informal and formal learning and to situate learning in real-world contexts.
- In the field of educational systems design, the CONNECT Virtual Science Thematic Park represents an example of designing new systems from the ground up. As such, it may inform current burgeoning theory in the process of educational systems design and in systems theory-such as the SIGGS theory (King & Frick, 1996). Additionally, the CONNECT approach will provide information for one of the key processes of educational systems design, transcendence: it will create knowledge regarding a new class of alternative schooling that will be informative to future educational designers.
- In the field of museum education, the CONNECT project will correct three deficiencies that are restricting current reform efforts to expand the educational role of museums: the limited number of model programs, the absence of a body of professional literature, and the lack of contact with the broader field of education. Indeed, the CONNECT project provides a framework for a closer and more effective collaboration between museums and schools, while keeping intact the strengths of these different educational environments. By describing and analyzing the functionalities of the virtual thematic park and by creating operational terminology, the CONNECT projects aspires to guide the design of future museum-school collaborations and to document efforts that seek to bring the worlds of formal and informal learning closer together.

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