

designing the classroom of tomorrow

Advanced Technologies in Education - symposium proceedings



# Advanced Technologies in Education

Proceedings of the international symposium,  
held in Athens, Greece

November 13-14, 2004

the symposium was  
co-financed by:



# International Symposium on Advanced Technologies in Education

## **Designing the School of Tomorrow**

Proceedings of the International Symposium  
held in Athens, Greece  
November 13-14, 2004

Edited by Eleni T. Chatzichristou  
on behalf of the School Foresight Consortium

Published by **Ellinogermaniki Agogi**

**Artwork:**

Vassilis Tzanoglos

Evangelos Anastasiou

---

the symposium was co-financed by:



Copyright © 2004 by Ellinogermaniki Agogi

All rights reserved.

Reproduction or translation of any part of this work without the written permission of the copyright owners is unlawful. Request for permission or further information should be addressed to the copyright owners.

Printed by **EPINOIA S.A.**

**ISBN:** 960-8339-49-9

## TABLE OF CONTENTS

---

|                           |   |
|---------------------------|---|
| <b>Introduction</b> ..... | 5 |
|---------------------------|---|

### **I. Learning in the Information Technology Era**

|                                                                                      |   |
|--------------------------------------------------------------------------------------|---|
| Understanding the Personal, Socio-Cultural and Physical Dimensions of Learning ..... | 9 |
| <i>John Falk, Institute for Learning Innovation, USA</i>                             |   |

|                                                                                    |    |
|------------------------------------------------------------------------------------|----|
| Are you a Technocrat? A Reformist? Or an Holistic? .....                           | 21 |
| <i>Abaron Aviram, Head of Center for Futurism in Education, Ben-Gurion, Israel</i> |    |

|                                                                                           |    |
|-------------------------------------------------------------------------------------------|----|
| School of Tomorrow: Visions .....                                                         | 27 |
| <i>Henrik Hansson, Institute of International Education, Stockholm University, Sweden</i> |    |

|                                                                         |    |
|-------------------------------------------------------------------------|----|
| Designing the Science Classroom of the School of Tomorrow .....         | 35 |
| <i>Sofoklis Sotiriou, Head of R&amp;D Ellinogermaniki Agogi, Greece</i> |    |

### **II. Connecting Formal and Informal Learning – Methods and Tools**

|                                                                                                                  |    |
|------------------------------------------------------------------------------------------------------------------|----|
| Science and Technology Learning Across the Lifespan: Connecting School, Free-Choice and Workplace Learning ..... | 49 |
| <i>Lynn Dierking, Institute for Learning Innovation, USA</i>                                                     |    |

|                                                                                   |    |
|-----------------------------------------------------------------------------------|----|
| The CONNECT Project: Bridging Formal and Informal Learning in Science Education . | 59 |
| <i>Eleni T. Chatzichristou, R&amp;D Ellinogermaniki Agogi, Greece</i>             |    |

### **III. Shaping the School of Tomorrow**

|                                                                                               |    |
|-----------------------------------------------------------------------------------------------|----|
| Media –Assisted Learning, Evaluation Strategy in CONNECT .....                                | 69 |
| <i>Franz X. Bogner, Zentrum für Math-Naturwiss. Unterricht, Universität Bayreuth, Germany</i> |    |

|                                                                                                                                 |    |
|---------------------------------------------------------------------------------------------------------------------------------|----|
| Dancing with the Muses: How Educational Technology might Help Bridge the Gap between Formal and Informal Science Learning ..... | 75 |
| <i>Sherman Rosenfeld, Weizmann Institute of Science, Israel</i>                                                                 |    |

|                                                                                    |    |
|------------------------------------------------------------------------------------|----|
| LeActiveMath: Personalization, Motivation and Tutorial Dialogue.....               | 83 |
| <i>Erica Melis, German Research Institute for Artificial Intelligence, Germany</i> |    |

|                                                                             |    |
|-----------------------------------------------------------------------------|----|
| The Lab@Future Project “E-Laboratories Collaboration Platform” .....        | 89 |
| <i>Costas Davarakis, Managing Director Systema Technologies S.A, Greece</i> |    |

#### IV. Quality and Standardization Issues in Education

|                                                                                          |    |
|------------------------------------------------------------------------------------------|----|
| Setting Standards in Education .....                                                     | 97 |
| <i>Menelaos Sotiriou, Head of International Projects Department, Q-Plan S.A., Greece</i> |    |

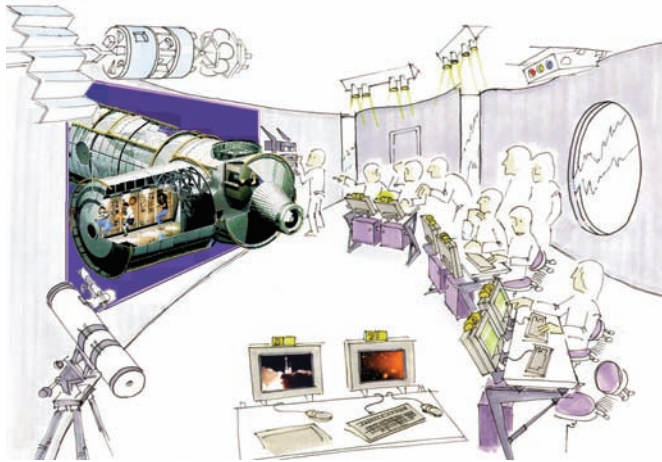
#### V. Broad-Band for All

|                                                                                                                                                        |     |
|--------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| The Use of Direct Video Broadcast – Return Channel Satellite (DVB-RCS)<br>Technology in Teleducation Applications. The Rural Wings EU IP Project ..... | 107 |
| <i>Nikolaos Uzunoglou, National Technical University of Athens, Greece</i>                                                                             |     |
| Connecting the Unconnected: The SchoolSat Experience. ....                                                                                             | 115 |
| <i>Sally Reynolds, Managing Director of ATiT, Belgium</i>                                                                                              |     |

#### VI. Designing the School of Tomorrow: The Things To Come

|                                                                                                                                                                            |     |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| The Future of Schools from a European Union Perspective – Selecting, Analyzing<br>and Disseminating the Most Innovative Approaches Towards the School of<br>Tomorrow ..... | 123 |
| <i>Henrik Hansson &amp; Scott Hall, Institute of International Education, Stockholm University, Sweden</i>                                                                 |     |
| Looking at the School of the Future. ....                                                                                                                                  | 133 |
| <i>Costas Tsolakides, University of Aegean, Greece</i>                                                                                                                     |     |
| Virtual Observatory: The D-Space Project. ....                                                                                                                             | 139 |
| <i>Elena Tavlaki, Head of Research Programs Division, OTE, Greece</i>                                                                                                      |     |
| WebTV for Schools. ....                                                                                                                                                    | 145 |
| <i>Caroline Schleiss, DIGITAL-BROADCAST-CHANNEL, Switzerland</i>                                                                                                           |     |
| Bridging the Digital Divide: Web-based E-Learning for Medical Practicioners in<br>the Developing World. ....                                                               | 149 |
| <i>Theodore Arvanitis, Dept. of Electrical &amp; Computer Engineering University of Birmingham, UK</i>                                                                     |     |
| Mobile Technologies in Education – Mobile Learning Applications in Language<br>Learning and History Education .....                                                        | 157 |
| <i>Eleni Malliou, ReD Ellinogermaniki Agogi, Greece</i>                                                                                                                    |     |
| Moments of the Conference .....                                                                                                                                            | 163 |

## Introduction



### designing the school of the tomorrow

Powerful new technologies promise to transform education and training in ways previously unimaginable. Rapid advancements in educational technologies in the years ahead could enable new learning environments using simulations, visualizations, immersive environments, game playing, intelligent tutors and avatars, reusable building blocks of content, address distributed communities of learners, and many more.

There are many challenges in the process of educational innovation that must be addressed in order to take advantage of these technologies to improve learning. Advanced technologies developed to meet other purposes must be translated into affordable tools for learners to use. Technical standards must be deployed to help guide the development of educational content that will be drawn from countless sources throughout the world. The technology community has to form stronger partnerships with the educational community. The educational institutions need to prepare for rapid technological change.

In this framework, the symposium brought together individuals and teams from a wide range of technology and education fields to look into the future and to share their visions as to what the learning experiences and educational technologies could be like. A rich collection of examples of futuristic scenarios and visions were presented and discussed in detail. These offered a glimpse of a future in which learners could explore worlds and cultures beyond their own, both in distance and time, as if they were there. And they will serve to remind us that we must strive to apply the power of technology in ways that empower people, enlighten the mind and enrich our lives.

*Sofoklis Sotiriou, Ellinogermaniki Agogi*



## **I. Learning in the Information Technology Era**



## Understanding the Personal, Socio-Cultural and Physical Dimensions of Learning

---

John H. Falk & Lynn D. Dierking,  
Institute for Learning Innovation, Annapolis, MD 21403, USA  
[falk@ilinet.org](mailto:falk@ilinet.org), [dierking@ilinet.org](mailto:dierking@ilinet.org)

*Intelligence and understanding are rooted not in the presence and manipulation of explicit, language-like data structures, but in something more earthy: the tuning of basic responses to a real world that enables an embodied organism to sense, act and survive.*

*Andy Clark, 1997*

### Abstract

Globally, Western societies are in the midst of changes as great as any in their history, changes that are affecting everyone. These changes, which directly influence educational institutions of all types, are tied to the shifting of Western economies from ones that are industrially-based to those that are information and knowledge-based. Also changing is our understanding of how and why people learn. Many of our current perceptions about the nature of learning are based upon a Behaviorist-Positivist conceptual framework; the dominant psychological model of the 20th century. This model of learning focuses primarily on the acquisition and retention of new information. Cognitive and neuroscience research are dramatically changing the way we think about the learning process. Learning has been revealed to be much more complex and relative; learning is a continuous and highly personal process. As a way to organize this complexity, Falk and Dierking have put forward what they call the Contextual Model of Learning. The Contextual Model is more a framework than a model. It views learning as a contextually-driven effort to make meaning in order to survive and prosper within the world; an effort that is best viewed as a continuous, never-ending dialogue between the individual and his or her physical and socio-cultural environment. This article describes that framework and how it can usefully help to understand learning both within and outside of school.

## 1. Introduction

Globally, Western societies are in the midst of changes as great as any in their history, changes that are affecting everyone. These changes, which directly influence educational institutions of all types, are tied to the shifting of Western economies from ones that are industrially-based to those that are information and knowledge-based [1]. The transition from a goods-based to a knowledge-based economy was noted first in America by Princeton economist Fritz Machlup [2], and substantiated a decade later by the U.S. Department of Commerce [3]. Knowledge and information (which Machlup felt were functionally the same) are rapidly becoming the major economic product of society. These changes are dramatically changing the way citizens in the developed world conduct their lives.

The engine that is driving this new transformation may be economics, but the fuel that it runs on is learning. Today Western societies, and incrementally all societies, are evolving into Learning Societies because the knowledge economy is being built upon ideas, and developing, let alone keeping up with new ideas, requires learning. It takes information and experience to generate good ideas. The best route to new information, more refined knowledge, and the need for relevant experience is learning. Messing about with ideas, above all, requires openness to new information and a commitment to learning all the time. Cradle-to-grave learning has long been a goal of Western society, but it is increasingly becoming both a necessity and a way of life. As society becomes more and more inundated with information, each individual needs to learn qualitatively and quantitatively better strategies for dealing with information [4]. In response to these changes, tremendous pressures are being placed on Western societies to reform, in fact ideally totally rethink how we support the public's life long need to learn. We need to not only change how we support learning in schools, we need to change how and when we support learning across an individual's entire lifetime. Fundamental to this process needs to be changes in how we think about nature of learning. Like our educational institutions, much of our current understanding of learning remains bound to out-dated, 20th century models.

## 2. Changes in Perceptions of Learning

Learning has always been critical to human survival; this was just as true in the traditional societies of yesterday as it is in our modern, technologically-sophisticated society of today. The fundamentals of human learning have also not appreciably changed. Two things, though, have changed. We are all aware that the tools with which we support learning have drastically changed. Perhaps less apparent is the dramatic change that has occurred in our understanding of how, why, and what people learn.

Many of our current perceptions about the nature of learning are based upon a Behaviorist-Positivist conceptual framework; the dominant psychological model of the 20th century. Numerous assumptions underlie this framework, but most follow from the somewhat simplistic notion that predictable behaviors/responses arise when known stimuli are applied to an individual. The application of this assumption applied to the educational contexts goes something like this: If you take a group of learners who are assumed to know nothing, or

virtually nothing, and provide them with a suitable educational intervention, they will exit “knowing” something. That something is the “thing” that the instructor/designer chose for them to learn. Because, according to this framework, learners are assumed to be virtual blank slates, their prior experiences, interests, and motivations are assumed to be, if not irrelevant, then not aggressively factored into the analysis of the learning process. This model of learning focuses primarily on the acquisition and retention of new information [5]. Behaviorist teaching strategies tend, therefore, to be more didactic and instructor-centered where the teacher provides the What, When, and How Fast of the learning experience. Although the Behaviorist-Positivist learning model has been helpful in advancing some of our understanding of learning, it has proven to have significant limitations.

Cognitive and neuroscience research are dramatically changing the way we think about the learning process. In particular, recent advancements in neuroscience research have enabled investigators to literally see the brain learn, and thus get out of the “blackbox” model so popular among earlier psychologists. Rather than the straightforward process suggested by the Behaviorist model, learning has been revealed to be a very complex, relative and constructive process ([5],[6],[7],[8],[9],[10]). This new framework, referred to as the Constructivist-Relativist model of learning, suggests that learning is a continuous, highly personal process. Learners start from different cognitive frameworks and build on learning experiences to create unique, highly individualized schemas. Operating from a Constructivist perspective requires accommodating to the diverse and individualized nature of learning. Certainly the Constructivist theory of learning is not a new development; the ideas have been circulating in academic circles for quite some time. But we do not have to visit very many educational settings to realize that the Behaviorist-Positivist learning model continues to thrive not just in schools but equally in free-choice learning settings such as museums. For example, many museum practitioners, consciously or unconsciously, operate as if by properly adjusting the lighting, composing the right label, and positioning an object “just so,” all visitors to the museum will emerge having had the same experience and having learned exactly the same thing.

In the Constructivist model, learning is seen as a highly contextual process. The learners’ prior knowledge, experience, interests and motivations all comprise a personal context, which is imbedded within a complex socio-cultural and physical context. Learning can be described as the interaction and negotiation of these three shifting contexts in time and space ([6],[11]): “In a world that allows for multiple perspectives, the conditions for meaning have become as important as the meanings themselves” [12].

From a Constructivist perspective, learning is not just about what the educator wishes to teach the learner. It is as much about what meaning the learner chooses to make of the educational experience.

### **3. Towards a Usable Model for Understanding Learning**

It is human nature to desire simple explanations for complex reality. For example, as presented in a book one of us (JHF) recently read [13], a physician described how during his days in medical school he was constantly overwhelmed with the quantity of information. He said some teachers could package the information very simply. “Here, this is what you need

to know.” Medical students loved those teachers, he said. But there were other teachers who always offered two or more (often contradictory) perspectives on things. This the students hated. “It involved more work on our part,” said the doctor. “Who wants to be told that some people think this, and some people think that? It was so much easier just to be told what is what.” But, he said, as the years went by and he became more and more experienced as a doctor, he realized that the concise, neatly packaged views were incorrect. The teachers had chopped off all the rough edges that didn’t fit into the system, unfortunately, what was chopped off invariably proved to be important information needed to make an effective diagnosis. In the end, the simplest solutions were not always the best.

For better or for worse, it is our opinion that learning is a phenomenon of such complexity that a truly simple model or definition will not result in a sufficiently realistic and generalizable model. You can only simplify the complexities of learning so much before they become less than useful. We put forward the Contextual Model of Learning (Fig. 1) as “a device for organizing the complexities of learning within free-choice settings” [6]. The Contextual Model of Learning is not a model in its truest sense; it does not purport to make predictions other than that learning is always a complex phenomenon situated within a series of contexts. More appropriately, the “model” can be thought of as a framework. The view of learning embodied in this “model” is that learning can be conceptualized as a contextually-driven effort to make meaning in order to survive and prosper within the world; an effort that is best viewed as a continuous, never-ending dialogue between the individual and his or her physical and sociocultural environment. The Contextual Model of Learning portrays this contextually-driven dialogue as the process/product of the interactions between an individual’s (hypothetical) personal, socio-cultural and physical contexts over time. The key feature of this framework is the emphasis on context; a framework for thinking about learning that has also been emphasized by others (e.g. [14],[15],[16]).

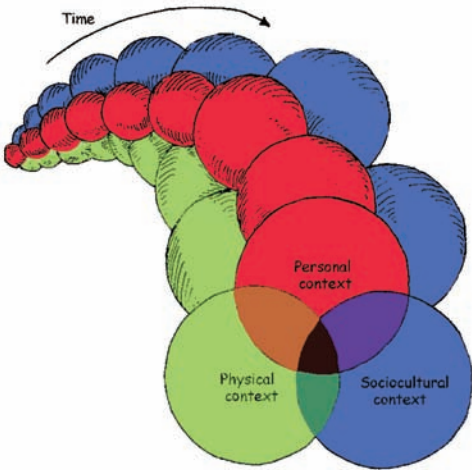


Figure 1. The Contextual Model of Learning [6]

The organization where we work, the Institute for Learning Innovation, a private American-based not-for-profit learning research and development organization, has used this framework as the basis for its investigations into the nature of learning and has committed its resources to understanding learning from a Constructivist-Relativist perspective across a wide range of educational settings, particularly free-choice learning environments like museums and libraries. It turns out to be important that we designate the setting because the where and why of learning does make a difference. Although it is probably true that at some fundamental, neurological level, learning is learning, the best available evidence indicates that if you want to understand learning at the level of individuals within the real world, learning does functionally differ depending upon the conditions under which it occurs. Hence, learning in museums is different than learning in schools by virtue of the unique nature of the museum and school contexts; and at many important levels, learning in a museum in Athens is different than learning in a museum in New York City. Although the overall framework we are about to suggest should work equally well across a wide range of learning situations, compulsory school-based learning as well as museum-based free-choice learning, the specifics have to date only been applied to museum contexts. In the final analysis, if you want to truly understand how, why and what people learn in places like schools, museums or libraries, specificity is essential. There is no simple, stripped down, a-contextual framework for understanding learning. Learning is highly situated. Thus, for the remainder of this paper we will talk about learning within a museum context.

#### 4. Contextual Model of Learning

The personal context represents the sum total of personal and genetic history that an individual carries with him/her into a learning situation. Building upon constructivist theories of learning, the influences of prior knowledge and experience on museum learning have been widely described and documented ([8],[17],[18],[19],[20],[21]); so, too, the role of prior interest (e.g. [18],[22],[23],[24]). The exact nature of a visitor's motivations, or "agenda", for visiting a museum has also been shown to significantly influence the visitor's learning outcomes (e.g. [25],[26],[27],[28]). More recently, it has been appreciated that the degree of choice and control over learning also affects visitor learning (e.g. [29],[30]). Thus, from the personal context perspective, one should expect new learning to be scaled to the realities of an individual's motivations and expectations, which in the case of museums normally involve a brief, usually leisure-oriented, culturally-defined experience. One should expect learning to be highly personal and strongly influenced by an individual's past knowledge, interests and beliefs. One should expect learning to be influenced by an individual's desire to both select and control his/her own learning.

Humans are extremely social creatures. We are all products of our culture and social relationships ([31],[32]). Hence, one should expect museum learning to always be socio-culturally situated. Factors affecting learning have been hypothesized to include such large-scale influences as the cultural value placed upon free-choice learning [31] as well as the cultural context of the museum within society ([33],[34],[35]); although this is almost certainly true, empirical evidence for these impacts are difficult to find. However, considerable research now exists which shows that visitors to museums are strongly influenced by the interactions and collaborations

they have with individuals within their own social group ([36],[37],[38],[39]). Research has also shown that the quality interactions with others outside the visitor's own social group, for example museum explainers, guides, demonstrators, performers or even other visitor groups can make a profound difference in visitor learning ([40],[41],[42]).

Finally, learning always occurs within the physical environment, in fact is always a dialogue with that physical environment [43]. Thus, one should expect visitors to museums to react to the physical context of the museum itself, which includes both the large scale properties of space, lighting and climate as well as the smaller scale aspects such as the exhibitions and objects contained within. Since museums are typically free-choice learning settings, the experience is generally voluntary, non-sequential and highly reactive to what the setting affords [6]. As such, visitor learning has been shown to be strongly influenced by how successfully visitors are able to orient within the space (e.g. [44],[45],[46],[47],[48]); being able to confidently navigate within a complex three-dimensional environment turns out to be highly correlated with what and how much an individual learns. Similarly, intellectual navigation, as supported by quality advance organizers ([49],[50]) has been shown to affect visitor learning from museums. Research has also shown that a myriad of architectural design factors such as lighting, crowding, color, sound and space subtly influence visitor learning ([44],[51],[52],[53]). Considerable research has focused on the exhibitions and labels themselves since they are designed to be the primary teaching tool within museums. Not surprisingly then, ample evidence exists that exhibition design features influence learning, in particular the sequencing, positioning and content of exhibitions and labels ([25],[54],[55]), as well as how many exhibit elements a visitor attends to, and for how long ([56],[57]). Finally, less well documented, but theoretically compelling is the expectation that learning from museums will not only rely on the confirmation and enrichment of previously known intellectual constructs but will equally depend upon what happens subsequently in the learner's environment since learning is not an instantaneous phenomenon, but rather a cumulative process of acquisition and consolidation ([58],[59],[60]). Thus, experiences occurring after the visit frequently play an important role in determining, in the long-term, what is actually "learned" in the museum. Recent longitudinal studies show that the learning that results from a museum experience does change over time, and not always just by declining ([22],[58],[60],[61],[62]).

The Contextual Model of Learning provides the large-scale framework with which to organize information on learning. Inside the framework hang the details. These details are myriad. The total number of factors that directly and indirectly influence learning from museums probably number in the hundreds, if not thousands. Some of these factors are apparent and have been summarized previously (cf. [6]), others are either not apparent or are not currently perceived by us to be important. After considering the findings from hundreds of research studies including the ones cited above, twelve key factors, or more accurately suites of factors, emerged as influential for museum learning experiences. These twelve factors are:

#### **Personal Context**

1. Visit motivation and expectations
2. Prior knowledge
3. Prior experiences

- 4. Prior interests
- 5. Choice and control

#### **Sociocultural Context**

- 6. Within group social mediation
- 7. Mediation by others outside the immediate social group

#### **Physical Context**

- 8. Advance organizers
- 9. Orientation to the physical space
- 10. Architecture and large-scale environment
- 11. Design and exposure to exhibits and programs

#### **Time**

- 12. Subsequent reinforcing events and experiences outside the museum

Individually, and collectively, these twelve factors significantly contribute to the quality of a museum experience. Although the relative importance of any one of these factors may vary between particular visitors, when any of these twelve factors are not supported, meaning-making is more difficult. Results from recent research [63] helped to demonstrate just how complex are both the processes and products of learning from museums. The study sought to answer two questions: 1) How do each of these variables individually contribute to learning outcomes? and 2) Does the Contextual Model of Learning provide a useful framework for understanding learning from museums? A random sample of 217 adult visitors to a life science exhibition at a major urban science center were investigated; visitors were interviewed prior to and after their visit, were tracked and observed throughout the visit, and were again interviewed nearly two years later. The data supported the contention that variables such as prior knowledge, interest, motivation, choice and control, within and between group social interaction, orientation, advance organizers, architecture, exhibition design and subsequent reinforcing experiences affect visitor learning. Individually, all of these factors were shown to significantly influence learning outcomes, but no single factor was capable of adequately explaining visitor learning outcomes across all visitors. The framework provided by the Contextual Model of Learning proved useful for understanding visitor learning because it turned out that the only way to arrive at a reasonable explanation for why visitors did what they did and learned what they learned was to consider each of these multiple factors simultaneously, rather than individually. As this study confirmed, learning from museums is an exceedingly complex phenomenon requiring considerable effort and ingenuity to comprehend and assess. We believe that this complexity equally applies to other learning situations and that the framework provided by the Contextual Model of Learning represents a useful way to investigate and understand that complexity. By no means does this framework answer all questions about learning, but it does help to shape what those questions might be. Which provides theoretician and practitioner alike with a better foundation for supporting and understanding the public's learning needs.

## 5. References

- [1] Dizard, W.P., 1982, *The Coming Information Age*. New York: Longman, Inc.
- [2] Machlup, F., 1962, *The production and distribution of knowledge in the U.S.* Princeton: Princeton University Press.
- [3] U.S. Department of Commerce, 1977, *The information economy*. Washington, DC: U.S. Government Printing Office.
- [4] Shenk, D., 1997, *Data Smog: Surviving the information glut*. New York: Harper Collins Publishers.
- [5] Sylwester, R., 1993, *A Celebration of Neurons: An Educators Guide to the Human Brain*. Alexandria, VA: Association for Supervision and Curriculum Development.
- [6] Falk, J.H., Dierking, L.D., 2000, *Learning from Museums: Visitor Experiences and the Making of Meaning*. Walnut Creek, CA: AltaMira Press.
- [7] Pope, M., Gilbert, J., 1983, Personal Experience and the Construction of Knowledge in Science. *Science Education*, 67, 193-203.
- [8] Roschelle, J., 1995, Learning in interactive environments: Prior knowledge and new experience. In: J. Falk & L. Dierking (eds.) *Public Institutions for Personal Learning*, pp. 37-51. Washington, DC: American Association of Museums.
- [9] Rosenfield, I., 1994, *The Invention of Memory: A New View of the Brain*. New York: Basic Books.
- [10] Solomon, J., 1987. Social Influences on the Construction of Pupil's Understanding of Science. *Studies in Science Education*, 14, 233-46.
- [11] Falk, J.H., Dierking, L.D., 1992, *The Museum Experience*. Washington, DC: Whalesback Books.
- [12] Roberts, L.C., 1997, *From Knowledge to Narrative: Educators and the Changing Museums*. Washington, DC: Smithsonian Institution Press.
- [13] Hagen, S., 1997, *Buddhism Plain and Simple*. Boston: Charles E. Tuttle Co., Inc.
- [14] Ceci, S.J., 1996, *On intelligence: A bioecological treatise on intellectual development*. Cambridge: Harvard University Press.
- [15] Ceci, S. J., & Roazzi, A., 1994, The effects of context on cognition: Postcards from Brazil. In: R.J. Sternberg & R.K. Wagner (Eds.) *Mind in context*. Cambridge, UK: Cambridge University Press. pp. 74-101.
- [16] Sternberg, R.J. & Wagner, R.K. (Eds.), 1994, *Mind in context*. Cambridge, UK: Cambridge University Press
- [17] Dierking, L. & Pollock, W., 1998, *Questioning assumptions: An introduction to front-end studies*. Washington, DC: Association of Science Technology Centers.
- [18] Falk, J.H. & Adelman, L., 2003, Investigating the impact of prior knowledge, experience and interest on aquarium visitor learning. *Journal of Research in Science Teaching*, 40(2), 163-176.

- [19] Gelman, R., Massey, C., & McManus, M., 1991, Characterizing supporting environments for cognitive development: Lessons from children in a museum. In L. Resnick, J. Levin, & S. Teasley (Eds.), *Perspectives on socially-shared cognition* (pp. 226-256). Washington, DC: American Psychological Association.
- [20] Hein, G. E., 1998, *Learning in the museum*. London: Routledge.
- [21] Silverman, L., 1993, Making meaning together. *Journal of Museum Education*, 18(3), 7-11.
- [22] Adelman, L.M., Dierking, L.D., Haley Goldman, K., Coulson, D., Falk, J.H. & Adams, M., 2001, *Baseline Impact Study: Disney's Animal Kingdom Conservation Station*. Technical Report, Annapolis, MD: Institute for Learning Innovation.
- [23] Adelman, L.M., Falk, J.H., & James, S., 2000, Assessing the National Aquarium in Baltimore's impact on visitor's conservation knowledge, attitudes and behaviors. *Curator*. 43(1): 33-62.
- [24] Csikzentmihalyi, M. & Hermanson, K., 1995, Intrinsic motivation in museums: Why does one want to learn? In: J. Falk & L. Dierking (Eds.) *Public institutions for personal learning*. pp. 67-78. Washington, DC: American Association of Museums.
- [25] Falk, J.H., 1993, Assessing the impact of exhibit arrangement on visitor behavior and learning. *Curator* 36(2): 1-15.
- [26] Falk, J.H., T. Moussouri & D. Coulson., 1998, The effect of visitors' agendas on museum learning. *Curator*. 41(2): 106-120.
- [27] Graburn, N.H., 1977, The museum and the visitor experience. In: *The visitor and the museum*, pp. 5-32. Prepared for the 72nd Annual Conference of the American Association of Museums, Seattle, WA.
- [28] Hood, M., 1983, Staying away: Why people choose not to visit museums. *Museum News*, 61(4), 50-57.
- [29] Griffin, J., 1998, *School-museum integrated learning experiences in science: A learning journey*. Unpublished doctoral dissertation. University of Technology, Sydney.
- [30] Lebeau, R.B., Gyamfi, P, Wizevich, K., & Koster, E., 2001, Supporting and documenting choice in free-choice science learning environments. In: J. Falk (Ed.) *Free-Choice Science Education*, pp. 133-148. New York: Teachers College Press.
- [31] Ogbu, J., 1995, The influence of culture on learning and behavior. In J. Falk & L. Dierking (Eds.) *Public Institutions for Personal Learning: Establishing a Research Agenda* (79-96). Washington, DC: American Association of Museums.
- [32] Wertsch, J.V., 1985, *Vygotsky and the social formation of the mind*. Cambridge, MA: Harvard University Press.
- [33] Bal, M., 1996, *Double exposures*. London: Routledge.
- [34] Bennett, T., 1995, *The birth of the museum: History, theory, politics*. London: Routledge
- [35] Hooper-Greenhill, E., 1992, *Museums and the shaping of knowledge*. London: Routledge.
- [36] Borun, M., Chambers, M., Dritsas, J. & Johnson, J., 1997, Enhancing family learning through exhibits. *Curator*, 40/4, 279-95.

- [37] Leinhardt, G. Crowley, K. & Knutson, K. (Eds.), 2002, *Learning conversations in museums*. Mahwah, NJ: Erlbaum.
- [38] Ellenbogen, K.M., 2002, Museums in family life: An ethnographic case study. In G. Leinhardt, K. Crowley, & K. Knutson, (Eds.), *Learning conversations in museums*, pp. 81-101. Mahwah, New Jersey: Erlbaum.
- [39] Schaubel, L, Banks, D., Coates, G.D., Martin, L.M.W., & Sterling, P., 1996, Outside the classroom walls: Learning in informal environments. In: L. Schaubel & R. Glaser (Eds.) *Innovations in learning* (pp. 5-24). Mahwah, NJ: Erlbaum
- [40] Crowley, K. & Callanan, M., 1998, Describing and supporting collaborative scientific thinking in parent-child interactions. *Journal of Museum Education*. 23(1), 12-23.
- [41] Koran, J. J., Jr., Koran, M. L., Dierking, L. D., & Foster, J., 1988, Using modeling to direct attention in a natural history museum. *Curator*, 31(1), 36-42.
- [42] Wolins, I., Jensen, N., & Ulzheimer, R., 1992, Children's memories of museum field trips: A qualitative study. *Journal of Museum Education*, 17(2), 17-27.
- [43] Clark, A., 1997, *Being There: Putting brain, body and world together again*. Cambridge: MIT Press.
- [44] Evans, G., 1995, Learning and the physical environment. In: J.Falk & L.Dierking (Eds.) *Public institutions for personal learning*. pp. 119-126. Washington, DC: American Association of Museums.
- [45] Falk, J.H. & Balling, J.D., 1982, The field trip milieu: Learning and behavior as a function of contextual events. *Journal of Educational Research*. 76(1): 22-28.
- [46] Falk, J.H., Martin, W.W. & Balling, J.D., 1978, The novel field trip phenomenon: Adjustment to novel settings interferes with task learning. *Journal of Research in Science Teaching* 15: 127-134.
- [47] Kubota, C.A. & Olstad, R.G., 1991, Effects of novelty-reducing preparation on exploratory behavior and cognitive learning in a science museum setting. *Journal of Research in Science Teaching*, 28(3), 225-234.
- [48] Hayward, D.G. & Brydon-Miller, M., 1984, Spatial and conceptual aspects of orientation: Visitor experiences at an outdoor history museum. *Journal of Environmental Systems*, 13(4), 317-332.
- [49] Anderson, D. & Lucas, K.B., 1997, The effectiveness of orienting students to the physical features of a science museum prior to visitation. *Journal of Research in Science Teaching*, 27/4, 485-495.
- [50] Falk, J.H., 1997, Testing a museum exhibition design assumption: Effect of explicit labeling of exhibit clusters on visitor concept development. *Science Education*. 81(6): 679-688.
- [51] Coe, J., 1985, Design and perception: Making the zoo experience real. *Zoo Biology*, 4, 197-208.
- [52] Hedge, A., 1995, Human-factor considerations in the design of museums to optimize their impact on learning. In: J. Falk & L.Dierking (Eds.). *Public Institutions for Personal Learning*, pp. 105-118. Washington, DC: American Association of Museums.

- [53] Ogden, J., Lindburg, D. & Maple, T., 1993, The effects of ecologically relevant sounds on zoo visitors. *Curator*, 36(2), 147-156.
- [54] Bitgood, S. & Patterson, D., 1995, Principles of exhibit design. *Visitor Behavior*, 2(1), 4-6.
- [55] Serrell, B., 1996, Exhibit labels: An interpretive approach. Walnut Creek: AltaMira.
- [56] Bitgood, S., Serrell, B. & Thompson, D., 1994, The impact of informal education on visitors to museums. In: V. Crane (Ed.), *Informal science learning: What research says about television, science museums, and community-based projects* (pp. 61-106). Dedham, MA: Research Communications Ltd.
- [57] Serrell, B., 1998, *Paying attention: Visitors and museum exhibitions*. Washington, DC: American Association of Museums.
- [58] Anderson, D., 1999, Understanding the impact of post-visit activities on students' knowledge construction of electricity and magnetism as a result of a visit to an interactive science centre. Unpublished doctoral dissertation, Queensland University of Technology. Brisbane, Australia.
- [59] Bransford, J.D., Brown, A.L. & Cocking, R. (Eds.), 1999, *How people learn: Brain, mind, experience, and school*. Washington: National Research Council.
- [60] Medved, M.I., 1998, Remembering exhibits at museums of art, science and sport. Unpublished doctoral thesis. University of Toronto.
- [61] Falk, J.H., Scott, C., Dierking, L.D., Rennie, L.J. & Cohen Jones, M., 2004, Investigating the Impact of Interactives on Visitor Learning: An Exploratory Study. *Curator*, 47(2), 171-198.
- [62] Goldman, K.H., Adelman, L.M., Falk, J.H., Owen, K., Buchner, K., & Burtnyck, K., 2001, Conservation Impact Study National Aquarium in Baltimore: Six month re-contact study. Technical Report, Annapolis, MD: Institute for Learning Innovation.
- [63] Falk, J.H. & Storksdieck, M. (in review). A Multi-Factor Investigation of Variables Affecting Free-Choice Science Learning. *Science Education*.



---

## Are you a Technocratic? Aa Reformist? Oor an Holistic?

---

*Aharon Aviram,  
Center for Futurism in Education  
Ben Gurion University, Israel  
roniav@inter.net.il  
Deborah Talmi  
Department of Psychology  
University of Toronto, Canada  
debbie@psych.utoronto.ca*

### **Abstract**

This article summarizes the paper “The Impact of ICT on Education: the three opposed paradigms, the lacking discourse”, written by Roni Aviram and Deborah Talmi [1]. In that paper, the authors analyzed and mapped a large number of views on the computarisation of education – as presented in recent papers, books and conferences proceedings, and identified three clusters of approaches that differ on the most basic assumptions regarding the integration of ICT and education. These approaches are living “side by side” both in “the field” and in more academic contexts, largely ignoring each other and not engaging in any meaningful discussion. The authors claim that, given the very doubtful results of the “computerization of education” up until now - such on going discussion is vital for any mindful and successful policy in the future.

### **1. Introduction**

Educationalists and experts hold one of three views about the integration of ICT and education into three clusters of views. Despite a seemingly rich variety of views, they cluster into three paradigms which reflect different starting points and perspectives. Here we present these three paradigms, which we term - without hiding our biases - the Technocrat, the Reformist, and the Holistic.

**1.- The Technocrat paradigm** characterizes those who avoid any discussion about the nature of ICT, its desirability or the extent school should or will change as a consequence of the integration of ICT and education. They take the ICT revolution as given, unavoidable and as consisting mainly of necessary instrumental and behaviorist changes (“working with computers or the Internet”), take schools as a given, ignore the issue of the desired or predicted results of the “meeting” between the forces of ICT and education, and refer only to ‘technocratic aims’ as the proportion no of students to computer, or location of computers in schools or the nature of connection to the Internet.

**2.- The Reformist Paradigm** characterize those who see ICT as a tool that can assist in promoting the “right” didactics. The most fashionable buzzwords that are mentioned in this context are: “interdisciplinary”, “constructivist”, “collaborative learning”. Adherents to this view conceive ICT revolution as consisting of more than just new instruments and behaviors; they rather take it to enhance a certain kind of attitude to knowledge and learning that supports constructive leaning (usually without feeling the need to sustain this view- in many cases it is presented as an axiom).

**3.- The Holistic paradigm** characterize those that unlike the educationalists and writers belonging to the previous two paradigms usually present an explicit set of assertions regarding the socio-cultural situation and the defining impact ICT has on it (cultural approach). They also have an opinion as to the desired values that should guide educational decision making (ideological approach). Not only do they aspire to have comprehensive theories and clear recommendations for the education system, they do not evade discussing the theories of their rivals (unlike the two previous groups). Included in this group are those who start from the cultural - ideological approaches. Their attitude is either conservative (e.g. Postman, 1995) or radical and extreme radical (e.g. Aviram & Comay, 2000[2], ; Kristmundson et al., 2000[3]).

We called these three clusters of perspectives, mind-frames and the proposed or already-implemented policies they entail towards ICT and education “paradigms” because they differ on fundamental issues. To better understand the opposed views let us take a look below the surface, to the suppositions each of these groups make about the worlds of ICT and education. As we will see, their suppositions about these worlds are different and to large extent contradictory.

## 2. Suppositions Underlying the Three Paradigms

Concerning the world of ICT, the upholders of the three above paradigms give (mostly tacit) opposed answers to the four following questions concerning the defining nature of the ICT revolution, its predetermined nature, and its ethical value:

- Is the ICT revolution neutral, that is, does not influence our lives, or is it a defining revolution?
- Is ICT revolution predetermined or can we influence it?
- Can the ICT revolution be judged ethically?
- If so - is it good or bad?

What are the views of the three emerging paradigms regarding the four above questions?

### 2.1 The Technocrat paradigm: ICT as a technological "progress"

The Technocratic paradigm is implicitly neutralist. Basically, Technocrats do not treat seriously what others take to be defining influences of the ICT revolution (i.e. the way it is redefining major aspects of our lives), and do not take ICT to have far-reaching impact on who we are. Moreover, this paradigm is also implicitly determinist: its members perceive ICT as a "necessary force" the educational system should adapt to, and the sooner the better. They neither imagine that society could, if it so chooses, mold ICT according to its needs and values, nor believe that the education system could channel the influences ICT holds in store. To put it simplistically, they buy computers for schools because there are computers to be bought and they are taken to represent "progress" or what is "in" - without further questions or thoughts.

It is reasonable to assume that adherents to this view give an implicit negative answer to the third question (concerning our ability to ethically judge the ICT revolution), and that their answer stems both from their determinism and neutralism concerning ICT and their lack of interest in questions of values and basic educational goals. Thus, Riffel and Levin (1994[7]) conclude from their field study that "technological imperatives (to have the latest, most powerful computers available) overtake unclear educational objectives...the overall educational focus of [the schools'] efforts remains unclear."

### 2.2 The Reformist Paradigm : ICT as promoting constructivist didactics

The Reformist paradigm is based on an understanding of some aspect of the defining nature of ICT, and it is therefore non-neutralist. It is also determinist: its adherents don't think they or anyone else can, or should, have a say concerning the general development of technology. If there is notion of indeterminism in this view it does not lie in its adherents' understanding of technology relationship to culture but rather in the educational use that can be made with it. Many of them seem to believe that since technology is there, schools must learn to do interesting and desirable things with it. They do ask themselves what educational purpose ICT might and should serve; their answer is that ICT can be used to promote the desired (constructivist) didactics.

From the above it follows that they do presuppose positive answers both to the third and fourth questions. Basically, they too perceive novel technologies to be "advancements", and therefore place an ethical judgement on ICT. Moreover, they find that ICT exerts a positive influence, since it encourages constructivist tendencies, or may potentially do so. This viewpoint is underlying the question posed by the editors of the SITES project report in the concluding chapter - "Is our education measuring up with regard to its innovative potential?"[5]. (Pelgrum & Anderson, 1999)

### 2.3 The Holistic paradigm: ICT as redefining our culture and lives

The third paradigm, the Holists, is actually defined according to its non-Neutrality, as its upholders treat ICT as a major defining force of culture. Its view is basically indeterminist, although different holists might hold different kinds of indeterminism. Postman [6](1995) believes it is impossible to preserve the good parts of "American cultural institutions and heritage" while allowing uncontrolled technological development, and advocates a serious discussion regarding the advantages and disadvantages of technology and the way it changes our perception of the world. Aviram & Comay [2](2000) strive to form "strategies for the channeling of the inevitable [ICT] revolution to socially and humanely beneficial directions"

(italics in original). One can say that these are two different kinds of indeterminism: strong indeterminism in Postman’s case – since his appeal for social discussion on the fundamentals of the ICT revolution is implicitly based on the supposition that society could change those fundamentals; and soft indeterminism in Aviram and Comay’s case – since here it is assumed that the mere fundamentals are given, but it is possible to channel the processes based on them.

Obviously, authors in this group do not evade the discussion of what the desired values of education are. They then judge the ICT revolution in regard to these values -answering the third question positively. As to their judgment, they vary from neutral to negative and positive. Thus, Hermant de Callatay [7] (2000) states that “Technology will have to serve the educational purpose. It should not be the other way around”(- a rather neural judgment). Postman believes ICT is harmful due to its influence on culture at large (Postman, 1992)[8] and on education); While we believe it to have both positive and negative potentials and that its impact on society and on education depends very much on the way we channel its introduction to education [9](Aviram, 2000).

The differences between the three groups stand out in Tthe table 1, which summarizes their presuppositions and the relationships amongst them.

TABLE 1: Suppositions

|                                                               | <i>Holists</i>                                                   | <i>Reformists</i>                                            | <i>Technocrats</i>                          |
|---------------------------------------------------------------|------------------------------------------------------------------|--------------------------------------------------------------|---------------------------------------------|
| <i>Will the educational system last in its present shape?</i> | No                                                               | <i>Yes, with some modification of the didactical aspects</i> | <i>No opinion (positive answer implied)</i> |
| <i>Should the educational system last?</i>                    | <i>Yes / No (depending on the values of the specific writer)</i> | <i>Yes, with some modifications</i>                          | <i>No opinion (positive answer implied)</i> |
| <i>Is the ICT revolution neutral or defining?</i>             | <i>Defining</i>                                                  | <i>Defining</i>                                              | <i>Neutral</i>                              |
| <i>Is the ICT revolution predetermined?</i>                   | <i>Non-determined</i>                                            | <i>Predetermined</i>                                         | <i>Predetermined</i>                        |
| <i>Can the ICT revolution be judged ethically?</i>            | Yes                                                              | Yes                                                          | <i>No opinion</i>                           |
| <i>Is ICT revolution good?</i>                                | <i>Yes / No (depending on the values of the specific writer)</i> | Yes                                                          | <i>No opinion (positive answer implied)</i> |

### 3. Conclusion: The Need for Rational Discourse

We have described the three general paradigms in the field of ICT and education, and showed that there are substantial differences between the suppositions these paradigms make about the worlds of ICT and education.

The most basic concepts of rationality and science entail that when there are three competing theories in a scientific field, a discussion between their upholders is to be expected. The field of ICT and education is a blatant anomaly when viewed in this light. Essentially, there is no rational discourse between the different views about ICT's introduction to education. Each of the upholders of the three above paradigms takes a stance, either explicitly or implicitly, but doesn't seem to be aware and/or to care about the existence of competing theories. Most authors, especially the Technocrats and Reformists, but to some extent the Holists as well, do not have a meta-level perspective on the place of their view in the discourse, which is a cornerstone of rationalistic-scientific conduct (see Aviram & Talmi [1], unpublished).

The question of the field's development is not only theoretical, but obviously a very practical one as well. The lack of rational discussion is true not only in regard to the theoretical debate; it is even more correct concerning practice (and how could it be different if practitioners don't have systematic theoretical debate to rely on?). Schools, districts, regions and countries develop and implement ICT products and models of ICT based education, but due to the basic lack of culture of rational discourse and rational development, in too many cases there are no clear threads of ongoing improvement on existing models. As it is, everybody is reinventing the wheel time and time again.

The different implementation policies stemming from the different views have an enormous impact on the future of the educational system and the society at large. Given the history of very ambivalent results (to say the least) in the productive introduction of ICT to education in the last twenty years and the huge investments involved, we cannot afford to continue treating this process in the shallow unmindful manner currently prevalent (we elaborate on this issue in Aviram & Talmi, unpublished). It is vital that we look below the surface of the process of ICT introduction to education, expose the fundamentals of the different views that have guided this process until now, and encourage an on-going rational and critical discussion among them. In order to make well-founded implementation decisions in the field, we must initiate a rational discourse between the different theories, and form a model for ICT-introduction that would reflect the state-of-the-art in the field.

#### 4. References

- [1] Aviram, A., & Talmi, D., ?,(in press). "ICT and Education - 'The Lacking Discourse'", in J. Hernandez and Goodson (eds.) *Geographics of Educational Change* . London: Kluwer
- [2] Aviram, A., Comay, O., 2000, From "Computers in the Classroom" to the critical radical adaptation of educational systems to the new emerging ICT culture, *Proceedings of the EDEN fourth Open Classroom Conference*, Barcelona, Spain, November 19-21.
- [3] Kristmundson, G., Jeppesen, K., Micheliadou, M., Guttorn, P., & Hansen, O. (2000) Indicators of the open, innovative and inclusive school, *Proceedings of the EDEN fourth Open Classroom Conference*, Barcelona, Spain, November 19-21. Goodson (eds.) *Geographics of Educational Change* . London: Kluwer.
- [4] Riffel, A., & Levin, B., (1997, ). Schools coping with the impact of information technology. *Educational Management and Administration*, 25(1), 51-64.
- [5] Pelgrum, W. J., & Anderson, R. E., (Eds.), . (1999, ). *ICT and the emerging paradigm for life long learning: A worldwide Educational assessment of Infrastructure, goals and practices*. Enschede, The Netherlands: Printpartners Ipskamp.
- [6] Postman, N., 1995, *The end of education: Redefining the value of school* (New York: Knopf).
- [7] Hermant de Callatay, C., 2000, Future developments in schools, *Proceedings of the EDEN fourth Open Classroom Conference*, Barcelona, Spain, November 19-21.
- [8] Postman, N., 1992, *Technopoly: The surrender of culture to technology* (New York: Knopf : Distributed by Random House).
- [9] Aviram, A., 2000, 'The Integration of ICT and Education: From Computers in the Classroom" to Mindful Radical Adaptation of Education Systems to the Emerging Cyber Culture, *Journal of Educational Change*, 1: 331-352.

## School of Tomorrow: Visions

---

*Henrik Hansson*

*Institute of International Education/Department of Education*

*Stockholm University, 106 91 Stockholm, Sweden*

*Henrik.Hansson@interped.su.se*

### **Abstract**

This article discusses visions of the future school as part of the objective in the EC-funded project Schoolforesight. The material used is student essays from an international contest in the framework of Schoolforesight. The participating students are from Bulgaria, Czech Republic, Estonia, Greece and Rumania. Their task was to write about their vision of the school 2020. Interviews with teachers from other countries about the future school and a broader trend analysis of societal change were also used to contrast and complement the picture. The most important aspect in the student essays was the stress on and need for an interesting, encouraging and motivating school, providing relevant knowledge and a good atmosphere between students and teachers. The school design could be categorised into three groups: "The school as a big Arena", "The Virtual School" and "The technology enhanced classroom". In addition to these radically different types of schools, one could add "The Ubiquitous Learning Environment" based on the development of wireless technology and an increasingly mobile society. Whereas the students generally had an optimistic attitude towards the future school and the use of technology (but there were also sceptics), the teacher interviews revealed a more concerned attitude. Some teachers feared that technology and media will create lazier students, provide less depth knowledge and cause problems for students to focus on the task. Other opinions were that technology would enable more creative and active students and also enable a more individualistic approach in education.

### **1. Introduction and aim**

The aim of the EC-funded project Schoolforesight is to popularize and disseminate innovative school projects using information and communication technology in order to reach a

broad audience in particular young students. A pool of more than 800 EC-funded school projects was analysed and finally 22 projects were selected in the areas of Science, Language, Collaborative Learning and Teaching, Art and Music, Geography, Culture and Personal/Social Education Mathematics, History, and Mobile Learning. The projects selected and the process of selection is described in another article [1]. But how is the future school perceived by students? To provide an answer to this question an international essay competition was conducted in five countries: Bulgaria, Czech Republic, Estonia, Greece and Rumania. The students' task was to write an essay about the school in 2020. First a national contest was held and this was administered by Ellinogermaniki Agogi, Greece, S.C. IPA S.A. Rumania, Center for Prospective Studies, Technical University of Sofia, Bulgaria, Alfa Omega Communications, Estonia and Gymnasium F.X. Saldy in the Czech Republic. The three best essays were thereafter competing for an international prize. The committee selecting the winners consisted of a group of teachers at Bladin's School in Malmö, Sweden, Scott Hall at the Institute of international education, Stockholm University and the author of this article.

The aim of this article is to discuss visions of the future school based on what the student essays revealed but also to go beyond their ideas and provide a more holistic framework. The broader purpose is to contribute to the discussion on the design of tomorrow's education – alternatives; hopes and fears, not only as perceived by students, but also by teachers. A minor interview study was done in order to investigate the visions held by teachers as complementary data. General trends and structural developments are taken into account when interpreting the student essays and teacher interviews in order to provide the different scenarios for the future of schools.

The material was analysed using a qualitative approach inspired by the school of grounded theory, but not in the orthodox way of simply "letting data speak" [2-4]. Another methodological source of inspiration is the hermeneutic approach, a qualitative approach more focused on interpretation and transcending the empirical data, "reading between lines" – focusing on understanding, questioning and contexts.

## 2. The future school – four visions

It was surprising to find out that the essays first and foremost focused on meaningful and motivating activities, basic values, and the relations with friends and teachers. The so called "social capital" played an important role in the essays [5]. Social capital is about trust, social relations and networks, aspects that are deemed essential in our society and increasingly so. In fact many of the visions for the future related to this non-technological field could be implemented already if the student's voice was heard. The technological aspect was a second theme. Before talking more about technology and its impact on school, its organisation and the changing social relations, one need to remember the students' principal point – school activities must be interesting, challenging, exciting, relevant and meaningful from the students point of view, if not... all investments in technology in schools will be wasted.

Another surprise when reading the essays were that some student opinions could as well be taken as workers opinions about a future paradise: one essay started with ... "in the future most pupils wish there was no school at all", or stated that they wanted to start at 10 am and

have Fridays off. Obviously students of today have mixed feelings for the current school. It is not self evident that school must lock students in during day hours for years, there are reasons for having them there, but also opportunities for a more flexible learning life in the same way work life is developing.

The student visions as expressed in the essays could be grouped in three categories: “The Arena school”, “The Virtual School” and “The Technology Enhanced ‘Classroom’”. A fourth complementary category could be added to these scenarios, “The Ubiquitous Learning Mode”. The Arena school is characterized as a large, modern, high tech, all purpose school building. The Arena school fulfils all pupils’ needs, physical, social, technical and educational. There is a cinema, high quality restaurants and cafés, laboratories, science and computer equipment, sports facilities. In this large school complex one meets friends and teachers and other staff face to face. It is fun and exciting. In fact it seems to be the centre of life and every day is a new adventure. Also off hours are spent in the facilities. Most essays expressed an Arena vision. There were also some students expressing doubts about a highly technical school environment, and one student even suggested a total rejection of it, a kind of “back to nature” revolt in the spirit of Jean Jacques Rousseau [6].

“The virtual school” is the total opposite vision. In this scenario a physical school does not exist. School enters home. From home the student interacts face to face (or maybe better: “e-face to e-face”) with schoolmates and the teacher via large screens on the wall. There is no commuting, no stress in the morning; in fact one can take part in the lessons via the breakfast table. The student expressing this vision stressed the importance of synchronous visual contact in order to “control” the children, who otherwise would try to get away with things or do other activities. The school day was perceived as a “normal” school day, but with all involved participating from a distance via transparent technology, “they appear to be in the same room”. Most students mentioned the importance of physical activity, especially since computer and screen interactions is a passive mode. The student writing about the virtual school suggested that the real life interactions took place after home based lessons. All students gather in the afternoon and evening in the local village or town in order to interact socially and do sports activities. This approach is a kind of distance education, but focuses on real time dialogues and the use of audiovisual technology available to all in their private homes. The expensive school arena is not needed, but instead investments have to be done in private homes. Gilly Salmon [7-8] among others has stressed the importance of dialogues in online courses as opposed to ready made content packages, but the technology in distance education so far has been restricted mainly to text chat and asynchronous text via e-mails or forums. The students envision a technology that enables a richer dialogue with face and body language in addition to voice and integration of persons acting from multiple locations.

“The technology enhanced classroom” was another common vision among students. It is simply the traditional classroom reinforced with technology: computers and Internet that enables more independent studies, international cooperation and access to information from a large variety of sources. Since some students who wrote the essays were participating from schools that seem to lack computers for student use, it was a great vision to just get access to a computer. In a European school context the resources are very different between countries – in Sweden for instance all schools are equipped with computers and Internet access. But some people think that it will not be desk or lap top computers in the future, but instead more

developed mobile phones so called “smart phones” that include all types of information and communication technologies. The student use of mobile phones, which already has a wide range of extra functions such as cameras, sms, Internet access et cetera, is such a problem in Swedish schools that national politicians discuss the issue and are considering giving teachers legal means to confiscate them in order to restore discipline. Sweden invests the most in the world in public education, but according to recent studies has severe problems with discipline in the classroom [9].

The student essays uncovered three distinct different visions of the future school: The Arena School, The Virtual School and the Technology Enhanced Classroom. A fourth plausible scenario of the future school could be: “The Ubiquitous learning mode”. This vision is learning via the availability of information and communication opportunities everywhere. The availability happens all the time via wireless high speed broad band networks. We can imagine small portable devices, but increasingly the needed equipment is built into the environment it self: in cars, in trains, at airports, hotels, restaurants et cetera. In Sweden wireless Internet is for instance already available at a certain hamburger chain covering the country. This means that “the classroom”, if that is the suitable term, can be anywhere and also that learning can take place in a life long and autonomous fashion in a totally new way. Even the most remote areas can now be reached via satellite and the infrastructure is quickly improving. “The digital generation” who knows no world without computers will be used to this “language and culture” in a totally different way than the generation born before the computer age. Marc Prensky even suggests that their brains are structured differently because of their intense use of videogames and because the logics in the digital world completely differs from the logics in the print world [10].

### 3. Teachers' fears and hopes

A group of teachers from England, Greece, Italy, Portugal, Spain and Sweden was asked to write down keywords signifying the future school in their opinion and to explain and discuss the keywords. The keywords are categorised and abstracted into the general concepts shown in the table below. As we can see there is a concern among teachers that media and technology development might create lazy and passive students, having problems to focus on deep learning. Commercialisation will force school to be more adapted to work life and less to “academic” learning. Less funding for education and lower teacher salaries in public systems is another perceived threat.

On the other hand some teachers were more optimistic (and in many cases one individual suggested both scenarios). The promises for the future according to the teachers was the ability to tailor school more to individual needs, to use the creativity and producer tools to make more meaningful learning activities and to use media in an entertaining and engaging way with a learning content. The risks and promises with new technology in education are discussed by Burbules and Callister among others, they emphasize the need for students to develop critical thinking when using Internet material [12].

Table. School of tomorrow: Teachers' hopes and fears

| Hopes                          | Fears                                   |
|--------------------------------|-----------------------------------------|
| <i>Active students</i>         | <i>Lazy students</i>                    |
| <i>Creators</i>                | <i>Consumers</i>                        |
| <i>Entertainment: learning</i> | <i>Entertainment: stupidity</i>         |
| <i>Focused: Homo Sapiens</i>   | <i>Unable to focus: "Homo Zap'iens"</i> |
| <i>Individual needs</i>        | <i>Mass approach</i>                    |
| <i>Humanistic</i>              | <i>Commercial</i>                       |

One teacher suggested that the future school could be summarized with a number of words starting with "inter":

- Interconnectivity. Everything is connected: school and work life, school and home. Media and communication channels: TV, phones, computers et cetera. See Pavlik and McIntosh on media convergence [11].
- Interactivity between students and students, students and teachers, teachers and parents et cetera
- Internet. More and more of our communication and information is carried by the Internet, for schools: homework, digital libraries, schedules to mention just some applications.
- International. Our world is increasingly international, locally – more immigrants and people with different cultural background in the local schools – and our ability and need to interact with the wider world.
- Interdependence. In this increasingly international world we are more and more dependent on each other and events even in remote areas can quickly affect our lives. The issues for example about environment, security, health are not something we can handle alone anymore.
- Interdisciplinary. The merging of old scientific disciplines to new fields of knowledge is constantly taking place. Problem solving is in focus and in order to solve a problem today one need skills and knowledge from a wide variety of disciplines.

#### 4. Conclusions

The students from Bulgaria, Estonia, Greece, Rumania and the Czech Republic provided visions of the future school that could be categorized as "The Arena school", the big modern super structure providing all one could ask for, "The Virtual School", the digital appearance of teacher and schoolmates in ones home and "The Technology Enhanced 'Classroom'", the traditional classroom updated and modified with learning technologies. In addition to these alternatives we added the "Ubiquitous learning mode", enabling studies and learning both formal and informal in all settings and in a lifelong perspective. Well, which one is the future? ...Maybe all? There are more to be considered than pedagogies and technology when forecasting the future school, economy: more or less funding to education? Social organisation

– is it possible to let all young kids loose outside the classroom? But one thing is for sure, the future school will be radically different from what we have been used to and not the least the “digital generation” growing up today will be a powerful change agent. In this article we have investigated some of their visions, but tomorrow they create the reality.

## 5. References

- [1] Hansson, H, Hall, S., 2004, The Future of Schools from a European Union Perspective - Selecting, analyzing and disseminating the most innovative approaches out of more than 800 EU-funded projects. E-Learn 2004--World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education Washington, DC, USA, November 1-5, 2004. Conference proceedings.
- [2] Strauss, A, Corbin, J., 1997, Grounded theory in practice. Thousand Oaks : SAGE.
- [3] Glaser, B, G., 2003, The grounded theory perspective II: descriptions remodeling of grounded theory methodology. Mill Valley, Calif.: Sociology Press
- [4] Patton, M, Q., 2004, Qualitative research & evaluation methods. London : SAGE.
- [5]. Putnam, R, D., 2001, Bowling Alone: the collapse and revival of American community. London : Simon & Schuster, 2001.
- [6] Rousseau, Jean-Jacques., 1993, Émile [Émile ou l'éducation: translated by Barbara Foxley]. London : J.M. Dent.
- [7] Salmon, G., 2000, E-moderating : the key to teaching and learning online. London : Kogan Page, 2000
- [8] Salmon, G., 2002, Eivities : the key to active online learning. London : Kogan Page.
- [9] Swedish National Agency for Education. PRESSMEDDELANDE 2004-12-09: Mer än varannan 10-12 åring saknar arbetsro i skolan. [More than 50% of the 10 – 12 year old students are disturbed by others when studying] (Retrieved 2004-12-13)
- [10] Prensky, M., 2001, Digital game-based learning. New York ; London : McGraw-Hill,
- [11] Pavlik, J, McIntosh, S., 2004, Converging media : an introduction to mass communication. Boston : Pearson : Allyn and Bacon, c2004.
- [12] Burbules, N, C, Callister, T, A., 2000, Watch IT: the risks and promises of information technologies for education. Boulder, Colo. ; Oxford : Westview, 2000.

## Acknowledgements

This work was partly financed by the European Commission, the Sixth Framework Program. The Schoolforesight project members have all contributed with stimulating discussions and by providing student essays from their countries: Ellinogermaniki Agogi, Greece, S.C. IPA S.A. Rumania, Center for Prospective Studies, Technical University of Sofia, Bulgaria, Alfa Omega Communications, Estonia and Gymnasium FX. Saldy in the Czech Republic. A great deal of work in selecting innovative EU-projects and reviewing student essays has been done

by master student Scott Hall, Institute of International Education, Stockholm, Sweden. I also want to thank the teachers at Bladin's international school who independently ranked students essays and of course last but not least the students who wrote the essays and teachers who participated in the interviews.



## Designing the science classroom of the School of Tomorrow

*Sofoklis A. Sotirion,*

*Head of R&D, Ellinogermaniki Agog, Greece*

*sotirion@ea.gr*

*Science, whatever be its ultimate developments, has its origin in techniques, in arts and crafts...  
Science arises in contact with things, it is dependent on the evidence of the senses, and however far it seems to  
move from them, must always come back to them.*

*B.Farrington, Greek Science, 1949*

### Abstract

What will science classrooms be like in the year 2020? How will teachers help all students to acquire skills, reasoning abilities, knowledge and attitudes that help them function in the 21st century? National efforts to reform the science curriculum provide guidelines that call for (a) integration of science with mathematics and other disciplines, (b) more time devoted to inquiry and long-term projects, (c) more group work and cooperative learning, (d) effective application of advanced tools such as graphing calculators and microcomputer-based laboratories, and (e) realistic assessment tied to non-academic outcomes. This paper argues that current reform guidelines will result in classrooms that are more exciting places to learn and apply science.

### 1. Introduction

Step into a time machine and move forward fifteen years to the year 2020. What will high school science classrooms look like? What have we learned about ways to teach science? How will we apply what we have learned about teaching and learning to help adolescents prepare for their lives in the Information Society? Will science learning environments be enhanced by effective use of new tools? Will students be motivated to achieve better? Will science teachers be more competent at their jobs? Will classroom environments promote outcomes like proc-

ess skills, problem-solving abilities, teamwork, stronger self-concepts, career goals that include science, and transfer of knowledge to novel situations? What will be different and what will look the same in 2020?

Science teaching in schools and in higher education is an important issue related to the Lisbon and Barcelona goals, part of which is to overcome Europe's shortage of scientists and researchers: According to a report of a 'High Level Group on Human Resources for Science and Technology in Europe', published in April 2004, Europe needs 700.000 researchers more in order to accomplish these goals. The report emphasizes that more students should be encouraged to choose scientific disciplines at university that lead to a future career in science. Therefore, school science teaching needs to become more engaging. It should be based on more hands-on experience and designed to meet the interests of young people. Powerful new technologies promise to transform education and training in ways previously unimaginable. Rapid advancements in educational technologies in the years ahead could enable new learning environments using simulations, visualizations, immersive environments, game playing, intelligent tutors and avatars, reusable building blocks of content, address distributed communities of learners, and many more. There are many challenges in the process of educational innovation that must be addressed in order to take advantage of these technologies to improve learning. Advanced technologies developed to meet other purposes must be translated into affordable tools for learners to use. Technical standards must be deployed to help guide the development of educational content that will be drawn from countless sources throughout the world. The technology community has to form stronger partnerships with the educational community. The educational institutions need to prepare for rapid technological change.

## 2. Pedagogical Considerations

Our working hypothesis is that amending 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, make better predictions, and reflect more effectively [1]. Additionally, working to reconcile the gaps and inconsistencies within their mental models, system models, predictions and results, will provide the learners with a powerful, explicit representation of their misconceptions and a means to repair them. Everyday experience suggests that students are eager to learn in informal settings such as excursions to museums and science centres. This positive attitude is believed to have two main roots: The freedom of leaving the formal setting of the classroom and the students' positive motivation towards informal learning beyond the school to a real life setting where contextual knowledge occurs. In order to achieve the best results from informal education one has to take advantage of the motivating effects of freedom and physical context. Our approach aims to bridge this divide, introducing new technologies and activities that fluidly link the use of physical materials with digital technology in creative inquiry and inventive exploration. Our aim is to demonstrate 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. In most science-education settings, there is a sharp division between the physical and the virtual. Our work aims at developing, testing and evaluating learning schemes that will be implemented on ambient, always available educational

environment developed upon emerging technology in order to facilitate in-situ learning, by maximizing the impact of information that is provided when the motivation of the student is highest.

Our working hypothesis is putting emphasis on the following factors:

- **Science for All Students:** Every student, not just the intellectual elite and college bound, can and should master the elements of scientific literacy. This term is usually defined as the ability to recognize and apply a rational approach to understanding the world, which has explanations for its behavior, and can be manipulated for human benefit. Citizens who are scientifically literate can discuss and make wise personal decisions about problems arising from acid rainfall, global warming, AIDS, increasing human population, decreasing energy and mineral resources, etc. Science-literate citizens believe that these problems are subject to rational solutions. They understand both the potential benefits and hazards of applied science and technology. Because all citizens will be taxpayers and voters and will make decisions every day that affect the aggregate societal welfare, it follows that all students should prepare for this responsibility by becoming familiar with science and technology as a tool for impacting the public, either for good or for ill. Personal actions that result in household and automobile fuel consumption, number of children born into a family, contributions to the waste stream, recycling, etc., add up to significant impacts on the planetary welfare. Taxpayer referenda that establish priorities for funding the technical costs of addressing these problems will be decided by how well schools have done their job of educating all students about the potential of science to “fix” our world. Government funding for research and development efforts in space, medicine, sub-atomic particles, global climate modeling, and other expensive human efforts will be available only if congress and vocal citizens believe in its merits. Some of today’s teenagers may be elected to congress; or others may find themselves in positions to make critical decisions; all need to know how to be responsible adults; schools must assure science literacy for all students. This push for universal scientific literacy has large implications for changes in science classrooms. If we need to provide science for larger numbers of students, we will need more science teachers. To integrate science with other subjects, we will blur the boundaries in the curriculum and require better communication and planning among teachers. To include physically and mentally challenged students in science, we will need to show teachers how this can be done and convince them that it is desirable. More minorities and females will need to see optional science courses as essential to their future plans. Multicultural role-models of both genders need to be shown as successful students of science many of whom are choosing science careers.
- **The Curriculum and Time Schedules:** A greater emphasis on interrelationships, traditionally termed “ecology,” will be found in the curriculum of the future. Predator-prey relationships, food chains, requirements for species survival, population dynamics, and the effect of humans on the ecosystem will be used as themes for integrated science. Teams of students will debate the global impacts of human consumption and waste management on other species. Loss of habitat and consequent pressure on animal and plant survival will be examined. Teachers will need help as they work more outside the textbook in a dynamic curriculum. This will mean electronic networking through the Internet and local re-education through in-service workshops. Universities

and local education agencies will play a more active role in teacher support. Finding ways to encourage more active student participation in learning will challenge all the stakeholders in science education. Currently, science classes in most schools are interrupted by scheduled bells at 40-45-minute intervals. Teachers are surely the only professionals who must perform their job within such arbitrary time blocks. Despite their need to set up, conduct and clear away laboratories and demonstrations, science teachers are allocated the same time as shop, gym, or algebra teachers. Schools in 2020 will have alternatives that offer extended time for science learning. Blocks of time will exceed the traditional 45 minute class hour, allowing science teachers to perform laboratory experiments and demonstrations with their students, to examine the resulting implications, and to explore the extensions of thinking that should follow. In place of the traditional series of six, 45minute classes, future schools will offer modular schedules, with a full year of credit offered for a semester of these double-long class periods. Such schedules will provide science teachers with opportunities to extend project work, field trips, and inquiry learning. There will be a distinction between allocated time and actual academic learning time. Non-academic disruptions of academic time will be reduced to maximize time on task. Schedules for science classes will be adjusted in response to questions like: How much can be “covered” in the allocated time?; Does “seat time” imply meaningful learning?; Do Carnegie units indicate real conceptual understanding and mastery of skills that are useful in the world outside the classroom? Exploring fewer topics in greater depth and for longer daily class periods will be the earmark of future science classrooms. This issue is explored in a report issued by the National Education Commission on Time and Learning [2]. The report offers eight recommendations for reinventing the school schedule to provide more time for student academic learning.

Table 1 contrasts traditional science curriculum practices with those recommended by new national guidelines from AAAS and the NAS. It is taken from the Science for All Students: The Florida Pre K-12 Science Curriculum Framework [3].

Table 1:  
Comparison of Traditional and Recommended Practices in Science Instruction

| Traditional                                                                                                                      | Recommended                                                                                                                                          |
|----------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Science for some</i>                                                                                                          | <i>Science for all</i>                                                                                                                               |
| <i>Behaviorist based</i>                                                                                                         | <i>Constructivist based</i>                                                                                                                          |
| <i>Behavioral objectives - learning is based on measurable behaviors</i>                                                         | <i>Conceptual objectives - learning is based on constructing meaningful concepts/ learning</i>                                                       |
| <i>Text based</i>                                                                                                                | <i>Hands-on/Minds-on</i>                                                                                                                             |
| <i>Passive</i>                                                                                                                   | <i>Active</i>                                                                                                                                        |
| <i>Confirmatory investigation</i>                                                                                                | <i>Problem solving investigation</i>                                                                                                                 |
| <i>Fact oriented</i>                                                                                                             | <i>Concept oriented</i>                                                                                                                              |
| <i>Teacher demonstrations</i>                                                                                                    | <i>Labs/Field experiences</i>                                                                                                                        |
| <i>Science is seen as a single subject with little relationship to mathematics, social studies, language arts, art, or music</i> | <i>Science is seen as part of an interdisciplinary world; emphasis is on relating science to the students' world, which is not compartmentalized</i> |

|                                                                                                         |                                                                                                                                                                                |
|---------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>The teacher imparts knowledge and students learn it; communication is learning generally one way</i> | <i>The teacher is a facilitator of and a learner as well; students are learners and teachers in some situations; networks emerge instead of one-way forms of communication</i> |
| <i>Limited use of technology</i>                                                                        | <i>Full integration of appropriate technology in instruction</i>                                                                                                               |
| <i>Exclusive use of pencil and paper assessment disconnected from instruction</i>                       | <i>Multidimensional assessment; assessment integrated with instruction</i>                                                                                                     |
| <i>Competitive learning</i>                                                                             | <i>Cooperative learning</i>                                                                                                                                                    |
| <i>Single exposure</i>                                                                                  | <i>Spiral curriculum</i>                                                                                                                                                       |
| <i>Many science topics covered with little depth</i>                                                    | <i>Few science topics covered with more depth</i>                                                                                                                              |

- **Integrated Science:** Science classrooms of the next decade will no longer separate subject matter by grade level. They will not dictate that all graders must take biology to the exclusion of the physical and earth/space sciences. Mathematics will become a central component of all science classes. Other school subjects will also find their place in science classes. Furthermore, science is to be part of a larger tapestry of all school subjects, especially mathematics, language arts, and social studies. This implies a need for students to think horizontally and to apply knowledge and skills in science that they have learned in other subjects. This also points to a need for teachers to work together in teams to plan and execute a curriculum based on common themes, communication, social needs, and mathematical tools. Examples include exploration of energy conversions, and what fossil fuel combustion means to our culture. Students would write about this, interview power plant employees, learn to read electric meters and calculate electric bills, examine rate structures and interview utility Boards of Directors, and study the laws of thermodynamics. A wide variety of subject matter would be explored during several days or even weeks of study. Bringing information into class discussions would be expected of each student. Students will use the Internet to discover resources and others' ideas in reaction to their own. Informal learning in museums and nature centers will enrich classroom science. Concrete, manipulative materials that exercise students' thinking in force and motion will be a prelude to later, more abstract study of friction, vectors, and Newton's laws. Seniors will be better prepared for calculus-based physics if they have been guided in exploring physics concepts in earlier grades. A good example of an integrated science curriculum is the program developed at the University of Alabama by Star Bloom and Larry Rainey for use throughout the state of Alabama [4]. This middle school curriculum consists of (a) weekly telecasts featuring scientists, students, and teachers engaging in activities that focus on the topic of the week; (b) classroom cooperative group activities emphasizing hands-on encounters with real world problems; and (c) student handbooks with additional background material that relates science to everyday events in student environments.
- **Group Learning:** The real world rarely puts people in isolation and asks them to come up with solutions without consulting others. Schools are finally moving toward cooperative learning groups in science classes. Three or four students of mixed ability are each assigned unique tasks within the team and helped to master the social skills required by these tasks. Just as athletic teams succeed when the entire team functions

well, so science learning proceeds best when each team member feels responsible for the success of both individuals and the group. Typical roles in cooperative teams include (a) the questioner, who asks what is known, what needed information is missing, how to proceed to obtain what is needed to solve the problem, and how certain the team is of its conclusions; (b) the record keeper, who maintains a written summary of what has been given, what has been acquired, graphs, tables, and preliminary conclusions; (c) the materials organizer, who sees that calculators, lab equipment, supplies are at hand and put away when they are no longer needed.

- **Assessment:** In the movie, "Apollo 13," the ground crew and astronauts were required to come up with solutions to a series of unrehearsed problems by applying science, engineering and common sense to their situation. They worked out their problems by breaking out of the mold; they could not check the "right answer" in the back of the book. Their success is a tribute to scientific problem-solving, and may represent a high water mark in technical education. There is a wealth of data to indicate that a generation of our science students are losing this ability to solve open-ended problems by inventing solutions. This points to a need to change the way we teach and learn science. Because the way we assess outcomes in science classes tends to drive the way we teach it, the classroom of the future will evaluate realistic situations that require application of science concepts, principles and theories. Assessment of student outcomes in science will be imbedded in a realistic framework so that students are not merely provided prompts and expected to pick the "best" answer from a set of multiple-choice options, or to choose the "best match" from a set of related terms, or to indicate whether a statement is true or false. In the real world, careers provide a series of inputs (givens) and require a creative application of theories and principles to derive a solution that makes sense in the context of the problem. There are not many employment opportunities for high school graduates whose problem-solving skills are limited to completing worksheets and turning them in for grading. Therefore, assessment will be imbedded in realistic situations that can be found outside the classroom. Assessment can easily be made a part of classroom activities based on realistic simulations. Students will be invited to take a more active role in determining what they know and do in science learning environments. Concept and skill self-inventories will be administered to students at the beginning of new units. In completing such inventories, students will encounter new as well as familiar terms and ideas, and see a preview of what they are expected to know at the end of the unit. Use of concept mapping, Venn diagrams, analysis of research reports, and Vee diagrams will help teachers and students evaluate science learning. Students will be expected to maintain portfolios that contain evidence of their skills, the quality of their writing, reflective thoughts on their personal strengths and weaknesses, and goals. A few states such as Vermont are already moving toward portfolio assessment for all students. While this type of assessment requires more time than machine scoring a multiple-choice test, it provides a richer record of students' abilities. It also places responsibility on students to examine their progress over time and to take pride in personal growth. New national standards and benchmarks require that students be placed in situations where they are given parameters of a problem and invited to propose solutions. Students are now expected to do more than respond to pre-written prompts on tests. The real test of America's skills is how well we can apply our knowledge of science and technology

to raw materials so that value is added and the resulting product can be sold competitively in the world market. For this question there are no answers in the back of the book!

Table 2 provides a summary of changes in assessment of science classroom learning [5].

Table 2:  
Predicted Trends in Measurement and Evaluation of Science Instruction

| <b>From</b>                                                                                | <b>To</b>                                                                                                                                                                                      |
|--------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Primarily group administered tests</i>                                                  | <i>A variety of administrative formats including large groups, small groups, and individuals.</i>                                                                                              |
| <i>Primarily pencil and paper tests</i>                                                    | <i>A variety of test formats including pictorial, laboratory performance and computer-aided tests and observations/ discussions/ interviews.</i>                                               |
| <i>Primarily end-of-course summative assessment</i>                                        | <i>A variety of pretest, diagnostic, and formative types of measurements.</i>                                                                                                                  |
| <i>Primarily measurement of low-level cognitive outcomes</i>                               | <i>Inclusion of higher level cognitive outcomes (analysis, evaluation, critical thinking).</i>                                                                                                 |
| <i>Primarily assessments of cognitive outcomes</i>                                         | <i>Inclusion of measurement of affective (attitudes, interests, and values) and psychomotor outcomes (observing, manipulating, etc.).</i>                                                      |
| <i>Primarily norm-referenced achievement testing and grading</i>                           | <i>Inclusion of more criterion-referenced assessment, mastery testing, and self and peer evaluation.</i>                                                                                       |
| <i>Primarily measurement of facts and principles of science</i>                            | <i>Inclusion of objectives related to the processes of science, the nature of science, and the interrelationship of science, technology, and society.</i>                                      |
| <i>Primarily measurement of student achievement</i>                                        | <i>Inclusion of measuring the effects of programs, curricula, and teaching techniques.</i>                                                                                                     |
| <i>Primarily teacher-made tests</i>                                                        | <i>Combined use of teacher-made tests, standardized tests, research instruments, and items from collections assembled by teachers, national and international projects, and other sources.</i> |
| <i>Primarily concerned with total test scores</i>                                          | <i>Interest in sub-test performance, item difficulty and discrimination, all aided by mechanical and computerized facilities.</i>                                                              |
| <i>Primarily a one-dimensional format of evaluation (e.g. a numerical or letter grade)</i> | <i>A multidimensional system of reporting student progress with respect to such variables as concepts, processes, laboratory procedures, classroom discussion, and problem-solving skills.</i> |
| <i>Primarily concerned with what students know or don't know</i>                           | <i>Special attention to student preconceptions, misconceptions, and alternative exploration.</i>                                                                                               |
| <i>Primarily assessing isolated bits of information or skills</i>                          | <i>Emphasis on the "whole," such as solving problems, investigation, concept maps, and embedded activities.</i>                                                                                |

|                                                                         |                                                                                                            |
|-------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|
| <i>Primarily verbal tasks</i>                                           | <i>Inclusion of tasks with data tables, graphs, charts, and sketches.</i>                                  |
| <i>Primarily tests requiring student selection or choice of answers</i> | <i>Inclusion of tests which require student performance, to include projects, reports, and portfolios.</i> |

3. The role of the New Tools

Technology will offer exciting new options for science teachers and their students. Links to high-speed microcomputers will open a wide variety of channels to meet almost every learning style. Virtual and Augmented reality is already being tested in secondary school science classrooms. Three-dimensional projections of simulated reality will become more common as tools to help students “experience” space, time and motion in controlled states. Thus, a student can simulate weightlessness, or friction-free motion, or an Earth-centered universe as easily as opening a window. Trying out these environments in virtual reality will make facilitate learning and make group and class discussions more much more interesting. Students will use personal “think-pads” to do calculations, obtain tutoring help, and keep up with schedules. Graphical display panels will be built into classroom walls, and used to show high-resolution colour video sequences that are keyed to textbooks and curricular guides. Overhead projectors will be fitted with liquid crystal display panels that connect with classroom computers to make a “dynamic chalkboard” for the classroom. Static and dynamic visuals will be available on videodisk for science teachers to use to show single- or multiple-concept topics. Three-dimensional displays will allow rich discussions of physiology, collisions in space, and molecular geometry. These displays will make it possible for science classes to take field trips to any location on the planet and examine plants and animals there.

The microcomputer-based laboratory will be expanded from its current state of monitoring temperature, light intensity, pH, and motion. To these parameters will be added new variables, such as population of humans on Earth, metabolic rate of selected students, location and direction of hurricanes, historical frequency and location of earthquakes, somatic cellular activity, solar flux onto the school, and many others. Current events will be exhibited in new ways that facilitate better understanding and learning. The science textbook will change. Universal bar codes on each page will allow students and teachers to use bar-code readers to access videodisk sequences that make each page come alive. Textbook publishers will provide computer programs to accompany each major topic. Hypertext and multimedia materials will make true self-paced learning possible for all students. Self-help features will mean that students can receive assistance without depending as much on the teacher. Role models will include all gender and ethnic groups. Each chapter will have imbedded assessment activities for individual students, small groups, and whole class testing. Toll-free numbers to publisher hot-lines will allow teachers to request customized tests over any topic from large banks of questions, many of which embody higher levels of thinking.



Figure 1: The advanced learning environments are expected to provide access to the scientific and cultural heritage resources (museums, science centres, research laboratories, collections and more) that will qualitative upgrade teaching and learning (formal and informal) in the school of the future.

In a decade or two, three complementary interfaces will shape how students learn:

- The familiar “world to the desk top” interface, providing access to distant experts and archives, enabling collaborations, mentoring relationships, and virtual communities-of-practice. This interface is evolving through initiatives such as Internet2.
- Interfaces for “ubiquitous computing” in which portable wireless devices infuse virtual resources as we move through the real world. The early stages of “augmented reality” interfaces are characterized by research on the role of “smart objects” and “intelligent contexts” in learning and doing.

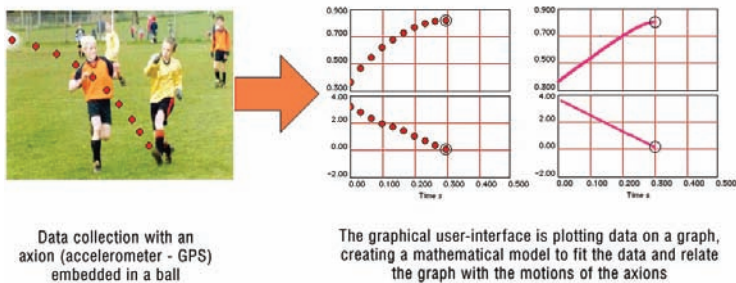


Figure 2: Lab of Tomorrow “Kick Life into classroom”: Playing with a “smart” ball with embedded sensors gathering and manipulating experimental data of real life activities. One of the most successful examples of the role of “smart objects” in science learning.

- “Alice-in-Wonderland” multi-user virtual environments interfaces, in which participants’ avatars interact with computer-based agents and digital artefacts in virtual contexts. The initial stages of studies on shared virtual environments are characterized by advances in Internet games and work in virtual reality.



Figure 3: Lab@future’s approach for teaching geometry through augmented reality applications.

#### 4. Towards the science classroom of the school of tomorrow

We should point to a future hybrid classroom that builds on the strengths of formal and informal teaching and learning strategies in ways that can support learning of all students. Our vision for the school of the future is that it will not be an island, a self-contained campus, a counter-world. The school of the future will be able to emit and absorb along different wavelengths, be immersed in contemporary culture, be open to the emotions, facts and news of its time. It will be permeated by society, but not unprotected: the relationship between school and society will be one of osmosis, where the advanced pedagogical tools filter, guide, and act as a membrane and interface. Look into a science classroom of the year 2020. Instead of seats arranged in rows and columns, you will find students sitting in a circle or in pods as they discuss whole class or small group topics. Computers will be available, equipped with modems to link the classroom with the Internet. Videodisc and videotape equipment will be used for viewing linear and random access sequences. Live animals, models, simulations, and collections of student work will be a part of the scenery. An open-door policy will invite visitors to join for observation or participation. Use of outside resources such as museums, nature centers, state and national parks will enrich the curriculum. The day will begin with teachers meeting together for team planning on how groups of students will move through the day. There will be less dependence on bells to dictate the daily schedule. Textbooks will be used as reference sources for information, but will not be the sole or even primary source. Access to electronically-stored information will be easy. Compact discs and remote databases available on the Internet will offer students and teachers current data on global and local systems. Assessment

will be ongoing, and built into small-group discussions. For a period of weeks, the whole class will deal with themes like matter and energy, force and motion, patterns and change. More emphasis will be placed on current events, with television broadcasts used to augment class discussions. Students will end the school day at different times and with less enthusiasm than in the past. Project work, team cooperation, higher levels of inquiry, and the stimulation of interactive technology will raise the motivation of students to apply science in their own cognitive world. Dinner table conversations and talk in school hallways will include more science. This will increase the scientific literacy of high school students, and contribute to our skills in the world economy. We have applied science and technology to adapt our environment. Every generation must redefine the future and relearn the values, tools, and principles that will influence it. We have the tools and the principles have not changed. It is the values that we struggle with. The scenarios above are images of plausible futures that depict how applying these interfaces might reshape teaching, learning, and the organization of educational institutions. The objective of these scenarios is not to detail blueprints of an unalterable future, but instead to show the range of possibilities enabled by emerging interactive media and the consequences-desirable and undesirable-that may flow from their application in pre-college and higher education settings. Such visions suggest decisions that researchers should make today to explore the potential of these technologies while minimizing unintended and negative outcomes of their use.

## 5. References

- [1] Mirland, 2003
- [2] National Academy of Sciences, 1994, National science education standards. Washington, DC: Author. National Education Commission on Time and Learning, 1994, Prisoners of time (Stock #065-00000640-5). Washington, DC: U.S. Government Printing Office.
- [3] Florida Department of Education, 1995, Science for all students: The Florida pre K-12 Science Curriculum Framework. (Tallahassee, FL: Author), p.37.
- [4] Bloom, S. and Rainey, L., 1994, Integrated science. Tuscaloosa, AL: University of Alabama.
- [5] Doran, R. L., Tamir, P. & Chan, A., 1995, Assessment in science. Arlington, VA: National Science Teachers Association, pp. 17-18
- [6] American Association for the Advancement of Science, 1993, Benchmarks for science literacy. New York: Oxford University Press.
- [7] Herman, J., Aschbacher, P. & Winters, L., 1992, A practical guide to alternative assessment. Alexandria, VA: Association for Supervision and Curriculum Development.
- [8] Johnson, R.T. and Johnson, D.W., 1982, What research says about student-student interaction in science classrooms. In M. B. Rowe (Ed.), Education in the 80's: Science. Washington, DC: National Education Association.
- [9] Kober, N, 1993, What we know about science teaching and learning. EdTalk, Council for Educational Development and Research, Washington, D.C. ERIC Document Retrieval Service No. ED 361 205.

- [10] McColskey, W., O'Sullivan, R., 1993, How to assess student performance in science: Going beyond multiple-choice tests. Greensboro, NC: Southeastern Regional Vision for Education.
- [11] Moshell, J.M., Hughes, C.E., 1993, Shared virtual worlds for education. In Proceedings: 4th Annual Virtual Reality Conference and Exposition. San Jose, CA.
- [12] National Science Teachers Association, 1993, Scope, sequence, & coordination: The content core. Arlington, VA: Author.
- [13] Natural Science for Youth Foundation, 1990, Natural science centers: directory. ERIC Document Retrieval Service No. ED 319 619.
- [14] Oh, Deer! [Computer software], 1983, St. Paul, MN:Minnesota Educational Computing Consortium. Rescue at Boone's Meadow [Optical media], 1992, Learning Technology Center. Warren, NJ: Optical Data Corp.
- [15] Roth, W. M., 1992, Bridging the gap between school and real life: Toward an integration of science, mathematics, and technology in the context of authentic practice. *School Science and Mathematics*, 92 (6), 307-317.
- [16] Scarnati, J. T., 1994, Interview with a wild animal: Integrating science and language arts. *Middle School Journal*, 25 (4), 3-6.
- [17] U. S. Congress, Office of Technology Assessment, 1995, Teachers and Technology: Making the Connection, OTA-EHR-616 (Washington, DC: US Government Printing Office).

## **II. Connecting Formal and Informal Learning – Methods and Tools**



## Science and Technology Learning Across the Lifespan: Connecting School, Free-Choice and Workplace Learning

---

*Lynn D. Dierking & John H. Falk,  
Institute for Learning Innovation,  
Annapolis, MD 21403, USA  
dierking@ilinet.org, falk@ilinet.org*

### Abstract

#### 1. Introduction

There is a quiet educational revolution going on worldwide. Societies are rapidly becoming nations of life-long learners supported by a vast infrastructure of learning organizations. However, the centers of this learning revolution are not the traditional educational establishments of schools and universities, but rather a vast network of organizations and media (museums, libraries, television, film, books, and increasingly the Internet), as well as the workplace ([1],[2], [3]).

Science and technology learning is an important part of this educational shift. People engage in science and technology learning every day, across their life spans—at home, at work and out in the world. As we strive to foster interest, knowledge and understanding about science and technology worldwide, we need to be aware of the vast number of ways, ages and places in which a person learns across their lifetime. For, as societies become increasingly Learning Societies, the traditional boundaries and roles that have distinguished various groups of science educators is disappearing. In the 21st Century, free-choice learning institutions such as museums, the Internet and broadcast media, as well as the work place with its increasingly dynamic and changing landscape, are assuming an ever more prominent role in providing the public with science and technology learning opportunities. All of these represent important, in fact we would suggest, essential ways that people learn and most importantly, contextualize their science knowledge and understanding throughout their lifetimes. If as science educators in the 21st Century we truly want to move beyond the rhetoric of supporting lifelong science learning, it is critical that we recognize, understand and learn how to facilitate free-choice and workplace learning as powerful vehicles for lifelong science and technology learning. This

should not be a nicety, or a supplement to the science and technology learning engaged in at school and the university, but as an equally essential component of lifelong science and technology learning. To not understand and embrace these two additional sectors as valuable players in the science and technology learning infrastructure of a community is to seriously impede our ability to enhance science learning worldwide for both school-age children and citizens of all ages.

There is a tremendous need for this shift in mind set. Although there is a great deal of discussion about improving the quality of science and technology education worldwide, the solutions suggested, either implicitly or explicitly, all seem to focus on schooling and teaching. In this changing world we would argue that we also need to recognize free-choice learning entities (museums, science centers, broadcast and print media, libraries and community-based organizations) and the workplace as important contributors to science and technology learning, playing an equally important role as schools and universities. It is also important to involve the science and technology educators choosing to “teach and facilitate” in free-choice and workplace settings as equally respected colleagues engaged in educational reform.

We and our colleagues at the Institute for Learning Innovation, a not-for-profit research institute based in Annapolis, MD, USA, with a mission of understanding, facilitating and advocating for free-choice learning, believe there is a unique opportunity to be leaders in this arena, as well as agents of change for future generations, introducing innovative models of science and technology learning to individuals, groups and society across people’s lifetimes. How can we suggest you play a leadership role in “Tomorrow’s Science and Technology Learning Society” through free-choice and workplace learning and what are the implications for the School of Tomorrow? This paper will attempt to answer those questions by focusing on the three following objectives:

- 1) Describe this learning revolution in more detail, suggesting the potential role it can play educationally in societies around the world;
- 2) Demonstrate the need for an infrastructure of education and research that supports the facilitation of all types of science and technology learning and share some initial leadership efforts; and,
- 3) Describe the implications for the School of Tomorrow and encourage you to play an advocacy role within the science and technology education community with fellow educators and researchers, and most importantly, with administrators and politicians, by more clearly identifying and describing the vast number of ways and places in which people of all ages learn about science and technology.

## **2. The Learning Revolution**

As world societies transition from being industrial to knowledge-based, learning across the lifespan becomes ever more important. Children and adults are spending more and more of their time learning, not just in classrooms, but on the job and through free-choice learning

at home, after work and on weekends. We learn continuously, from many different sources, and in many different ways. There are three main places in a society where this learning is centered—schools and universities, the workplace, and the free-choice learning sector. All three are important; all three are essential for lifelong learning.

Formal education is the centerpiece of most societies' current educational efforts. Schooling provides a foundation for the development of basic skills and introduces students to new realms of knowledge and higher education (universities, trade schools, etc.) offer opportunities for students to become specialists in a field of their choosing. But formal education alone is not sufficient to educate Tomorrow's Learning Society. After all, less than 3% of our lifetime is spent in formal instruction and children spend 85% of their waking hours outside of school, either in informal settings like museums, zoos & libraries or in everyday settings such as home [3].

In addition to schooling there is also a need for career-directed learning. The workplace is where we learn the skills and abilities necessary to do productive work, and in the process earn the income we need to sustain our lives. And adults in the workplace are increasingly learning more and more about science and technology. As workplaces continue to automate and embrace new cutting edge technologies, the ability to learn and adapt to new situations is crucial. Employers can no longer predict the skill sets they will need in their work forces, but instead are seeking staff members who are adaptable and able to learn new skills.

In turn, corporations are appreciating the role that personal growth and learning plays in supporting a self-fulfilled and creative staff. For instance, Kazuo Inamori, founder and president of Kyocera, a world leader in advanced ceramics technology, is one of a small number of organizational leaders recognizing the importance of individual and team learning. It is his belief that if his employees themselves are not motivated to grow and develop technologically, there is no way that the organization can grow intellectually, productivity-wise or develop further technologically. He teaches his employees to "look inward as they continually strive for perfection and the corporation provides a multitude of opportunities for personal and spiritual growth, even allowing meditation time during the workday.

In addition to schooling and workplace learning, there is also a need for free-choice learning, where people are provided an opportunity to explore thousands of science and technology topics, whether shallowly or deeply, occasionally or frequently, to find out more about what is useful, compelling or just plain interesting to them. Free-choice learning, learning which is guided by a person's needs and interests and which people engage in throughout their lives is one of the areas of most rapid expansion. From the birth of the Internet to the proliferation of educational programming offered by IMAX, educational television, and museums, there are more opportunities for self-directed learning than ever before, much of this science and technology-related. In a typical day, a person might surf the Internet in a local library to track down information about arthritis, attend an amateur astronomy club meeting, watch a nature documentary on television or interact with exhibitions on robotics at the local science center.

Ideally of course, these educational sectors are not isolated but fully integrated into a pervasive and accessible network for citizens of all ages, including, but not limited to, school-age children and those in the university and trade schools. To demonstrate the importance of this

network of learning resources, John Falk and colleagues at the Institute launched an investigation to help determine how, when, where and why people learn about science and technology [4]. To do this they conducted two large scale strategically sampled telephone surveys. In each study, they randomly called hundreds of Los Angeles residents (close to two thousand in all) in five representative communities in the Los Angeles area and asked them questions about their science and technology knowledge. These were average folks--some were poor, some were affluent, some had graduate degrees, some had not completed high school. Represented were young and old individuals of virtually every imaginable race, ethnicity and background. They asked these people if they were interested in science and technology--overwhelmingly they said they were. Interest in science and technology seemed to be universal, true of virtually all individuals, regardless of education, race, ethnicity or gender. They asked them if they felt they were knowledgeable in science and technology--by and large they thought they were "sort of knowledgeable." Then they asked each person to describe some area of science and/or technology in which they felt they knew more than the average person. They also asked people to tell them why they had that greater than average knowledge in this area of science and technology and from what source they acquired the knowledge.

Virtually everyone in the sample felt that there was at least one area of science and technology they had some reasonable knowledge of, a knowledge that exceeded the norm. The areas described ranged from astronomy to zoology. Some people described very specific areas of scientific knowledge such as the physics of the internal combustion engine or the physiological basis of depression; others gave more general categories of knowledge such as health or the environment. Most people claimed that the motivation behind their knowledge was simply interest and curiosity, although occasionally the motivation to learn about a topic was a personal crisis such as the need to learn about the disease of an ill relative. Professional and work-related reasons were also commonly given. Across the board, though, at some point in each individual's life, something about the science and/or technology topic they claimed a special knowledge of had piqued their curiosity. And it was this curiosity for the subject, which had primarily prompted them to continue pursuing greater knowledge and understanding of the subject. Most fascinating of all were the sources of science and technology knowledge that the public identified. Roughly a third of the people surveyed claimed to have primarily learned their favored science topic in school. Just under a quarter of the sample said they learned their science on the job, as part of their work. Approximately half of all those surveyed (the largest number of people) claimed to have learned about the science and/or technology topic during their leisure time, through some form of free-choice learning. People described learning science and technology from the Internet, reading magazines and books, going to museums, zoos and aquariums, and participating in special-interest clubs and groups. Although schooling was an important source of scientific learning for some, it was not the primary source for most. A recent study by the National Science Board supports these findings [5]. Researchers found that 50% of American adults read a daily newspaper including articles on science and technology, 15% read one or more science magazines each month and a majority of Americans watched one or more science television shows each month. Approximately two-thirds of adults visited a science center or natural history museum at least once a year and a third of Americans reported that they had purchased one or more books on science and/or technology topics during the preceding year. These studies lend tremendous support to the important role non-school sources play in sustaining lifelong learning in general and science and technology learning in particular. The data would suggest that even a traditional school subject such as science, is not exclusively, or even primarily, learned in school. Similar investigations have

been conducted to determine where the public learns history [6]. And similar to these studies of science and technology learning, it was found that the majority of Americans attributed their knowledge and understanding of history to free-choice learning sources such as family members and television or to the workplace, not to school or university.

The above is not intended as a condemnation of school-based learning. The point is merely to emphasize the fundamental role played by non-school-based learning. These studies were conducted in the United States but we would anticipate similar results globally. Each of the three educational sectors significantly contribute to the science and technology learning of the public.

### 3. Science & Technology Learning Infrastructure

Nearly a decade ago, educational evaluator Mark St. John proposed that we should rethink how we look at the entire learning enterprise, suggesting that the school and free-choice learning sectors (and we would add the work place) be considered components of a single, larger educational infrastructure [7]. He used the term infrastructure to describe the system of supports, conditions, and capacities that permit the smooth functioning of daily life. Infrastructures represent essential under-girding for a variety of activities, for example, the highway infrastructure facilitates transportation and an infrastructure of community services such as a fire and police department permits a community to function smoothly. The learning infrastructure in a community supports and facilitates the learning that takes place there. From this perspective, the learning infrastructure is vital to a nation's economic, as well as intellectual and spiritual wellbeing. The educational entities that provide citizens with current and accurate knowledge and information, whether about health, politics, economics, the arts or science, form the fundamental backbone of the knowledge economy. The explosion of the Internet and the World Wide Web provides significant testimony to the perceived value of having a readily accessible tool that can provide virtually anyone, anywhere, with any information, any time. The Web, though, is just one aspect of an ever expanding and, hopefully improving, network of learning resources available to the general public.

The science and technology learning journey of 21st Century citizens will require many way stations, each helping to fulfill part of the citizen's learning needs. What the world needs is a richly integrated, broadly supported learning infrastructure, a system of support that will enable millions of unique individuals to meet their widely varying science and technology learning needs any time of the day, at any point in their life. This basic science and technology learning infrastructure already exists, composed of schools and universities, the Internet, print and broadcast media, libraries, community-based organizations, the work place, and friends and family (see Fig. 1). Ideally all of these educational entities work together to support and sustain science learning across the life span [8].

The science and technology learning infrastructure serves as a web of influence that shapes people's understanding, attitudes, aesthetic beliefs, etc., for although schools and universities are important, so are museums and science-technology centers, electronic media, increasingly the Internet, as well as community-based organizations, libraries, the workplace and a whole host of others. The entire science and technology learning infrastructure provides value and support to any nation, and the entire infrastructure needs to be valued and supported.

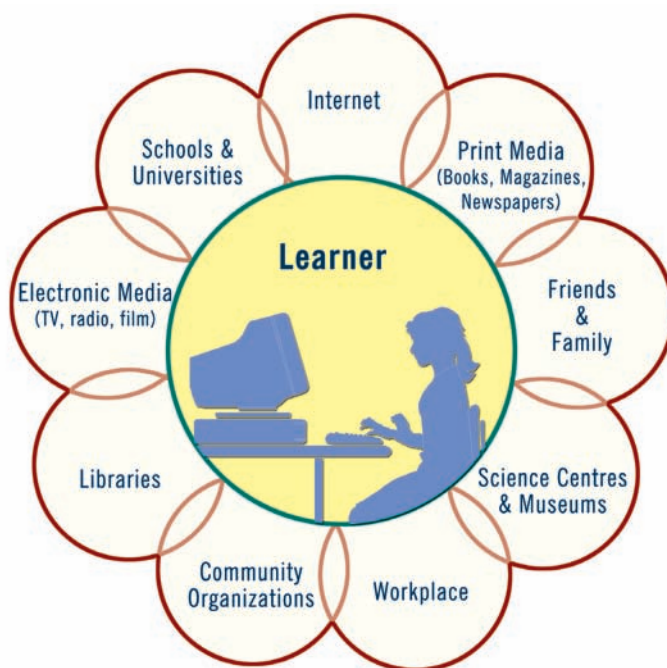


*Figure 1. Science and Technology Learning Infrastructure*

This means we look for science and technology teaching and learning in novel places. For example, the Institute is currently working with the Astronomical Society of the Pacific, based in San Francisco, CA. With our assistance, over the last ten years they have been exploring and experimenting with ways to tap into the vast resource of amateur astronomers. With funding from the National Science Foundation, they have involved these astronomers in supporting elementary and middle school teaching in classrooms through Project ASTRO and are now involved in Family ASTRO, an effort to provide fun and engaging astronomy experiences to families through the network of museums, science-technology organizations and community-based organizations such as scouts. This effort represents a creative way of brokering connections within the science & technology learning infrastructure.

#### **4. Implications for the School of Tomorrow**

So what are the implications of these ideas for the School of Tomorrow? Probably the single most important takeaway is that the School of Tomorrow can not just be about school. Although as we have said, the formal education sector--pre-K through graduate school--is vital to any nation's education, it is not, in and of itself, sufficient. A successful education system cannot be based solely upon schooling; it must also include free-choice and workplace learning also. For societies globally to fully transform into functional Learning Societies, the active involvement of all three educational sectors will be required. As long as we're all in the same vehicle, we would be well advised to drive in the same direction. There is no evidence that this is currently happening. Although many of the industrialized nations possess the educa-

tional capacity to be world leaders in twenty-first century learning, they are squandering this opportunity through lack of clarity, direction and purpose. To totally achieve the promise of a fully functioning Learning Society requires that all three sectors--formal schooling, workplace and free-choice learning sectors—are integrated fully and in synchrony. Currently, all three are alive and well, but all three are functioning largely in isolation, each driven by widely differing perceptions of what their goals and role in society should be. The good news is that the key constituents for change are already in place but the bad news is that the infrastructure is loosely connected and no one at the top seems to see how the pieces could and should become interconnected. Change will require undoing deeply ingrained beliefs and habits and must happen from the bottom up, with vision from the top down. This will not be easy.

We also need to modify the goals of our educational efforts. The focus should be on facilitating individual learners, rather than on reforming any single institution. In a Learning Society, the lifelong learning path we choose defines who we are as individuals. Each individual's learning path is unique and should be supported by a whole range of institutions and individuals over the course of a lifetime. Although there will be many institutions and individuals involved in helping someone learn, and many reasons for them doing so, some closely and others more distantly related to the individual's personal goals, ultimately, all involved in the educational process must accept one premise. The goal of all education should be individual growth and fulfillment. This goal should not be driven by the needs and interests of the institution involved in supporting that learner, whether a corporation, a school, a museum or a television station. The goal of education must always be to support the learning needs of each and every unique citizen in the society.

We also need to appreciate that each person is both a lifelong learner and an educator; as global societies we need to figure out how to support and encourage each person to be both a learner and an educator. We must learn to embrace the fact that not only is every citizen a lifelong learner, but every citizen is also a lifelong educator! Whether we are 3 or 103 years of age, each of us has much to learn, and each of us has a role in helping others to learn. For years in the United States, we have been bombarded with rhetoric about a teacher shortage but in actuality there is no teacher shortage in America. If we think about education as encompassing more than schooling, there are 285 million learners in America, and by a wonderful coincidence, there are 285 million teachers, a perfect one-to-one ratio. We need only to figure out how best to support and encourage each and every one of us to be both learners and teachers. The deficiency in the system is not the human resources, but the commitment and knowledge of how to convert our human resources into effective practice.

For example, if a parent or guardian better understood how important their interactions with their infants and young children were, and how to facilitate those interactions, more children would grow up in intellectually stimulating environments. At the present, large segments of our populations grow up deprived, not because of a lack of interest or desire on the part of their parents, but due to a lack of parental experience and knowledge about how to optimize the educational home experiences of their children. In our current system, economic disadvantage becomes perpetuated through educational disadvantage. In a transformed educational system, priority would be placed on helping each and every parent better understand their roles and abilities as their children's first and most important educators, rather than trying to compensate entirely with schooling. Every parent would be provided the support necessary to

perform these educational functions rather than made to feel inadequate, as is often currently the case and every child would not only be a learner, but also a teacher to their parents, rather than erroneously being told and shown daily that only adults have any knowledge worth communicating. The adult-child relationship is only one facet of the social and cultural context of learning. A wealth of research documents how important mentors and facilitators are in most people's lives. Sometimes that mentor is a professional educator, but often the mentor is a family member, a friend, an acquaintance, or co-worker. All of us benefit from the guidance of others when learning and ultimately, none of us can be taught anything, we can only have our learning facilitated by someone willing to share his or her knowledge and experience with us. Many of us are fortunate enough to have found a mentor in our lives, someone who has been willing to help us achieve our potential, someone who through the sharing of his/her experiences, shortens our learning journey even if only slightly. All three educational sectors should strive to increase the number of mentors and facilitators they support, ultimately trying to help each participant experience the joys of being both a learner and a teacher.

In practical terms these ideas suggest that ideally the School of Tomorrow integrates free-choice and workplace learning and allows students to meaningfully use these learning resources to accomplish their learning goals. The Smithsonian Early Education Center, housed at the National Museum of American History in Washington, D.C., U.S.A., allows children free access to the resources of the entire museum community, before and after school. In Des Moines, Iowa, also in the United States, an elementary school is located adjacent to a shopping mall and utilizes the mall and all of the downtown businesses as part of normal classroom space.

It will also be important for the School of Tomorrow to allow students themselves to have more power and ownership over what, how and where they learn. Once again, there are examples in the United States of how this can work and we are sure there are examples internationally as well (The Ellinogermaniki Agogi in Greece is one). Particularly innovative, in Albany, New York, deep within an urban neighborhood which includes some of the poorest families in the United States, one school is changing the way they think about what and how they teach. Each student in this new public elementary school is developing his or her own personal learning contract. In collaboration with their teachers and parents, each student gets to figure out not only what they want to learn, but how, in what order and in what ways, and even in many cases where best to learn. In this new model of teaching, the teacher and parents become helpful guides for a student's own personally directed learning journey. The school, as well as the community in which it is situated, becomes the vehicle for helping to launch a lifetime of learning. There is a similar system-wide pre-kindergarten to high school effort in a suburban community outside Indianapolis, Indiana, USA.

In the School of Tomorrow, adults and children in free-choice and workplace learning settings are equally respected teachers and facilitators of science & technology learning, as are the students themselves. There are also working examples in the U.S. of how to approach this goal. The high school students at The Henry Ford Museum in Dearborn, Michigan, not only use the objects and documents of the institution to learn about innovation and invention, but the students are taught by curators. In turn, the curators use the students to help with their teaching and educational jobs. The "In Their Footsteps / Senior to Senior Program" in Astoria, Oregon, pairs high school seniors with senior citizens to collect oral histories of community

elders that are then turned into multimedia programs for the public (digital videos, CD-Roms, and web sites). The high school seniors receive the benefits of the collected knowledge and wisdom of their senior partners, as well as insights into history and “on the job training” in multimedia production. Their senior partners are introduced to the latest in multimedia technology and re-introduced to history, while community elders are provided a forum in which to share their stories. All participants in the program benefit by these intergenerational exchanges. And some of the largest and most progressive companies in America such as IBM, Southwest Airlines and Hewlett Packard, not only allow, but encourage employees to volunteer their time and talents in the community, particularly in educational efforts, both in schools but in the free-choice learning sector as well.

And finally, ideally the School of Tomorrow will not just focus on school-age children. This pervasive and integrated network needs to be accessible to citizens of all ages. In Brooklyn, public school facilities are now open nearly twenty-four hours a day to allow the entire community access to educational resources concentrated there; and the public library has become a major player in both child and adult learning programs in this recently immigrant-dominated community. As we work on the CONNECT project (Designing the Laboratory of Tomorrow by using Advanced Technologies to Connect Formal and Informal (Free-Choice) Learning Environments), in addition to trying to integrate virtual field trips, museum wearables and on-line content from science centers and museums across the continent, we are trying to see if there are ways to engage the interested public in some of the activities (or to at least be able to access archived events).

In a transformed educational system, each sector would fulfil its responsibilities continuously. There would be no exclusive responsibility that schools have for the education of children, and no exclusive responsibility that the workplace has for the education of adults. Responsibility would be equally shared by all sectors, across all time. Schools would play a role in the education of adults, and yes, the workplace would play an active role in the education of children. The free-choice sector, too, would be actively integrated into the educational support of all citizens. We believe that if all three sectors truly pooled their resources, if the lines between school, work and leisure were sufficiently blurred, there would be more than sufficient capacity to provide quality learning experiences for all citizens, all of the time.

## **5. Advocating within the Science & Technology Education Community**

So what can you do to participate in this exciting movement? First we would encourage those of you involved in the international science and technology education community to play an advocacy role for this important perspective on science and technology learning. If you are involved internationally make sure that all parts of the science and technology learning infrastructure are at the table as well. Invite fellow educators and researchers in the workplace and free-choice learning sectors to participate in your international efforts. They have much to share and much to learn from you. The Institute certainly has appreciated its opportunity to collaborate on a European Union project with many of these same goals.

There is also much to do back in your own local communities. If you do not already know what is going on in the area of science & technology learning in other parts of the learning infrastructure, find out. As you develop new efforts and sustain existing ones, ensure that all the science and technology education partners are involved.

Most importantly, we need to work together to educate administrators and politicians about this broader perspective of lifelong science and technology learning. By more clearly identifying and describing the vast number of ways and places in which people of all ages learn science and technology, we stand a much greater chance of transforming education and subsequent learning to meet the demands of a changing world.

## 6. References

- [1] Falk, J.H., Dierking, L.D., 1998
  - [2] Falk, J.H., Dierking, L.D., 2001
  - [3] Falk, J.H., Dierking, L.D., 2002, *Lessons without limit: How free-choice learning is transforming education*. Walnut Creek, CA: AltaMira Press.
  - [4] Coulson, 2000; Falk, 2001
  - [5] Miller, J., 2001, The acquisition and retention of scientific information by American adults. In: J.H. Falk (Ed.) *Free-Choice science education: How people learn science outside of school*. New York: Teachers College Press.
  - [6] Rosenweig, R., Thelen, D., 1998. *The presence of the past: Popular uses of history in American life*, New, NY: Columbia University Press.
  - [7] St. John, M., Perry, D., 1993, A framework for evaluation and research: Science, infrastructure and relationships. In S. Bicknell & G. Farmelo (Eds.), *Museum visitor studies in the 90s* (pp. 59-66). London: Science Museum.
  - [8] Jonston, D.J., 1999, *Assessing the visiting public's perceptions of the outcomes of their visit to interactive science and technology centres*. Ph.D. dissertation. Curtin University of Technology.
- Falk, J. H., 2002, The contribution of free-choice learning to public understanding of science. *Interciencia*, 27(2): 123-131.
- Falk, J.H., Brooks, P., Amin, R., 2001, Investigating the long-term impact of a science center on its community: The California Science Center L.A.S.E.R. project. In: J.H. Falk (Ed.) *Free-Choice science education: How people learn science outside of school*. New York: Teachers College Press.
- Falk, J.H., Dierking, L.D., 2000, *Learning from museums: Visitor experience and the making of meaning*. Walnut Creek, CA: AltaMira Press.

## The CONNECT Project: Bridging Formal and Informal Learning in Science Education

*Eleni T. Chatzichristou, Sofoklis Sotiriou*

*Research & Development Dept., Ellinogermaniki Agogi, Athens, Greece*

*elenichatz@ea.gr, sotiriou@ea.gr*

*N. Uzunoglou, National Technical University of Athens, Greece*

*T.N.Arvanitis, D.D.Williams, Dept. of Electronic, Electrical & Comp. Engineering, Univ.*

*Birmingham, UK*

*A. Wichmann, Center for Learning and Knowledge Technologies (CeLeKT), Växjö University, Sweden*

*K. Hoeksma, University of Duisburg-Essen, Germany*

*L.D. Dierking, Institute for Learning Innovation, USA*

*H.S. Salmi, HEUREKA – The Finnish Science Center, Finland*

*A. Hoffstein, S. Rosenfeld, Weizmann Institute of Science, Israel*

### Abstract

The CONNECT project<sup>1</sup> proposes an innovative pedagogical framework that bridges formal and informal learning environments, making convergence of education and entertainment. It develops and evaluates personalized learning paradigms, which integrate contextual information into classroom settings employing highly interactive visualization, embedded systems and augmented reality (AR) techniques. The CONNECT project will evolve through a systematic, multi-step implementation and assessment process. The current paper presents the main ideas of the project and its current status<sup>2</sup>.

---

[1] The CONNECT project is co-financed by the European Community, within the framework of the Information Society Technologies (IST) priority, Sixth Framework Programme and by the National Science Foundation (NSF).

[2] The CONNECT consortium is composed by the following partners: Institute of Communication and Computer Systems (Greece), Fraunhofer Institute of Technology (Germany), INTRASOFT (Belgium), University of Duisburg (Germany), Växjö University (Sweden), University of Education Ludwigsburg (Germany), University of Birmingham (UK), Ellinogermaniki Agogi (Greece), HEUREKA (Finland), @BRISTOL (UK), Evgenides Foundation (Greece), Estonian Energy Center (Estonia), ECSITE (Belgium), Institute for Learning Innovation (USA), LEGO (Denmark), Weizman Institute of Science (Israel)

## 1. Introduction

Current research in computer-mediated learning employed in many fields of science, such as medicine [1], mathematics and geometry [2], attempt to enhance reality with synthetic information. In the context of learning, such a utilization of synthetic data can improve the learner's perspective in the understanding of complex concepts and phenomena. The concept of augmented reality (AR) [3] incorporates the use of technology applications that allow the use of 3D scenes of synthetic computer-generated objects to enhance and augment the view of the real environment [4].

The CONNECT project exploits the interactive, technological capabilities of AR and builds upon the

- Importance of visualization and of hands-on experience as vital components to the learning process
- Learning as an active process of discovery and participation based on self-motivation rather than on more passive acquaintance with facts and rules
- Collaboration and joint construction of knowledge

The CONNECT project aims at creating a learning environment, using advanced ICT, that connects informal learning strategies and formal curricular activities in science education. To do this it integrates everyday “free-choice” activities with the formal science curriculum. Furthermore, its concern is to make the shift from the teacher-directed learning and the vertical dissemination of knowledge, to learner-centred curricula that promote the development of life-long learners.

The aim of the CONNECT project is not solely to produce more scientists and technologists, but to form citizens who are scientifically literate in a world that is increasingly influenced by science and technology.

## 2. The Pillars of the CONNECT Project

The CONNECT project will run for 36 months and will be advanced through a continuous interplay between technological and pedagogical developments, following several runs of field trials.

During these trials novel educational activities will be implemented and validated in different learning environments (schools, science museums, science thematic parks).

### 2.1 Pedagogical Approach

It is well known that students are eager to learn in informal settings such as museums/science centres [5]. There are at least two reasons for that: The freedom that they enjoy when leaving the formal setting of the classroom and the positive motivation that they experience towards learning in real life settings. Taking into account these realizations, the CONNECT project has built a network of schools, science museums and science thematic parks in four countries Greece, the UK, Sweden and Finland, that will act as a pilot group and will further expand to

other countries at the end of the project.

In these settings, a series of field experiments (tangential to the curriculum) will be performed, including pre- and post-visit curricular activities. The students will follow individual pathways of learning, the teacher (rather than being the focus) helping students to work independently, co-operatively and in an increasingly self-organized way. During the field trips to the science museums/thematic parks, the CONNECT system is designed to provide 3D graphics superimposed on the students' field of vision together with other multimedia information, thus allowing to "extend" the real exhibits with virtual objects.

This is particularly powerful for visualizing complex concepts in physics that are fundamental yet imperceptible (such as electric or magnetic fields, forces, etc). To illustrate the activities for field trips, an Hierarchical Task Analysis (HTA) method is adopted, as it provides clarity and completeness in stipulating the range of tasks available to the user at specific points during the CONNECT visit experience [6].

Furthermore, the CONNECT system is designed to promote student interactivity allowing for remote classes to observe, either on-line or off-line, the activities during the visit to the science museum/park

## 2.2. Technological Approach

The Virtual Science Thematic Park (VSTP) (Fig. 1) is an advanced learning environment that

- acts as the main hub of all resources available in the CONNECT network of science museums/centers
- serves as distributor of information and organizer of educational activities
- facilitates the virtual visits and
- inter-connects the members of the network.

The VSTP comprises the CONNECT Platform and the mobile AR Unit.

The CONNECT Platform contains

- a database system for storing and retrieving the multimedia knowledge data scenarios that consist of text, images, voice and video
- the content creation and browsing tool and
- a mechanism for uploading (or selecting from the database) media objects

An application server provides connection between the platform and the mobile AR system, through wireless network.

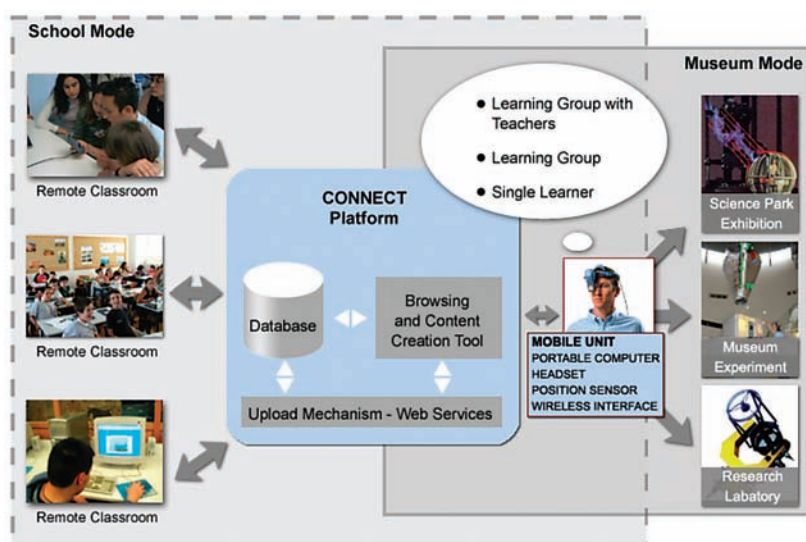


Figure 1. The Virtual Science Thematic Park

### 3. The CONNECT Project's Runs

Students and teachers will be involved in repeated cycles of tests in the framework of their normal curriculum in order to demonstrate the qualitative upgrade of science teaching and learning with the advanced learning environment that the CONNECT project introduces. For each cycle there will be a systematic evaluation of the

- usability of the integrated learning environment and its components – are user needs met?
- pedagogical approach (framework, quality of learning, ethnological study) - impact of the proposed educational approach?

#### 3.1 The Test Run

The first cycle of the pilot applications, the 'Test Run', will have a three month duration and students', teachers' and museum staff's reactions to the proposed pedagogical approach will be monitored and analysed in detail.

For the Test Run there were four exhibitions selected (one in each pilot science center):

- a) The Air Track exhibit at the Eugenides Foundation (Greece)
- b) The Air Foil exhibit at the @Bristol science center (UK)
- c) The Bio Tube exhibit at the Xperiment Huset science center (Sweden)
- d) The Hot Air Balloon exhibit at the HEUREKA science center (Finland)

### 3.1.1. The Air Track Exhibit (Eugenides Foundation, Greece)

The exhibit demonstrates a cart sliding on an air track, under the influence of an external horizontal force. It is possible to blow air through tiny holes on the surface of the airtrack reducing friction and thus facilitating the cart's motion. Carts of different mass or with different surface texture are available. Through this exhibit the students can experiment with the laws of motion, investigate the nature of the frictional forces and deduce the law of friction. The concept of friction is a national curriculum topic for primary science in most countries. The exhibit can be further incorporated in a broader thematic area of learning about the concept of force. Virtual augmentation of this exhibit includes 3D visualization of the forces acting on the cart, of the microstructure of the contact surfaces, of the airflow, interactive graphs, additional text, etc (Fig. 2).

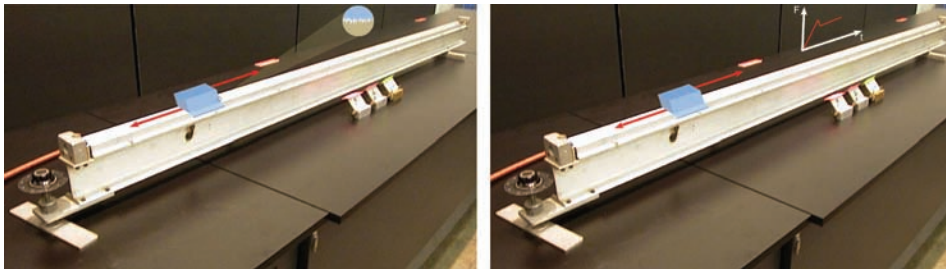


Figure 2. The Air Track exhibit. Some possibilities for augmentation are illustrated.

### 3.1.2. The Air Foil Exhibit (@Bristol, UK)

This exhibit demonstrates Bernoulli's law: for a horizontal fluid flow, an increase in the velocity of flow will result in a decrease in the static pressure; the equation describing this effect is known as Bernoulli's law. The most practical example of this is in the action of an airfoil: the shape of an airplane wing is such that air flowing over the top of the wing must travel faster than the air flowing under the wing, and so there is less pressure on the top than on the bottom, resulting in lift. The airfoil exhibit uses a simple fan that blows air across an experimental wing. The wing itself can be tilted by the visitor at different angles to the wind, this resulting in different lifts. Virtual augmentation of this exhibit includes 3D visualization of the forces acting on the wing, of the airflow, graphs, additional text, etc (Fig. 3).

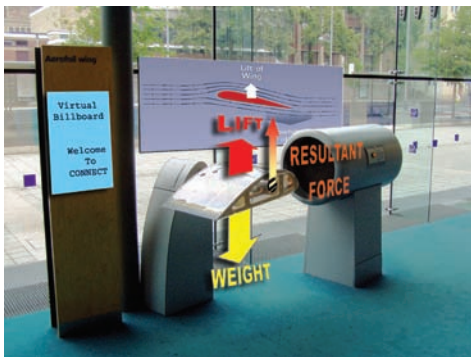


Figure 3. The Air Foil exhibit. Some possibilities for augmentation are illustrated.

3.1.3. The Bio Tube Exhibit (Xperiment Huset, Sweden)

The exhibit shows plants growing without soil in a controlled environment inside a vertical tube. The visitor can optimize conditions for plant growth by changing the parameters light intensity and humidity.

CO<sub>2</sub> and O<sub>2</sub> sensors are used as dependent variables to measure the photosynthesis rate of the plants. The Bio Tube augmentation focuses on the visualization of imperceptible phenomena within the photosynthetic process. The amounts of CO<sub>2</sub> and O<sub>2</sub> in the air are represented as dots within the Tube. In addition arrows will indicate the CO<sub>2</sub> intake when photosynthesis takes place (Fig. 4).



Figure 4. The Bio Tube exhibit.  
Some possibilities for augmentation are illustrated.

3.1.2. The Hot Air Balloon Exhibit (HEUREKA, Finland)



The exhibit shows a balloon that uses heated air to provide buoyancy and thus rise. Since warm air is less dense and thus lighter (it has expanded and occupies more space) than cool air, the difference between the weight of the hot air and of the cold air that it displaced, is what pushes the balloon up. Augmentation of this exhibit includes visualization of the forces acting on the balloon, graphs, additional texts, etc (Fig. 5).

Figure 5: The Hot Air Balloon exhibit.  
Some possibilities for augmentation are illustrated.

### 3.2 The Final Run

With the experience gained during the Test Run and after the appropriate modifications for improvement and optimization of the educational tools, of the augmented reality hardware (tracking system, personal displays), of the CONNECT platform and of the didactical approach, the project will be implemented in real environments during a second five-month cycle, the first phase of the Final Run. This phase will be performed with scenarios that will be developed by the project's pedagogical team, similarly as in the Test Run. After the final improvements of the system are installed, the second phase of the Final Run will take place. During this final phase, the teachers and museum staff will collaborate in order to create their own pathways and to make the most of the field trips, motivating their students. It is hoped that at the end of these three-phase Runs the students will have adopted a scientific method, designing and conducting their own scientific experiments, collecting and displaying their data, and writing reports of their results.

Ultimately, a greater number of science centres and schools will join the virtual science thematic park in order for a pan-European network to be created and for the CONNECT approach to be validated.

More information is available at the web site of the CONNECT project (Fig. 6).



Figure 6. The web site of the CONNECT project:  
<http://www.connect-project.net>

## 4. References

- [1] Tang, S.L., et al., 1998, Augmented reality systems for medical applications. IEEE Eng. Med. Biol. Mag. 17, pp. 49–58.
- [2] Kaufmann, H., Schmalstieg, D., 2003, Mathematics and geometry education with collaborative augmented reality. Computers & Graphics, 27, pp. 339–345
- [3] Argotti, Y., et al., 2002, Dynamic superimposition of synthetic objects on rigid and simple-deformable real objects. Computers & Graphics, 26, pp. 919–930

- [4] Azuma, R., 1997, A Survey of Augmented Reality. *Presence: Teleoperators and Virtual Environments*, 6(4): 355-385.
- [5] Salmi, H., 2003, Science centres as learning laboratories: experiences of Heureka, the Finnish Science Centre. In: Subramaniam, R (ed.): *International Journal of Technology Management* 2003 – Vol. 25, No. 5 pp. 460-476.
- [6] Shepherd A., 2001, *Hierarchical Task Analysis*. London: Taylor & Francis; 2001.

### **III. Shaping the School of Tomorrow**



## Media Assisted Learning Evaluation Strategy in CONNECT

---

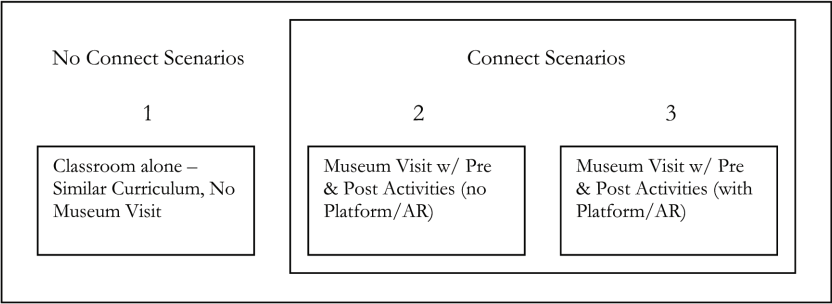
F. X. Bogner  
*Zentrum für Math-Naturwiss. Unterricht (Z-MNU)*  
*Universität Bayreuth, Germany*  
*Franz.Bogner@uni-bayreuth.de*  
*and the CONNECT-WP9-team*

### Abstract

The CONNECT evaluation approach addresses two main issues. The first one tackles the (potential) added value of the specific CONNECT technology itself, particularly the platform and augmented reality (AR). This includes the challenge whether a field trip experience provides better results with regard to its linkage of classrooms and science centres when the are supported by the specific (augmented) internet platform compared to one without such an advanced technology. The second issue contends with the (potential) added value for teachers and students when following the specific CONNECT scenario (and if, under what circumstances).

### 1. Introduction

A quasi-experimental approach is designed to find answers to these issues providing three different treatment groups: One sample of classes will be taught with the selected content without any museum visit (control group). Another one consists of classes visiting the museum and completing pre- and post-visit activities without any CONNECT technology (the platform & AR). Finally, a third sample is visiting the museum and completing pre- and post-visit activities by making use of the CONNECT technology (the platform & AR).



The evaluation approach includes **quantitative** and **qualitative** aspects as well. The quantitative survey concentrates on monitoring (i) cognitive effects, (ii) attitudinal variables (e.g. towards field trips and museums) and (iii) motivational variables as well. Although the CONNECT survey still is on the planning stage, related studies may provide suitable information about the potential of learning impacts due to ICT approaches in a lab or a classroom. For instance, an instruction within the educational ICT-program “Life in Winter” (which lasts for 4-6 school hours) provides a significant shift within the assessment scores of the participating pupils.

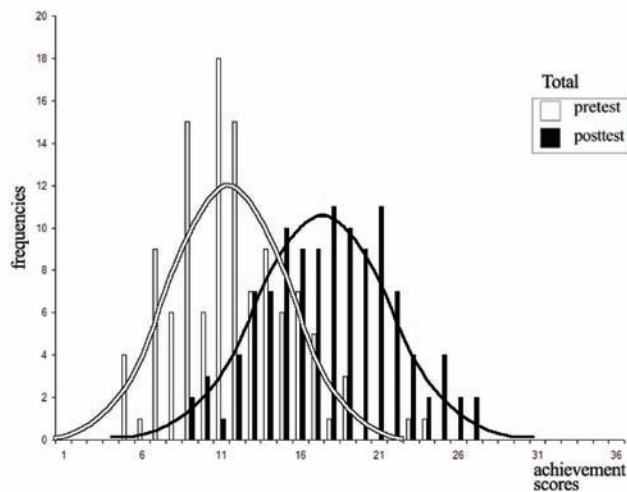


Figure 1: Pattern of cognitive scoring in pre- and post-test surveying the pupils' learning outcome

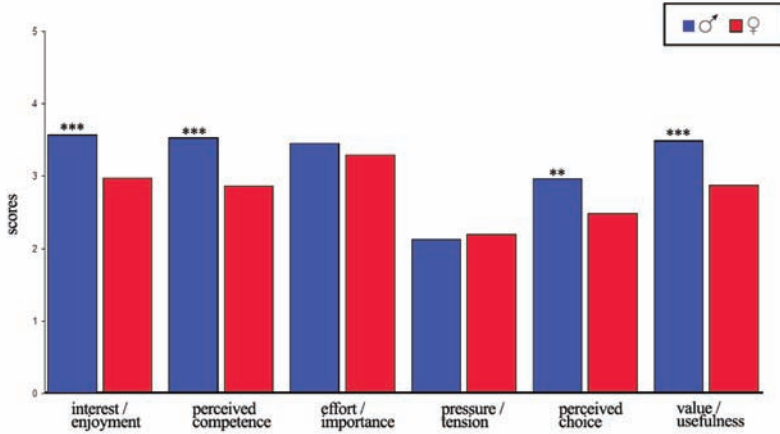


Figure 2: Gender specific scoring pattern with regard to the 6 motivational dimensions of the Deci&Ryan inventory [1].

Similarly, the application of Intrinsic Motivation Inventory (IMI, [2]) specifically surveys six dimensions which validity and reliability has been proven to the selected age group of pupils, too: Interest/Enjoyment, Perceived Competence, Perceived Choice and Value/Usefulness detailed a gender specific pattern while Effort/Importance and Pressure/Tension did not. Salmi [3] found that school students having intrinsic motivation gained both better cognitive results and tended to apply deep-learning strategies in the learning process.

## 2. Results & Discussion

CONNECT evaluation which is due to be applied soon, our survey will additionally consist of items covering the understanding of the exhibit, for instance, by identifying the focus of students observations, their understanding the meaning of AR visualizations or their understanding of the over-all exhibit. Additionally, the survey includes the pupils' usage of the knowledge acquired in a different context (explaining or relating to different phenomena). The simple way of thinking will be traced by raising hypotheses or planning a simple experiment. However, we have to take care of avoiding overloading our evaluation survey by monitoring too many variables (our participants will be adolescents).

The qualitative survey will include an observation, video analysis, interviews, focus groups, open-ended questionnaires (e.g. [4]).

In general, there are two primary audiences to be monitored which are teachers and students as well. The teacher's attitudes towards the visited exhibit, their motivation and post-grading of the visit can only be assessed in a more qualitative way, just because of low sample sizes.

Teachers

| What assessed?        | Methodology   | Instrument | When               |
|-----------------------|---------------|------------|--------------------|
| Attitudes             | Questionnaire | [15 items] | All Testing Runs   |
| Motivation            | Questionnaire | [30 items] | All Testing Runs   |
| Postgrading the visit | Questionnaire | [1 item]   | All Testing Runs   |
| Feedback by teacher   | Questionnaire | [1o item]  | All Testing Runs   |
| Overall change        | Focus Groups  | Interview  | Testing Runs 1 & 3 |

Students

| What assessed?        | Methodology   | Instruments                     | When             |
|-----------------------|---------------|---------------------------------|------------------|
| Background variables  | Questionnaire | [25 items]                      | All Testing Runs |
| Cognitive assessment  | Questionnaire | [25 items]<br>exhibit dependent | All Testing Runs |
| Attitudes             | Questionnaire | [15 items]                      | All Testing Runs |
| Motivation            | Questionnaire | [30 items]                      | All Testing Runs |
| Postgrading the visit | Questionnaire | 1 item                          | All Testing Runs |
| Overall change        | Portfolios    |                                 | All testing runs |

The evaluation of both, the technological and pedagogical pathway, will take place in a formative and summative form. The formative evaluation is more complex and it will be completed within a “test run” where various aspects of instructional materials will be surveyed. The purpose of formative evaluation is to validate or ensure that the goals of the instruction are being achieved and to improve the instruction, if necessary, by means of identification and subsequent remediation of problematic aspects [5]. Giving an example: if learning materials for third graders has to be designed, a third grader should be part of any Formative Evaluation. The summative evaluation provides information on the product’s efficacy (i.e. its ability to do what it was designed to do). For example, did the learners learn what they were supposed to learn after participating in an instruction. In a sense, it should provide information about “how a learner did” and by extracting this information the quality an educational “product” may be assessed, too.

Summative evaluations typically are quantitative approaches by using numeric scores or grades to assess learner achievements.

Our Evaluation Phase will be completed during the first and second test runs in 2005 given the assumptions that the AR system is fully operational at all four sites. Scenarios have undergone further development and refinement. After refinement the instruments will apply in the final run for a total of 10 teachers and about 800 students per site. Local museum staffs will assist with data collection. We have to take care of the language barriers. We will assess the system for mainly three target groups: teachers, students, and museum staff. For sure, the upcoming year will become a busy year for the CONNECT’ scenario.

### 3. References

- [1] Girwidz, R., Robitzko, R., Schaal, S., Bogner, F.X., 2004, Media assisted learning in the subject integrative learning unit "Life in Winter". (manuscript).
- [2] Deci, E.L., Ryan, R.M., 2000, The "What" and "Why" of Goal Pursuits: Human Needs and the Self-Determination of Behavior. *Psychological Inquiry*, 11/7, 227-268.
- [3] Salmi, H., 2003, Science centres as learning laboratories: experiences of Heureka, the Finnish Science Centre. *International Journal of Technology Management*, 25/5, 460-475.
- [4] Hofstein, A. & Rosenfeld, S., 1996, Bridging the Gap between Formal and Informal Science Learning. *Studies in Science Education*, 28, 87-112.
- [5] Weston, C., McAlpin, L. & Bordonaro, T., 1995, A model for understanding formative evaluation in instructional design. *Educational Technology Research and Development*, 43/3, 29-46.



## **Dancing with the Muses: How Educational Technology might Help Bridge the Gap between Formal and Informal Science Learning**

---

*Sherman Rosenfeld  
Davidson Institute of Science Education,  
Weizmann Institute of Science,  
Rehovot, Israel  
ntsber@weizmann.ac.il*

### **Abstract**

Until recently, formal and informal science learning were considered as being quite different. Each approach was developed by different communities of practice which were relatively isolated from each other. Today, the divisions between these two approaches are blurred, largely due to the impact of information technologies but also due to educational research, which shows that both approaches are based on the same principles of learning. Today, there is a growing recognition that science learning can be advanced by bridging the gap between formal and informal science learning.

How might information technologies help bridge this gap?

The “gap” metaphor suggests these technologies might act as “bridges”, to help transport educational tools and resources in both directions, between different communities of practice. But members of the “receiving communities” should be involved as co-designers. This perspective is illustrated by two examples: (a) an intranet software environment for Project-Based Learning, (“The Golden Way”) and (b) a dynamic web-based collection of science museum resources, geared to formal science standards (“The Bay Area Museum Collaboratory”). These examples illustrate the importance of combining technological and social design, so that technology continuously evolves to fit teacher and student needs.

## 1. Introduction: Metaphors We Live By

Because learning is so integral to being human, we often seem to take it for granted. Lakoff and Johnson [1] suggest that our thoughts and actions are governed by our own metaphors, of which we are unaware. For example, most of us unconsciously regard arguments in terms of war. As they write, our everyday language is colored with this unconscious metaphor (e.g., “Your claims are indefensible”. “His criticisms were right on target”). If it is true that “metaphor is as much a part of our functioning as our sense of touch, and as precious”, then perhaps we should ask ourselves: “What are our metaphors of learning and teaching? About the process of developing technologies to promote learning and teaching?

One metaphor is connected to Greek myths surrounding the Muses, daughters of Zeus who presided over the arts and sciences. People who were engaged in these pursuits often sought the inspiration of the Muses in special shrines called “mouseion”, the basis of the modern word for “museum”. I suggest that we think of learning and teaching, as well as the process of developing technologies to promote learning and teaching, in terms of dancing with the Muses. (See Fig. 1) [2]

I will use another metaphor when discussing informal and formal science education: bridging the gap. [3] These two metaphors dancing with the Muses and bridging the gap will help guide the central argument of this paper.



*Fig. 1. Apollo Dancing with the Muses*

## 2. A Tale of Two Learning Cultures

**1. Background.** In the past, science learning was characterized as taking place in two different contexts: formal and informal. Even the terms positioned these “two cultures” as opposite from each other. Formal learning took place in schools; it was compulsory, structured, teacher-led, teacher-centered, with fewer unintended outcomes and focused on solitary work. Informal learning took place in places like museums; it was voluntary, unstructured, learner-led, learner-centered, with many unintended outcomes, and focused on social intercourse. [4]

Moreover, these two cultures, on the whole, were isolated from each other. A different “community of practice” was connected with each culture. Curriculum and research efforts in formal science learning were guided by academic institutions and Departments of Education, while efforts to promote informal science learning environments were undertaken by different people – museum curators and volunteer staff [5]. These two communities of practice rarely interacted with each other; their concerns seemed to be different, they participated in different conferences and published their educational research in different journals.

**2. A New Reality.** This remarkable isolation is no longer the norm. Informal science education is now a “mainstream topic” within the mainstream science education community, at least in the United States and U.K. Research articles on “free-choice learning” are common in journals that once refused to publish them. [6] Organizations to connect informal science learning environments with schools exist in the U.S. and Europe. [7] In short, the “dichotomy” approach, presented above, has given way to a “hybrid” approach, in which formal learning contexts (such as schools) are encouraged to adopt informal learning methods (such as free-choice exploration).

A major reason why the distinctions between formal and informal learning have become blurred is because of the advances of information technology, especially computer-mediated communications, and modern society’s shift from an industrial-based to a knowledge-based society. [8]-[9]. Also, educational research shows that both formal and informal learning are based on the same principles of learning, and that both learning contexts can include a variety of learning methods. For example, it is increasingly clear that school learning needs to be based on “learner-centered” environments, i.e., “environments that pay careful attention to the knowledge, skills, attitudes and beliefs that learners bring to the educational setting. [10] However, while informal learning experiences can enrich school science, we have a poor idea about how these experiences can best be integrated into the (school) curriculum. [3]

How might educational technology can help “bridge the gap” between formal and informal learning environments? The “gap” metaphor suggests these technologies might act as “bridges”, to help transport educational tools and resources in both directions, between what are still different communities of practice. But who should design these bridges and determine their criteria of success? My perspective is that the “receiving communities” should be involved in the “bridge-building” efforts, as co-designers. In the following paragraphs, I present two examples of such efforts.

**3. The Golden Way.** Project-Based Learning (PBL) in Science and Technology is a teaching and learning approach which has been developed and implemented in Israeli schools for the past 14 years at the Weizmann Institute. [11]-[13]. Its goal is to incorporate students “free-choice learning” into the formal science and technology curriculum, using PBL. In order to guide teachers and their 7th-12th grade students in this approach, a networked software environment was developed, called “The Golden Way”, which included detailed. [14] Using the metaphor of a “guided journey”, which students undertake with subject-matter topics of their choice, the software was designed to provide specific pedagogical guidance (see Fig. 2).

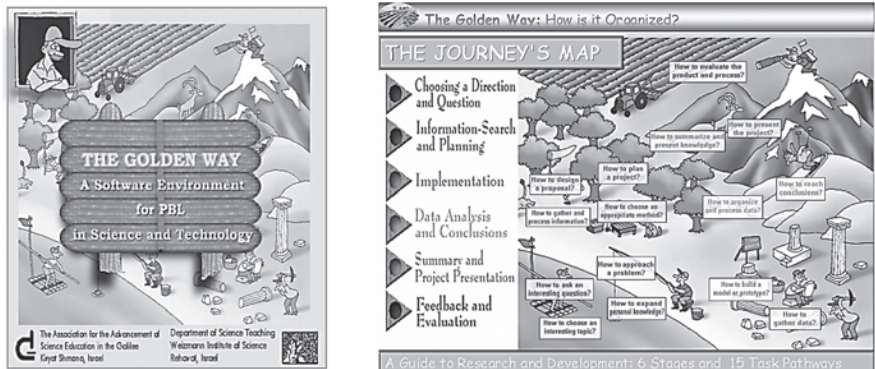


Fig. 2. The Golden Way software environment. The “Journey’s Map” has 6 common stages and 15 “task pathways.” Each pathway presents tasks, examples of student products and guidance. The software was co-designed by a community of practice to support its shared PBL practices.

The software was pilot-tested and co-designed with practicing PBL teachers over several trials, spanning a number of years. Each revision reflected an improved user interface and more effective student activities. Participating teachers from about 50 schools communicate with each other online and via regular conferences. This community of practice makes it possible for the teachers to distribute and learn about “best practices” while participating in the co-design of new PBL activities and software applications.

**4. The Bay Area Science Education Collaboratory.** How might science museum resources be aligned to the science standards and effectively used by practicing teachers in their schools? This question catalyzed an ambitious effort to make accessible the online and physical resources of 6 San Francisco Bay Area science museums, including the Exploratorium, to 6th grade science teachers. The resulting dynamic website is being co-designed and used by an “online design and learning community” of 6th grade teachers (Fig. 3). This community of practice engages in professional development on three levels: as consumers/users, as resource contributors and as coaches/editors. [15]

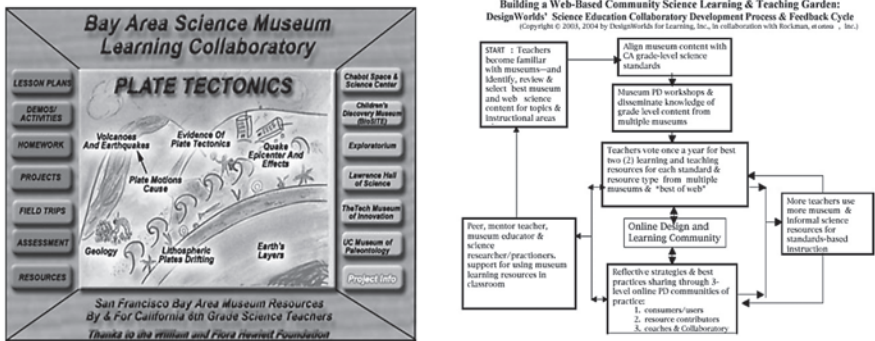


Fig. 3. The Bay Area Science Education Collaboratory. This web-based resource is being co-designed by a community of teachers, in a professional development program.

An evaluation of this project showed that the participating teachers increased their use of museum web services in the design of their classroom teaching. [16]

### 3. Conclusions

These examples illustrate how information technology can help bridge the gap between formal and informal science learning. Note that each technology (networked software and a dynamic web-based resource, respectively) brings “free-choice learning” into the formal classroom. Each technology serves as a “bridge” for connecting two (once separate, now overlapping) communities of practice.

It is crucial to recognize the role that “participatory design” played in the design of these technologies, both used as integral parts of professional development programs. In the former case, practicing 7th-12th grade PBL teachers were engaged in co-designing the software and its implementation in their schools. In the latter case, practicing 6th-grade teachers were engaged in co-designing the web-based resource they use in their classrooms.

Each product resulted from combining technological and social design, so that the technology continuously evolved to fit teacher and student needs.

It is also necessary to note the limitations of these examples, in order to avoid the common pitfalls of educational technology. [17] For example, in each case the “participatory design” of the teachers worked well during the professional development framework, when outside experts were involved. But when the teachers were “on their own”, without outside support, their use of these technologies dropped significantly.

Nonetheless, these examples illustrate the importance of linking participatory design with the evolution of technological tools. In effect, these examples illustrate how diverse individuals -- teachers, museum professionals, students, research scientists, subject-matter experts, software designers and the like -- can be linked together as co-creators, “dancing with the Muses” in the process of learning. In this dance, sometimes one gains inspiration from others and sometimes one gives inspiration to others. A community of practice engages in the creation of a technology to help reinforce its own shared practices, and the technology enhances the community’s practice, so that both the community and the technology co-evolve over time. [18]

### 4. References and Notes

- [1] Lakoff, G. , Johnson, M., 1980, *Metaphors We Live by*. Chicago: University of Chicago Press.
- [2] There are many other possibilities. For example, see “Learning Metaphors” by Lawley and Thompkins. <http://www.devco.demon.co.uk/LearningMetaphors.html>
- [3] Hofstein, A., Rosenfeld, S., 1996, “Bridging the Gap Between Formal and Informal Science Learning”. *Studies in Science Education*, 28:87-112.

- [4] Modified from Wellington, J., 1990, "Formal and Informal Learning in Science: the Role of the Interactive Science Centers", *Physics Education*, 25. 247-252.
- [5] Historically, the function of public education in museums, zoos and aquaria, (for school groups and the casual visitor) evolved relatively late, after the function of collecting and conserving the collections.
- [6] It is worth noting the important role played by John Falk, Lynn Dierking and their colleagues from the Institute of Learning Innovations, in this development.
- [7] CILS (the Center for Informal Learning in Schools) is an NSF-funded organization in the US. An European counterpart (PENCIL) has just been formed.
- [8] For an excellent discussion of how the Knowledge Age will continue to affect education, see: Trilling, B., Hood, P., 1999, "Learning, Technology and Education Reform in the Knowledge Age, or, 'We're Wired, Webbed, and Windowed, Now What?'" *Educational Technology*, May-June, pp. 5-18.
- [9] Stewart, T.A., 1997, *Intellectual Capital: The New Wealth of Organizations*. N.Y.: Doubleday. Stewart quotes 1991 as the year when U.S. spending for information technology (computers and telecommunications hardware and software) was greater than its spending for Industrial Age capital goods: 1991. He calls this Year One of the Knowledge Age.
- [10] Bransford, J., Brown, A., Cocking, R., 1999, (Eds) *How People Learn: Brain, Mind, Experience and School*. Washington: National Academy of Sciences.
- [11] Rosenfeld, S., Ben-Hur, Y., 2001, "Project-Based Learning (PBL) in Science and Technology: A Case Study of Professional Development." In Valanides, N. (Ed), *Science and Technology Education: Preparing Future Citizens: Proceedings of the 1st IOSTE Symposium in Southern Europe*. Paralimni, Cyprus.
- [12] Rosenfeld, S., Loria, Y., Scherz, Z., Eylon, B., 1999, "An 'Interlocking Loops' Model to Support Teacher Development and School Change in Project-Based Learning." *Proceedings of the European Association of Research on Learning and Instruction (EARLI)*. University of Gothenburg, Sweden.
- [13] For educational and activities relating to PBL, see [www.PBLnet.org](http://www.PBLnet.org)
- [14] Loria, Y., Shaltiel, L., Pieterse, E., Rosenfeld, S., 1999, "The Development of Software to Support Teachers and their Students in PBL: 'The Golden Way'." *Conference Proceedings of the European Association of Research on Learning and Instruction (EARLI)*. University of Gothenburg, Sweden.
- [15] DesignWorlds for Learning, "Bay Area Science Education Collaboratory".  
[http://www.designworlds.com/Hewlett/BA\\_ScienceCollab/index.html](http://www.designworlds.com/Hewlett/BA_ScienceCollab/index.html)
- [16] Kahn, T. and Rockman, S., 2003, *Bay Area Science Education Collaboratory Project: Final Report*. See "Links" on website listed in [14].
- [17] Cuban, L., 1986, *Teachers and Machines: The Classroom Use of Technology Since 1920*. N.Y., Teachers College Press.

- [18] One of the most significant questions, in this collective work, is how to guide people from different disciplines (each having different priorities, thinking styles and values) to cooperate effectively. An excellent treatment of this problem (with practical solutions) can be found in: Kim, S. "Interdisciplinary Cooperation".
- In Laurel, B. (Ed.) *The Art of Human-Computer Interface Design* N.Y.: Addison-Wesley, pp. 31-44.

## **5. Acknowledgements**

The author would like to thank Ted Kahn for discussions on an earlier draft of this paper.



## LeActiveMath: Personalization, Motivation and Tutorial Dialogue

---

*Erica Melis*  
*German Research Institute for Artificial Intelligence D-66123 Saarbrücken,*  
*Germany melis@dfki.de*

### Abstract

LeActiveMath is an ambitious research project that starts with cutting-edge technology and knowledge representation the partners have developed. Several tools and components, including natural language facilities, are being developed, integrated, and tested in one system. They take advantage of the semantic knowledge representation. They are and will be motivated by pedagogical and cognitive results. In particular, the system diagnoses and reacts to the learner's motivation and supports the learner's initiative.

### 1. Introduction

LeActiveMath is the Specific Targeted Research Project in the 6th Framework Programme-Priority "Information Society Technologies", key action Technology-Enhanced eLearning in call FP6/2002/IST/1. This project is coordinated by the German Research Center for Artificial Intelligence.

LeActiveMath builds on the eLearning environment ActiveMath [1] which resulted from research and development at the University of Saarland and at the German Research Center for Artificial Intelligence (DFKI). This system already generates courses providing some user-adaptability, i.e., these courses depend on the learner's goals, their level of mastery of the subject, and a set of individual user preferences. By exploiting this information the pace of learning, the level of detail, the way of presenting the content, the presentation format, and the number and difficulty of examples and exercises is personalized for the individual learner.

LeActiveMath will deliver an innovative web-based intelligent e-Learning system for math-

ematics that will be used in high school and college or university level classrooms as well as for self study. Its objectives have been stimulated by the experience of using ActiveMath in reality and by results from cognitive psychology research results.

The value added compared to previous systems is due to

- intelligent feedback and tutorial dialogues
- integrated interactive tools that understand the semantics of learning objects
- pedagogically grounded elements and strategies
- reaction to the student's motivational and emotional state
- advanced personalization
- open, inspectable student model
- accessible exercise repository
- free non-commercial usage

From a more specific technological point of view there is more added value because of

- a truly open and distributed architecture with one student model
- reusability of single components and tools
- integration in one configurable system
- innovative semantic knowledge representation and integrated tools using it.

## 2. Personalization/Adaptation

From the general experience and our own usage of ActiveMath we conclude that learning scenarios and suggestions as well as tutorial strategies have to be based on empirical data as well as on pedagogical theories. Therefore, AI-researchers and pedagogists collaborate to formalize and implement a problem-based learning scenario as well as other 'valid' scenarios and strategies.

The handling of competencies and competency levels as, e.g., employed in the PISA studies [2], will enable the system to provide examples and exercises at an appropriate yet challenging level to the individual student [ 3] .

The fact that a wide range of representations should be familiar to a student led us to implement the availability of different flavours of a learning object for a learner.

Other dimensions of adaptability and personalization are

- the individual local feedback that is given in exercises together with a choice of tutorial strategies again, depending on the learner
- the individual global suggestions that can be made for the student's learning [4]

The trends in the history of tutoring systems point the way to the third generation of tutoring systems like LeActiveMath. These trends include

- (1) a large the amount of computation of the system. While first-generation tutors simply retrieve and display stored data, second-generation systems have some form of student modelling. Third-generation tutors will plan tutorial actions, do plan revision and natural language processing as well as support increased learner-responsibility and extended student modelling.
- (2) The bandwidth of the user interface is increasing, i.e., the variety of response that the tutoring system can handle is increasing. Therefore, complex interactive learning (with stronger back-engines) can be included and can respond to the student's activities.
- (3) The pedagogical theories underlying tutoring systems are becoming increasingly constructive, which mirrors a general trend toward constructivism in learning theory. That is, students are being asked to derive or induce knowledge rather than just remember what they are told. The systems engage the student in extended tutorial exchanges and interact with the student on the basis of cognitive models of the student and the student's ongoing activity.
- (4) The systems will employ the semantics of the domain objects in order to be interoperable and to 'understand' the content of exercises etc.
- (5) The different paradigms rely upon different paradigms of learning and pedagogy and seem to measure progress differently. As one result, e.g., third-generation systems will more often provide an open student model (inspectable and modifiable for certain students).

### 3. Motivation

It is well known that emotional and motivational influence learning a great deal. LeActiveMath's research investigates the use of a range of factors for student modelling relating to affect, attitude, motivation and to the student's goals, context, personality. LeActiveMath will pioneer a first representation of the motivational and emotional state in the learner model and try to conclude reactions for the scaffolding of the learner, in particular in dialogues for problem solving. The theory that is taken to base the implementation on stresses the role of autonomy and approval [5] for the learner's motivation. Other dimensions of motivation and emotion will be investigated later in the project.

### 4. Tutorial Dialogues and Feedback

Several empirical investigations proved that human-human tutorial dialogues improve learning results. There is great benefit to be gained from integrating dialogue theories and dialogue system technology that have been developed in the computational linguistics community with the wealth of knowledge about student learning and tutoring strategies that has been built up in the ITS community. The tutorial dialogues and other dialogue-based learning interactions

planned in LeActiveMath have not been developed yet in any other project.

Therefore, several attempts have been made to include written natural language tutorial dialogues into intelligent tutoring systems. For instance, recent work at Edinburgh University (BEETLE) [6]) integrates principled and flexible dialogue management based on the “Information State Update” approach of TRINDI [7] and planning of multi-turn tutorial dialogue strategies, in the domain of basic electricity and electronics. Based on this experience, tutorial dialogues for mathematics (derivatives) are being developed in LeActiveMath.

## 5. Conclusion

There are many more aspects that will all be integrated into the learning environment LeActiveMath, among them:

- interactive concept map tool with feedback based on CoolModes [8]
- multi-functional dictionary
- several service systems
- open learner model, more fine grained learner model and learner history
- intelligent feedback in interactive exercises
- usage of competency levels to determine pedagogically appropriate requests
- a moderate constructivist approach to maths learning.

Multidisciplinary research characterizes the work in LeActiveMath. The pedagogists contribute their notion of competencies and competency levels which in turn has to be modelled and operationalized for learner modelling and suggestion generation, two technologies that heavily rely on artificial intelligence research. Similarly, metadata definition from the semantic Web research have to be used for course planning, tutorial strategies and reuse of material which, in turn, will themselves be based on pedagogical and cognitive theories and results.

Some of the research areas involved are intelligent tutoring systems, adaptive hypermedia, user modelling, web technology, computational linguistics, automated reasoning, machine learning, computer algebra systems.

## 6. Acknowledgement

This publication is partly a result of work in the context of the LeActiveMath project, funded under the 6th Framework Program of the European Community – (Contract IST-2003-507826). The author is solely responsible for its content. The European Community is not responsible for any use that might be made of information appearing therein.

## 7. References

- [1] Melis, E., Andrès, E., Bündenbender, J., Frischauf, A., Goguadze, G., Libbrecht, P., Pollet, M., Ullrich, C., 2001, ActiveMath: A generic and adaptive web-based learning environment. *International Journal of Artificial Intelligence in Education*, 1002(4):385–407.
- [2] Deutsches PISA-Konsortium, 2001, PISA 2000: Basiskompetenzen von Schülerinnen und Schülern im internationalen Vergleich. Leske + Budrich.
- [3] Klieme, E., Avenarius, H., Blum, W., Döbrich, P., Gruber, H., Prenzel, M., Reiss, Riquarts, K., Rost, J., Tenorth, H.-E., Vollmer, J., 2003, Zur Entwicklung nationaler Bildungsstandards. Eine Expertise, [www.dipf.de/aktuelles/expertise\\_bildungsstandards.pdf](http://www.dipf.de/aktuelles/expertise_bildungsstandards.pdf)
- [4] Melis, E., Andres, E., 2004, Global feedback in ActiveMath. *International Journal of Computers in Mathematics and Science Teaching*, accepted.
- [5] De Vicente, A., Pain, H., 2002, Informing the detection of the students' motivational state: An empirical study. In S. Cerri, G. Gouaderes, and F. Paraguacu, editors, *Proceedings of ITS 2002, 6th International Conference on Intelligent Tutoring Systems*, pages 933–943. Springer, Biarritz, France.
- [6] Zinn, Claus, Moore, Johanna D., Core, Marc G., 2002, A 3-tier planning architecture for managing tutorial dialogue. In *Proceedings of the 6th International Conference in Intelligent Tutoring Systems (ITS2002)*, Biarritz, France, *Lecture Notes in Computer Science*. Springer-Verlag.
- [7] Lewin, Ian, Rupp, C.J., Hieronymus, Jim, Milward, David, Larsson, Staffan, Berman, A., 2000, Siridis system architecture and interface report (baseline). Technical report, Siridis Deliverable D6.1, July 2000
- [8] Pinkwart, N., 2003, A plug-in architecture for graph based collaborative modeling systems.  
In H.U. Hoppe, M.F. Verdejo, and J. Kay, editors, *Shaping the Future through Intelligent Technologies. Proceedings of the 11th Conference on Artificial Intelligence in Education*, pages 535–536. IOS Press.



## The Lab@Future Project “E-Laboratories Collaboration Platform”

---

*Dr. Costas Davarakis  
Systema Technologies S.A.,  
Athens, Greece  
costas@systema.gr*

### **Abstract**

This paper presents Lab@Future, an advanced e-learning platform that uses novel Information and Communication Technologies to support and expand laboratory teaching practices. For this purpose, Lab@Future uses real and computer generated objects that are interfaced using mechatronic systems, augmented reality, mobile technologies and 3D multi user environments. The main aim is to develop and demonstrate technological support for practical experiments in the following focused subjects namely: Fluid Dynamics - Science subject in Germany, Geometry - Mathematics subject in Austria, History and Environmental Awareness – Arts and Humanities subjects in Greece and Slovenia.

### **1. Introduction**

The Lab@Future project (the project full name being - ‘School LABoratory anticipating FUTURE needs of European Youth’) is a research and development project, funded by the European Union (EU) as part of the Information Society Technologies (IST) program. In this paper we present the incurred developments opposite the trends for a common exploitation of the results, the day after evaluation and validation completion.

## 2. Lab@Future Distributed Platform

### 2.1 Session definitions

A collaborative e-learning session (referred to later as a session) is constituted by a group of persons working collaboratively, handling experiment specific data, performing experiment specific applications and using a set of groupware tools as support of their work. The groupware tools provide the basic communication and collaboration services to the users registered in the session [1].

Two phases are defined within a session, respectively an asynchronous phase and a synchronous phase. When a session is created, it enters an asynchronous phase that is continuously active until the session is deleted by the administrator. In the asynchronous phase, the registered users are authorized to access independently (i.e. without any synchronization among them) the e-learning content of an experiment (for instance, access to experiment specific Web pages, access to experiment-specific virtual scenes) and to perform independently experiment specific applications. During the asynchronous phase, only asynchronous communication tools, like E-mail or news groups, are available to the users.

When a synchronous phase is running, it is the responsibility of each user to explicitly join/leave this synchronous phase. As a consequence, all the users, who have joined a synchronous phase of a session, are aware of each other, and may use different synchronous collaboration and communication tools to work together and implement a pedagogic scenario. It is important to notice that the asynchronous and synchronous phases are not mutually exclusive and may coexist. That is, when a synchronous phase starts, the asynchronous phase keeps active. In this way, users are always allowed to work asynchronously while taking also part in a synchronous activity.

A session is created, configured and deleted by an administrator. The administrator is also responsible to start and end a synchronous phase, either manually or by configuring a specific time schedule.

### 2.2 Experiments

The following sections describe the main functionality of the Lab@Future e-Learning application experiments, namely the Fluid Dynamics, the Mathematics and the Arts & Humanities Experiment, which have been evaluated [2].

#### 2.2.1 Fluid Dynamics

The main functionality of the Fluid Dynamics experiment is the use of a Mixed Reality environment as an assistant tool for teaching Mechatronics [3]. The Toolkit is implemented as a distributed and collaborative Mixed Reality Web Service that integrates real and virtual, local and remote media under one common interface. With a special kind of coupling between the computer and real hardware, it is possible to build hybrid systems that are a mixture of real and virtual parts by using bidirectional connections for physical phenomena (air pressure and electricity).

Users have the possibility to learn the topic of Fluid Dynamics not only by theory but also in practice. They cannot only create virtual experiments but can connect them to real hardware.

The Web Service gives also access to supporting material for each experiment. This material can be used for self-education and/or homework composition.

The Fluid Dynamics experiment specific platform suite consists of several modules that together build the deriveSERVER system. Each component of the system has its own dedicated task, e.g. simulation. A central module, which controls the communication and data flow between the different subsystems, is the Mixed Reality (MR) Server. It maintains the resources of running experiments. The user sees only the HTML based Front End, the Virtual Construction Kit (VCK).

The virtual model is interfaced to the real hardware process, utilizing diverse innovative devices such as the Hyperbond [4], an image recognition system, etc. With the help of video-streaming changes to the real hardware it can be observed at distant places. All software components are realized as specialized software agents that communicate via standard Internet protocols (TCP/IP). The network of communicating clients forms the overall (software) system.

Lab@Future experiment scenarios relevant to course topics in the subject area of fluid dynamics are: industrial safety circuit, swivel driver and comparison of real and virtual behavior of double acting cylinder.

### 2.2.2 Geometry

Within the scope of the Geometry Experiment a system called Construct3D is developed, which is a novel tool for teaching descriptive geometry using collaborative augmented reality. The system incorporates the following laboratory equipments used during teaching and learning:

- Personal computers (PCs) (these include laptops and desktop)
- Head -Mounted Displays (HMD) used for presenting the output of our system i.e. the real world augmented by the virtual elements generated by the application
- Trackers used for obtaining head and hand position and orientation information:
- USB and Firewire webcam based tracking
- Electromagnetic tracking
- Computer-vision tracking
- Ultrasonic/inertial tracking
- Inertial tracker used for measuring head movements
- BARCO projection table
- P5 virtual glove

Each student has his or her own head-mounted display and interaction hardware, so they don't share these devices. This approach enables students to actively participate in the learning process. Since these displays are optical see-through HMDs, they can see each other and are able to communicate simply by speech as well allowing for natural, familiar and therefore effective means of exchanging information. In addition to the HMDs, there is also a provision

for students to watch the 3D construction procedure passively on a large projection screen or computer screens. The large projection screen or computer screens can be “shared” or viewed by several users thereby enabling several students to passively participate in the learning activity.

One or more tracking servers are needed to process the data coming from the input devices of the users i.e. the pen and the panel of the Personal Interaction Panel that provides an Augmented Reality GUI (3D menus and pointer). This data is then sent to the machines needing it through the Local Area Network using multicast. The output images for each user can be rendered either on a central machine that processes the data coming from the tracking server(s) and renders the images for the HMD or the monitor of the user, or each user has his/her own machine for the same tasks. The machines associated with one or more users run the Studierstube collaborative Augmented Reality platform, which uses the tracking data and user interaction information to render the graphical elements representing the user and the current application status, while the Construct3D application is running on top of Studierstube. Geometry experiment learning scenarios within Lab@Future framework include: hybrid AR classroom, projection screen classroom, distributed hybrid classroom and remote collaboration.

All the machines – the input and output components - connect to the ESS of the Mathematics Experiment, which serves as the interface for the Lab@Future platform. More specifically, on the ESS of the Geometry Experiment the Studierstube collaborative augmented reality application is running. The Construct3D application is using and being run in the Studierstube framework. There can be multiple machines running Studierstube, in this case the Construct3D application runs in a distributed manner, the scene graph of the virtual scene and the updates to the scene are synchronized over the network.

The desired outcomes from teaching and learning geometry in Lab@Future environment are focused on enabling students to:

- Acquire an improved comprehension of complex spatial problems and relationships.
- Recognize structures & properties of geometric objects.
- Recognize basic geometric shapes in a bigger context.
- Create & modify objects by modeling and transforming them.
- Apply fundamental geometric knowledge in scientific & technical problems.
- Recognize & apply geometry as a language.
- Interpret & develop geometric representations.
- Learn correct use of specific tools in accordance with the problem to be solved.
- Learn to use special 2D and 3D educational software.
- Learn a programming language & use communication tools to describe and explain geometric objects & procedures.
- Acquire preciseness in expressing ideas through the use of drawing as a means of intercultural understanding.

- Prepare for the professional world by learning to be precise & organized.
- Capture, understand, analyze and model natural and artificial objects and models.
- Develop creativity.
- Improve fine motor skills.

### 2.2.3 Arts & Humanities

#### 2.2.3.1 History

The main functionality of the History experiment is the use of Mobile Technologies as assistant tools during the visit of a high school classroom at an archeological monument. The experiment is implemented in the following way: the class of the moderator school visits a remote environment (outside the school premises). The moderator class students are holding mobile devices such as PDAs or Cell Phones enabled with WLAN access. Through these devices the students can communicate with the students of remote classrooms who are sitting in front of networked desktop computers in their classroom. The PDAs and desktop computers also allow access to supporting material residing on web servers, over the Internet. Finally the mobile devices could also include a digital camera for taking pictures at the remote site to be shared with the remote students, or used later for homework composition.

Lab@Future experiment scenarios that are relevant to history are: comparing the real monument with its virtual representation on the PDA, looking for information in relevant websites through their PDA device and using this information in order to enrich the learning impact of the educational visit, communicating and exchanging information through the mobile devices and using PDAs and GRS Mobiles phones when studying classical art.

The ESS of the History Experiment serves as the interface for the Lab@Future platform. As mentioned earlier in the paper, History experiment also uses the Lab@Future adaptation framework to overtake the various constraints induced by mobile contexts.

## 3. Conclusions

Lab@Future defines a generic - universal “mixed and augmented reality” platform energizing mobile and wireless information interaction and addressing issues of the constructivist theory of learning, in combination and dialogue with activity theory, especially the theory of expansive learning. It provides a constructivist and expansive framework that introduces innovative features to e-learning, which can serve successfully as a common teaching environment in schools throughout Europe.

## 4. References

- [1] Baudin, V., Faust, M., Kaufmann, H., Litsa, V., Mwanza, D., Pierre, A., Totter, A., 2004, The Lab@Future Project, “Moving Towards the Future of E-Learning”, WCC Toulouse France, IFIP/World 18th Computer Congress, 22-27 August, 2004.

- [2] Courtiat, J.-P., Davarakis, C., Faust, M., Grund, S., Kaufmann, H., Mwanza, D., Totter, A., 2004, "Evaluating Lab@Future, a collaborative e-learning laboratory experiments platform", EDEN 2004 Annual Conference, New Challenges and Partnerships in an enlarged European Union, Open, Distance and e-Learning in Support of Modernisation, Capacity Building and Regional Development, 16-19 June, 2004, Budapest University of Technology and Economics.
- [3] Bruns, F. W., 1999, Complex Construction Kits for Engineering Workspaces. In: N. A. Streitz et al: Cooperative Buildings. Lecture Notes in Computer Science 1670, Springer Berlin, pp. 55-68
- [4] Bruns, F. W., Erbe, H., 2004, Mixed Reality with Hyper-Bonds – a Means for Remote Labs. Proc. IFAC 11th Symp. on Information Control Problems in Manufacturing, Salvador, Brazil, April 2004.

## **IV. Quality and Standardization Issues in Education**



## Setting Standards in Education

---

*Menelaos A. Sotirion*

*Head of International Projects Department, Q-Plan S.A., Greece*

*sotirion@qplan.gr*

### **Abstract**

Standards do not drop from the heavens ready to be used. Rather they are made by human beings with their feet on earth. This fact must be kept in mind as questions about standards or expectations for schools, students, educators and school officials become an issue when someone start discussing about them and how they could implemented in real life. The popular rhetoric of educational reform is increasingly colored with the terminology of standards as public policy views shift from an exclusive focus on inputs into schools to consideration of outcomes, such as student achievement, graduation rates, and drop-out rates.

This paper is trying to give the real facts about using standards in education and of course to propose methods about the implementation and setting up of standards in education. It presents the actions that have taken place through out the implementation phase of an educational procedure providing distance education. The reason that standards have not yet been implemented in the educational procedures and specially to the distance learning courses is mainly the fear of stakeholders (authorities, institutions, educators, even the students) in using and implementing standards as well as the lack of the existence of a guide about how to organize all the needed processes and procedures for the implementation of a distance learning course. Using technological solutions and all the information and communication technologies (ICT) in the educational procedure it is needed to have a clear and precise Implementation Guide.

Keywords:

Standards, e-learning, learning standards, evaluation methods, Implementation Guide

## 1. Using Standards

At one time, standard-setting (the process of defining points for educational decision-making) was primarily of interest to measurement specialists and psychometricians. Now on both the national and international levels, educational administrators and policy-makers are engaging both educators and noneducators in formal exercises to define acceptable and/or desirable levels of student performance for the school system [1]. As such, the process of setting educational standards can be seen from a number of perspectives. Standard-setting can be viewed as a(n) [2]:

- forum where the match between what educators intend to do and what they actually have done is deliberated,
- intersection where educational ideals meet reality,
- exercise which gives voice to the underlying appreciative knowledge of professionals and nonprofessionals about the potential for youth,
- evaluative process for placing an interpretative framework around assessment data in either statistical and textual form,
- due process mechanism for adjudicating outcomes for a school system,
- psychometric technique for calibrating test questions,
- means for applying social meaning to measures of learning,
- instrument for clarifying professional and public expectations about curricular and instructional effectiveness,
- public policy arena where competing stakeholder interests and values are drawn together and reconciled to define education system outcomes for public accountability purposes, or
- decision-making process which in turn establishes points for further educational decision-making.

Because it both represents and reflects diverse values about what we think important in education, a standard is often subject to controversy [3]. Virtually all scholars concur that standard setting is a judgmental exercise. A standard therefore can be only as good as the judgments and evaluative processes used in setting it. Popham has argued that serious standard-setting which relies, “on decent collateral data, wide-ranging input from concerned parties, and systematic efforts to make sense out of relevant performance and judgmental data is not capriciously arbitrary [4]. Rather, it represents the efforts of human beings to bring their best analytic powers to bear on important decisions”.

Critics usually adopt one of two lines of argument when questioning the credibility of standards. One is based on the belief that testing and standards represent a form of standardization that denies the individuality of people and undermines the unique, transactional nature of teaching [5]. Large-scale assessments provide educators and trustees with beacons and external referents to guide successful professional practice, in the same way radar guides a pilot around the airport and safely onto the runway. No one can say that radar measurements and flight standards detract from the pilot’s skill and harm the passenger, even though they certainly do shape the flight path in positive ways.

The second criticism is that standards, because they are human creations, are arbitrary [6]. It is true that all methods are arbitrary in the sense that there is no scientific procedure which simply involves plugging numbers into a formula. Different methods will produce different standards. Yet we must not label standards as unacceptable just because they are arbitrary. The word “arbitrary” can mean either “that which is determinable by a judge or tribunal” or whimsical, that is “selected at random and without reason”. When criticizing standards as arbitrary, critics are clearly employing the second, negative definition, whereas the first definition more accurately reflects serious standard-setting efforts. Even if standard-setting is subjective, Livingston and Zieky (1982) point out, “once a standard has been set, the decisions based on it can be made objectively. Instead of a separate set of judgments for each test taker, you will have the same set of judgments applied to all test takers. Standards cannot be objectively determined, but they can be objectively applied” [7]. In short, a standard enables equality of treatment, as much as it permits judgments of educational quality. Finally it must be taken into consideration to everyone that wants to set standards in the educational procedures that must work at least on two categories of standards [8]:

- Technical Standards
- Educational - Learning Standards (methods, practices etc)

There are already standards in the field mentioned above and are ready for use<sup>1</sup>. Some of them are already implemented in some European or National Research projects<sup>2</sup>.

### 3. Need for the Implementation Guide

In order to use standards in the educational procedures and especially in schools and courses that use ICT, it is essential to realize some specific actions such as:

- Every initiative that is based on ideas and proposals concerning the educational procedure must be realised and accompanied by specific processes and procedures that must be identified and followed.
- Every project concerning the implementation of educational applications must be accompanied by an “Implementation Guide”
- Recommend the standardization of the methodologies and practices, and even more the evaluation scheme. The availability of a standardization scheme is particularly important, as is the establishing of conditions conducive to change and to adaptation of the ways in which education and training systems are organized.

---

<sup>1</sup> <http://www.cenorm.be/cenorm/index.htm>, <http://www.iso.org/iso/en/ISOOnline.opennerpage>, <http://www.etsi.org>  
<sup>2</sup> ZEUS Project in Greece ([www.dias.ea.gr](http://www.dias.ea.gr)), CONNECT Project ([www.connect-project.net](http://www.connect-project.net)), many project of ESA (<http://www.esa.int/export/esaCP/>), and many projects of European Commission in the action of Technology Enhanced Learning ([http://www.cordis.lu/ist/directorate\\_c/telelearn/projects\\_fp6.htm](http://www.cordis.lu/ist/directorate_c/telelearn/projects_fp6.htm)).

The Implementation Guide in the educational procedures it seems to be the most important factor for the success. It must be emphasizing on the new way of teaching and learning using new technologies and technical aspects. It will invoke changes in how the target groups are educated, in how their performance is assessed, and in the relationship between the educational institution and the rest of the community. It will be the first step on a journey of educational reform that might take many years. It will be the map. The achievement of the high quality training requires the combined and continued support of all involved actors, researchers, policy makers and curriculum developers, educators, teachers, students and parents. It will analytically describe the developed pedagogical approach and it must include the practices and the methods for the implementation of the “classroom” activities as an example of good practice. Among others the guide could address the following points:

- Fields and subjects suitable for the introduction of the new tools at the primary level of education.
- Motivating and de-motivating factors influencing the application of ICT for training and professional development.
- Organisational aspects (prerequisites, infrastructure, necessary person-power) for a successful implementation
- Specifications for the technological infrastructure
- Description of Standard critical processes and procedures that are needed to be deploy.
- A standard management framework with critical management processes that are needed in order to assure the level of quality for the proposed training program

The Implementation Guide must contain all the specification, practices and methods that are needed to implement e-Learning with the proposed way and it must be separate in three sectors:

- a. training and education specifications (methods and practices)
- b. technological specifications (methods and practices)
- c. specifications for providing the integrated service (methods and practices)

In the Figure 1 below there is presented an example of contents of the Implementation Guide

|                                                                                 |
|---------------------------------------------------------------------------------|
| <b>CHAPTER 1: INTRODUCTION</b>                                                  |
| <b>CHAPTER 2: PROJECT'S SPECIFICATIONS</b>                                      |
| 2.1 CURRENT SITUATION                                                           |
| 2.2 STANDARDS - RESOURCES USED                                                  |
| <b>CHAPTER 3: IMPLEMENTATION PREREQUISITES</b>                                  |
| 3.1 REQUIRED USERS' SKILLS                                                      |
| 3.2 REQUIRED INSTRUCTORS' SKILLS                                                |
| 3.3 TECHNOLOGICAL REQUIREMENTS                                                  |
| <b>CHAPTER 4: METHODOLOGY FOR SYSTEM DEVELOPMENT AND PROJECT IMPLEMENTATION</b> |
| 4.1 TRAINING NEEDS                                                              |
| 4.2 GENERAL PROJECT'S DESCRIPTION                                               |
| 4.3 SCENARIOS' AND IMPLEMENTATION PROCESSES' DESIGN                             |
| 4.4 CONTENT DESIGN AND DEVELOPMENT                                              |
| 4.5 TRAINING METHODOLOGY                                                        |
| 4.6 ADAPTATION - MODIFICATION PROCESSES                                         |
| <b>CHAPTER 5: ASSESSMENT AND IMPLEMENTATION RESULTS</b>                         |
| 5.1 ASSESSMENT                                                                  |
| 5.2 CONCLUSIONS                                                                 |
| 5.3 CRITICAL SUCCESS FACTORS                                                    |

*Figure 1: Indicative Contents of the Implementation Guide*

Special care must be given to the presentation of the evaluation scheme and the evaluation results that are expected to provide arguments in favour of the proposed learning scheme and the ICT application to the targeted groups. This evaluation procedure must be recommended in order to have a continuously improving training programme with high quality standards.

The evaluation scheme, the methods and practices have to follow a systematic and continuously improving way of implementation. This must be accomplice through the Implementation Guide that will recommend the standardization of the methodologies and practices, and even more the evaluation scheme. The availability of a standardization scheme is particularly important, as is the establishing of conditions conducive to change and to adaptation of the ways in which education and training systems are organized. Furthermore it has to be considering the technological parameter. The steps to confirm whether methodologies and practices that are standardized are the appropriate are presenting in Figure 1. After the evaluation and the data analysis there will be enough information in order to start writing the Implementation Guide.

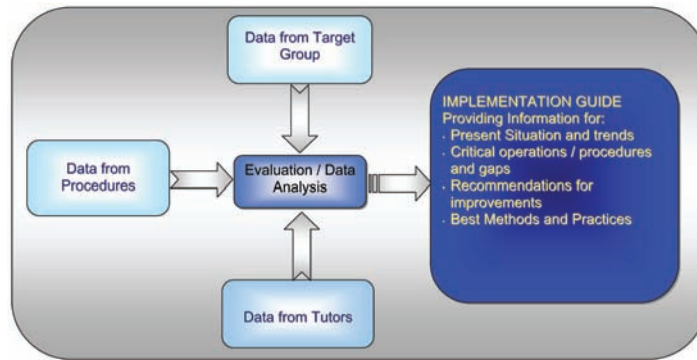


Figure 2: The proposed approach for the development of the Implementation Guide.

The evaluation scheme must be organized in a way to assure that all the modules that are important in the implementation of the educational procedure are evaluated. Hence the evaluation must be realized to all the categories that are shown in Figure 3 to cover all the fields of the evaluation.

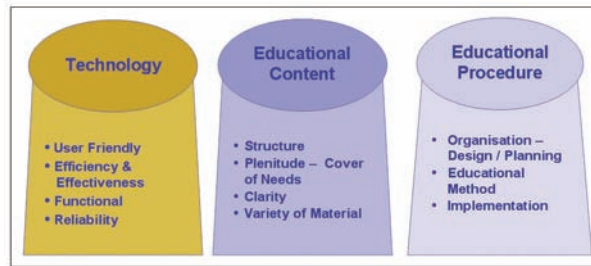


Figure 3: Categories of the Evaluation Scheme.

In order to collect all the abovementioned information it is important to use some instruments [1]. These instruments must be selected and used in such a way in order to have the most objective results and hence the most reliable evaluation for the education procedure that was followed. The most reliable process is the combination of the following instruments:

- Questioners
- Videos of the realization of the courses
- Interviews with all the people involved

The most important procedure after the collection of the data is the analysis of them and the criteria and factors that will be used for the evaluation. The statistical analysis must be already set up before the implementation of the courses and must be included in the Implementation Guide.

### 3. Conclusions

In conclusion it must be consider the Implementation Guide as an essential need in order to set standards successfully in the educational procedure and especially using ICT. The objectives and the aim of the developing the Implementation Guide are:

- Creation of a training framework that correspond to the needs of the stakeholders (teachers, students and the community)
- Identify and present best training practices and methodologies
- Standardisation of the educational procedure
- Present a model for the continuous provision of training and support to the stakeholders
- Establishment of a continuous procedure for the evaluation of the training framework in order to continuous modify and adapt new procedures or methods for the creation of a user friendly environment
- Identify and follow the basic principles and standards of an educational program
- The Implementation Guide contains all the specification, practices and methods that are needed to implement e-Learning with a proposed way (e.g. Open and Distance Learning via broadband networks) and it is separated in three sectors:
  - training and education specifications (methods and practices)
  - technological specifications (methods and practices)
  - specifications for providing the integrated service (methods and practices)

### 4. References

- [1] Cizek, G.J., 1996, Standard-setting guidelines. *Educational Measurement: Issues and Practice*, 15(1), 13-21.
- [2] Saskatchewan School Trustees Association, 1996, Setting standards in education: Saskatchewan Standards Symposium. SSTA Research Centre Report # 96-02.
- [3] Hambleton, R.K., Powell, S., 1983, A framework for viewing the process of standard-setting. *Evaluation & the Health Professions*, 6 (1), 3-24.
- [4] Popham, W.J., 1978b, Setting performance standards. Los Angeles, CA: Instructional Objectives Exchange.
- [5] Bourque, M.L., Hambleton, R.K., 1993, Setting performance standards on the national assessment of educational progress. *Measurement and Evaluation in Counselling and Development*, 4 (26), 41-48.
- [6] Shepard, L., 1980, Standard-setting issues and methods. *Applied Psychological Measurement*, 4 (3), 447-467.

- [7] Livingston S.A., Zieky, M.J., 1982, Passing scores: A manual for setting standards of performance on educational and occupational tests. Princeton, NJ: Educational Testing Service.
- [8] CWA 14644 (CEN Workshop), 2003, Quality Assurance Standards.

## **V. Broad-Band for All**



## **The Use of Direct Video Broadcast Return Channel Satellite (DVB-RCS) Technology in Teleducation Applications The Rural Wings EU IP Project**

---

*Nikolaos Uzunoglu  
Microwaves and Fiber Optics Laboratory  
National Technical University of Athens, Greece  
nuzn@cc.ece.ntua.gr*

### **Abstract**

The important features of Satellite DVB-RCS technology and the possibility of implementing this technology in developing tele-education environment are analyzed. The possibility of utilizing broadband wireless technology together with Satellite technology could provide a widely acceptable solution to education community especially for Rural Areas. The possibility of achieving a feasible and low cost solution is analyzed and key features of the proposed telecommunication system architecture are reviewed. The proposed solution to decrease the “Digital Divide” of sparsely populated areas is discussed while the principle features of a European Commission Integrated project is presented briefly.

### **1. Introduction: DVB-RCS Technology**

The importance of Satellite technology was initially perceived by A. Clark as early as 1946 proposing the use of three artificial satellites around the world to be able to connect any point on the earth with these three transponders. The use of satellites to provide connection between on earth points at large distances started to be implemented in 1960's using analog telecommunication technologies. The basic technology still used in satellite transmission technology is the frequency translation of received signals from a ground station and retransmission of received signals towards earth in a slightly different frequency. This technology essentially is the analog repeater technology used in terrestrial microwave links. In case of terrestrial microwave links traditionally repeaters are installed in mountain tops to achieve as much as high geographical

coverage. Considering the fact that the satellites could be placed in orbits as much as hundred kilometers it is clear that very large geographical cover ages could be achieved using satellites orbiting more than 100 km above the earth. Furthermore the placing a satellite at an orbit of 36,000 km above the earth on the equatorial plane earth results into a geosynchronous orbit that is the satellite rotation is almost equal to earth rotation (1 full rotation in 24 hours). The use of geosynchronous provides the advantage that the ground terminals-transceivers to have fixed antennas pointing towards a specific direction to transmit and receive signals using beams aiming the satellites. However from the early days of satellite communications a serious drawback of the geosynchronous satellites has been the very loss of signals incurred because of the very large distance two ways propagation distance (72,000 km). In order or to compete with this large attenuation one has to use the following technological features:

- At the ground transmitting station emit as much as possible high signal power towards the satellite
- Antennas used at the ground transmitting and receiving stations should have as much as possible directive beams. The uses of highly directive beams guarantees significant increase of receive power levels at the ground and satellite based receivers.
- Achieve the highest possible receiver sensitivity by using low noise receiver techniques.
- Sophisticated modulation and demodulation techniques to achieve the best use of received weak signals to extract information.
- Improve the satellite transponder technology in terms its transmission signal power levels, receiver sensitivity and antenna directivities provided the required geographical coverage is achieved.

All the above mentioned technological issues has been worked out by large research groups, telecommunication companies and organizations during the last 30 years to achieve optimum solutions and make satellite technology widely used by wider communities. It is important to emphasize the fact that in parallel with satellite telecommunications transmission technology the communications technology in 1980's show the revolutionary introduction of fiber optics telecommunications which allowed the possibility of expanding the digital technology widely starting with the worldwide telephone system facilitating its digitization after an almost 100 years analog technology life.

Considering the technological limitations of the 1960's in the field of microwave electronics and especially of space electronics one has to rely on the use rather large size parabolic shape antennas such as of 20-30 m in diameter requiring very expensive structures to achieve precise pointing of the beams towards the satellites. The absence of microwave amplifier technology resulted in the first decade satellite communications to be restricted to state monopoly telecommunication organization. In parallel numerous military systems has been developed providing worldwide coverage of specialized communications networks. The development of GaAs based (Gallium Arsenide) microwave monolithic integrated circuits as spin-off of military programs in mid-1980's provided the opportunity of development of satellite distribution of Television (TV) signals into very wide geographical areas facilitating many political and technological changes. In this case the analog TV reception is achieved with a reasonable

receiver antenna size such as of the order of 60-120 cm in diameter. However, only reception capability exists in these Receive only Satellite systems. Recently the use of hybrid methods using receive only internet terminals using terrestrial links for return path has shown the capability of satellites to provide, even though in part, wide band services. The principal obstacle in the development of a fully autonomous satellite terminal with a wide band transmission capability is the requirement of a rather large size antenna such as 2-4 meters in diameter. The present day microwave technology allows the development of broadband terminals with full autonomy using antennas of 1.8 meters. These terminals are known as VSAT (Very Large Antenna Terminals). The rather large antenna diameter is the main obstacle of widely using VSAT terminals to cover social needs such as telemedicine and teleeducation applications needed urgently in rural areas where the telecommunications infrastructure still is in pre-ISDN era. Taking into account the fact that no dramatic technological improvements is expected to take place in the above mentioned satellite communication technologies, in recent years the DVB-RCS (Direct Video Broadcast-Return Channel Satellite) technology has been developed. The essential new technology used in DVB-RCS systems is the introduction of HUB with large power transmission and antenna diameter. All communications between satellite ground terminals passes through the HUB stations. This means that the increase of the HUB station power levels and antenna diameter-directivity is provides the opportunity to decrease the antenna size (60cm) and transmitter power (2-4W) of the common terminal. Standardization of DVB-RCS networks is expected to promote the spreading of satellite technology to fill the "Digital Gap" which resulted because of the liberalization of telecommunications in Europe and elsewhere. The introduction of DVB-RCS technology is expected to revolutionize the use of satellite technology and also to provide wide access to Rural Area societies to broadband services such as teleeducation, telemedicine, teleworking and entertainment. This task could be achieved provided satellite operator will respond to this need and also through pilot project the importance of this technology will be proved in practice. The introduction of two up/down traveling of signals because of the use of DVB-RCS Hub results into a double time delay in information transmission and this inevitable drawback should be treated by using proper communication protocols.

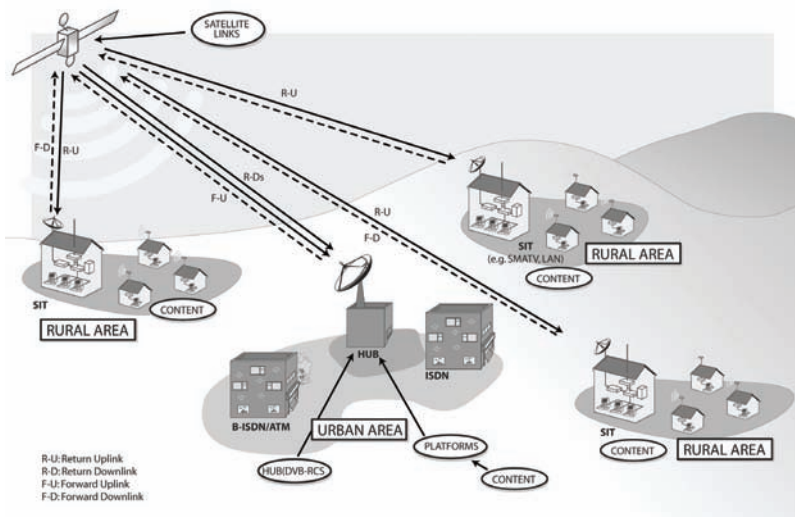


Fig.1 DVB-RCS System Architecture

## 5. Teleducation Architecture

The basic components needed in developing a wide continent area teleducation system are:

- Teleducation service provision centers
- DVB-RCS Hub ground station supporting the communication between ground terminals and HUB station as well.
- Ground terminal nodes connected to local area network to provide access to numerous users.
- Application software developers to provide educational contents.

The availability of low cost DVB-RCS terminals and the auxiliary units to be installed at the rural region is of primary point. The terminal should be easy mountable free of usual problems encountered in satellite terminals in pointing precisely antenna axis. The stability of the antenna with environmental factors is also a highly important to achieve high reliability. The auxiliary units needed at the DVB-RCS rural region terminal is the communication controller unit as well as a Personal Computer Terminal with internet protocol interface. The terminal bit rate should be at least 2Mbit/sec downlink and 512kbit/sec uplink. This capacity should be used to serve the users through a local area network which could use standard wired local area technologies (i.e. Ethernet, TCP/IP etc.) or Wireless Local Area Network Technologies such IEEE 802.11 (Wireless LAN) technologies providing an easy implement able networking technology. Considering the lack of networking infrastructure in rural areas the use of Wireless LAN technologies is extremely attractive not only in terms of easy implementation but also low cost. Designing correctly the Local Area Network expansion to larger number of users could be achieved. In Fig.1 a typical illustration of a rural area environment is presented.

The DVB -RCS Hub is a Channel infrastructure serving large number terminals serving teleducation (or other application) communities. The networking capability of HUB station is an important issue guaranteeing the optimum use of available electromagnetic spectrum. The antenna diameter of the HUB station is 4-8 meters depending of the satellite transponder characteristics. The cost of a DVB-RCS Hub is significant as compared to the low cost satellite terminal. The HUB station should have connection to land based wide band networks to provide the access to internet service providers and especially to teleducation content providers.

It should be emphasized that the availability of an excellent technology DVB-RCS technology satellite technology system is only a prerequisite to develop a successful Teleducation System. The role of pedagogues specializing in distant education is of equal important since any advance technology could fail to provide desire results if is not supported with a correct pedagogy strategy.

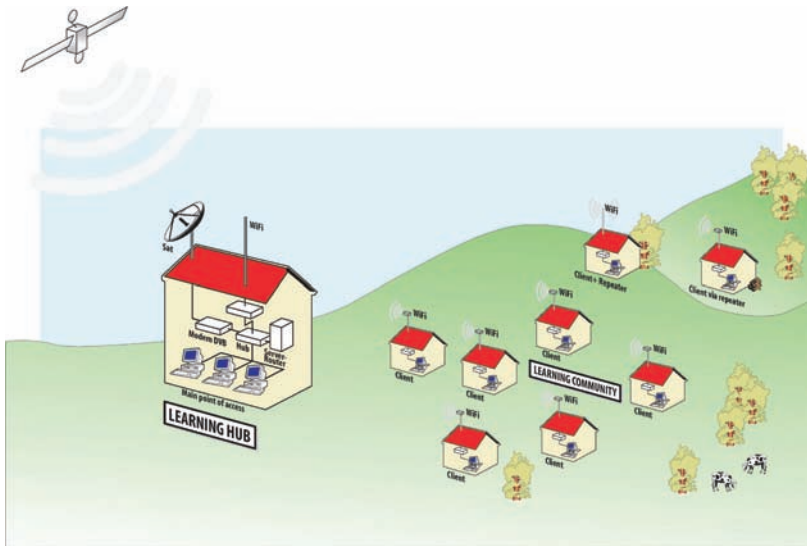


Fig.2 DVB-RCS and Wireless Local Area Network Architecture

### 3. An Implementation Approach: Rural Wings European Commission IP project.

The above mentioned approaches has been used to formulate an new European Integrated Project (IP) within the 6<sup>th</sup> Framework Project under the Acronym. The project will be coordinated by the Microwave and Fiber Optics of the Institute of Communication and Computer Systems-National Technical University of Athens while two leading European satellite service providers EUTELSAT and HELLAS-SAT are members of the project. In the following Table 1 the Consortium Members of the Rural Wings project are shown.

The Rural Wings project will be based on innovation practices and techniques deployed in industrial environments, aiming to the optimization of the new products' development process. The ultimate goal is the transfer of knowledge and the adjustment of these practices in different knowledge spaces (at school, at work, at home) as a mean for interaction between user needs and technological developments: The needs of users in rural areas feed the integration of the educational environment with dynamic requirements for new services or for the adaptation of existing ones. In this way the users' perception of their problems/needs leads the development of technology and of learning practices.

In recent years there have been several initiatives in the field of satellite telecommunications applications, in order to address the needs of rural communities. This indicates the unique advantages of satellite technologies for providing high quality wireless broadband connection to any type of population within large geographical areas. Rural Wings is an ambitious project that proposes to develop an advanced learning platform through satellite DVB-RCS access

technologies, promoting a user-centred methodological approach which constitutes its major innovation. The main aim of the present approach is to support the creation of a new culture in rural communities promoting digital literacy and reducing resistance to the use of new technologies. It will go a step further encouraging users to add their significant contribution to the emerging applications by involving them in meaningful activities, tailored to address the needs of different user groups. Thus, Rural Wings aims to offer stimulating and creative learning environments to support vibrant user communities and will attempt an extended implementation in dozens of pilot sites in 18 countries worldwide. It is expected that Rural Wings project will help to catalyse the satellite broadband take up in Europe and beyond.

| Satellite and telecommunication Industry | Universities                        |
|------------------------------------------|-------------------------------------|
| Astrium                                  | Athabasca University                |
| Avanti                                   | University of Barcelona             |
| EMS Technologies                         | POLYTECHNIC UNIVERSITY OF BUCURESTI |
| EUTELSAT                                 | UNIVERSITY OF AEGEAN                |
| HELLAS SAT                               | UNIVERSITY OF POTSDAM               |
| FORTHnet                                 | BEN GURION UNIVERSITY               |
| Institutions within Universities         | UNIVERSITY OF FONTERA               |
| ICCS                                     | UNIVERSITY OF SALTA                 |
| MITMLab-2B1                              | Institutions                        |
| IIE /MULTIMEDIA                          | INSEAD                              |
| SME                                      | FORTH                               |
| Q-PLAN                                   | IEP                                 |
| Alfa-Omega                               | Ellinogermaniki Aqoqi               |
| ProgressTV                               | Foundations                         |
| Karjalan Nettinikkarit                   | ERC                                 |
| CCD                                      | PBF                                 |
| TELEMEDICINE                             | FVG                                 |
| Fourier Systems                          | Governmental Authorities            |
| Networks                                 | CRC (CANADA)                        |
| EDEN                                     | Goerceada Belediyesi                |

Table 1. Rural Wings Project Members

4. Conclusions

A short presentation of key technological aspects of satellite communications has been presented. The important features of Direct Video Broadcasting-Return Channel Satellite (DVB-RCS) shown to be a suitable technology for teleducation applications together with wireless local are networks to provide services to an extended user community. A short description of the Rural Wings IP project is provided.

## 5. References

- [1] Clarke, A., 1945, "Extra-terrestrial Relays", Wireless World.
- [2] Evans, B., (Editor), 1999, Satellite Communication Systems, IEE Publications.
- [3] ETSI EN 301 790 V.1.3.1 (2003-03), Digital Video Broadcasting (DVB) Interaction Channel for Satellite Distribution Systems.
- [4] European Commission-White Paper-A new European frontier for an Expanding Union – An action plan for implementing the European Space Policy, COM (2003) 673.



## Connecting the Unconnected: The SchoolSat Experience

---

*Sally Reynolds*  
*Managing Director ATiT*  
*Belgium*  
*sally.reynolds@atit.be*

### **Abstract**

How to integrate ICT into schools in an appropriate and meaningful way remains one of the most fraught questions in education today as teachers and policy makers alike strive to make the most out of the Internet and other technologies in the classroom. Choosing appropriate content, building the necessary skills amongst teachers, finding a way to integrate computer supported learning in all subjects, these are familiar issues. However basic access to the Internet should not be ignored as Irish schools face a situation where large numbers of secondary and especially primary schools have still only very basic access, depending largely on PSTN, and at best ISDN networks, to access the Internet. City schools are offered more and more choice according as ADSL services roll-out and competition drives costs down, but what about the rural schools and schools in towns with populations too small to attract a competitive broadband offer? Despite the best efforts of all concerned, broadband access to the Internet in Irish schools remains considerably below European norms and there is a danger that Irish pupils will find themselves on the wrong side of a digital divide in terms of their access to and use of resources and opportunities afforded by fast access to the World Wide Web. County Donegal is one of those remote and rural parts of Europe that has difficulty meeting the access needs of schools in the region with broadband only recently coming to the main towns in the county with little chance of its extension outside these towns in the coming 5 years. This is one of the reasons why Donegal is such an outstanding region to take part in a project to test the viability for schools to access the Internet via satellite in the European Space Agency (ESA) supported project, SchoolSat.

## 1. The project: SchoolSat

SchoolSat is a pilot project set up in 2001 to investigate the potential of satellite to provide Internet connectivity for schools. The impetus for SchoolSat came from ATiT, a small Belgian firm, which had carried out research on behalf of ESA to identify those school populations in Europe most likely to benefit from satellite access. Putting together a consortium which included the National Technology Centre in Ireland (NCTE); Web-Sat, a Irish-based satellite service provider; and the Donegal Education Centre representing Donegal schools, ATiT applied for and were successful in attracting ESA funding for a pilot project in Donegal which ran from February 2002 to February 2003.

SchoolSat provided broadband Internet access to nine secondary schools in Donegal and the Donegal Education Centre. Each school was equipped with a small (84 cm) receive and transmit dish, connected to a dedicated computer that acted as the satellite gateway connected to the school's LAN and offering the Web-Sat Internet access service with up to 4Mb download to the school and 64 Kbits return. The schools taking part represent just under a third of the secondary schools in Donegal and included every type of second level school in the county, including vocational schools and community schools. The selection also included schools of different sizes, ranging from Carndonagh Secondary school, the largest secondary school in Ireland with about 1,350 pupils to the vocational schools on Aranmore Island with just 43 pupils. Within the schools taking part, the teachers selected were also very mixed. They included maths teachers, history teachers, language teachers, physical education teachers as well as several IT teachers. During the selection of teachers to take part, a conscious effort was made to include a representative group of teachers, rather than to select the most technically skilled. Once the project got off the ground, teachers in the schools taking part were supported in their use of the Internet through a series of workshops and regular contact with one another and the project team through an online computer conferencing system, FirstClass.

During the project lifetime, 2 distinct but related evaluation activities took place. The first, led by Dr. Aidan Mulkeen, an independent expert appointed by NCTE to evaluate the pedagogical value afforded by enhanced access to the Internet and the second led by ATiT to assess the practicalities and cost effectiveness of putting in place a satellite supported network for Irish schools. Both evaluations resulted in public reports which are summarised here.

## 2. Satellite supported access to the Internet: from an educational point of view

One of the first observations in SchoolSat was that the satellite system provided Internet access that was considerably faster than the previous access via ISDN. As the technology is already in commercial use with a range of clients, this observation wasn't a big surprise. But the fact that the satellite system was particularly useful in a schools context was.

When an individual is browsing, ISDN probably provides a reasonably fast response, and the speed of the response is often determined by the delays in the Internet, rather than the

bandwidth of the connection from the ISP to the user. Internet connectivity in the somewhat unusual environment of schools is different for a number of reasons. One of them is the high concentration of traffic into particular times, and may have marked peaks. Classes using the Internet are likely to involve all students beginning their browsing within seconds of each other, while there may be other times when there is no use at all.

The faster access enabled uses of the Internet which were not viable with slower access. In Carndonagh for example, they were able to use the Skool.ie site with 24 students online simultaneously. In Letterkenny, students could all access Hotmail at the same time, while before it used to take weeks just to get them all registered. In Buncrana the school reported that ISDN used to “grid to a halt” once there were more than 6 or 7 computers connected, while they could now use the Internet with an entire class.

The increased speed of access changed the nature of usage in the school considerably. From the teachers and schools point of view, the satellite system opened up an entirely new way of using the Internet in the classroom. “For the first time”, according to Colm Toland from Cardonagh school, one of the teachers taking part, “whole classes can use the Internet at the same time, something, which simply wasn’t possible in the past”. Students at Carrick Vocational school did not have any access to the Internet due to the lack of access facilities in the area. “Schoolsat has given us that access in a very efficient and effective way. Students and teachers can now make use of the wide range of educational material available on the net. Students will now be ‘Internet ready’ when they leave school to attend college or enter the workplace” according to George McMullin, another teacher taking part. All nine schools made valid educational uses of the Internet. In some cases these formed a substantial part of the teaching of a particular subject. A series of different types of activity were carried out.

There were a variety of forms of project work. Topics ranged from “placenames” to “Michael Collins”. In almost all cases the students were reported to like this approach and to be more engaged than usual. Some of the projects involved the entire class, but others involved only a sub-group. Some schools reported that the students were particularly attracted by the possibility of work being published online.

In others, searching for material was used as a reinforcement activity. Some teachers reported that students were more likely to take in material they found on the web, even if it was very similar to what they would have heard in class. They also found that students searching for information would often find alternative views, different interpretations of a poem for example, and have a greater sense of the complexity of an issue. Some felt that this approach offered multiple benefits, as the students learned to search properly, got more information and learned to discover things for themselves. When using the “search and report” method, often in pairs, the students also gained in presentation skills, and were very motivated.

A number of the schools reported the use of online software. The most frequently discussed was Skool.ie, which was listed as one of the three most used sites by six of the nine schools. Another frequently used site was the my-etest site, which provides quizzes to match particular textbooks. One school made particularly heavy use of Skool.ie, and used it in whole-class teaching contexts. The general method used was to teach a topic in the normal way, and then to use the online resources as a reinforcement activity.

The schools using my-etest reported that students, especially weak students, were very enthusiastic about it, and were anxious to get back and improve their scores. This is consistent with the general pattern of research in the area of this kind of automated testing. For example in the UK, research on Integrated Learning Systems (ILS), has reported similar increases in motivation and determination to improve, particularly from weaker learners.

Other uses of the Internet were reported in schools. In one case a teacher used a computer and data projector for whole-class teaching. There was also very heavy use of the Internet in careers guidance. Sometimes this took the form of use of online resources such as Qualifax or the CAO system, and in other cases it involved searching for information about Universities, courses etc.

Teachers perception was that there were real learning benefits. The main benefit reported was increased motivation. Teachers doing project work also reported increases in the students taking responsibility for their own learning, and were pleased with the quality of work done. The teachers using online tests reported that they seemed particularly engaging to the weaker students, who were anxious to get back to increase their score.

One of the main conclusions of SchoolSat is that broadband Internet connectivity can facilitate greater use of the Internet in schools, particularly allowing whole class activities. The example of the nine schools demonstrates that the Internet can be used in valid educational ways within the constraints of Irish schools.

### **3. Satellite supported access to the Internet: from a service provider point of view**

From the service provider point of view, SchoolSat proved that putting a service like Web-Sat in a school environment was viable and provided a great deal of evidence as to the service requirements of a schools community. On average, each school transferred about 1GB maximum of data each month with a usage ratio of approximately 1:20 where each school downloaded about 20 times more content than they transmitted. Technical problems were minimal and to a large extent such a service can be expected to run trouble-free with the minimum of maintenance. Problems, where they occurred, had far more to do with connectivity into the schools LAN and local maintenance issues that they had to do with any difficulty to do with the satellite service.

Having said that, it is clear that in order for a satellite supported service to be viable, it has to be made available to a community of school users and is not a service that can be offered on an individual basis. In rather simple economical terms, it is just not viable to offer a service such as SchoolSat to individual schools as installation, maintenance, and service provision all require specific levels of buy-in to make such a service sustainable. Significant economies of scale can be called upon in order to build a reasonable business case, but without these, satellite service providers will struggle to offer a reasonable and long-term solution for Irish schools regardless of brash marketing campaigns.

This requirement for some form of centralised service provision is not all bad news however, and another significant outcome from SchoolSat was that given schools' tendency towards predictable and pre-defined content, they are in a good position to benefit from the added-value of satellite multicasting services. During the 12 months pilot in Donegal, it was evident that a great deal of Internet traffic was to a small set of web sites. School communities tend to be conservative and inclined to visit the same sites, where quality, suitability of content and safety can be guaranteed. This means that a satellite supported service that delivers a set of pre-described content to the local server is eminently suitable and one which can deliver significant economies of scale. To this end, Web-Sat and ATIT are now building a schools' multicasting offer which can offer end-to-end multicasting and caching services to schools aimed at maximising their use of the Internet and delivering safe and reliable content to the classroom using state-of-the-art technology.

#### **4. SchoolSat: where to from here?**

SchoolSat continues in Donegal despite the fact that the funding from ESA ended in February 2003. The service to the schools taking part continues due in part to the direct support of NCTE and more recently with the partial support of Údarás na Gaeltachta. This support has guaranteed the continuation of the Web-Sat service to the schools taking part until June 2004. After that, the situation is unclear as the Irish educational authorities struggle with the challenge of putting in place an equitable and viable broadband access service for all Irish schools. One thing remains clear however, given the geographical spread of Irish schools with more than half located in rural communities or towns of less than 10,000 people and that is that satellite services remain the only viable way to offer broadband access to the Internet in the foreseeable future for many schools. While not cheap, the only way such services can be offered at an affordable price is for them to be offered on a reasonably centralised basis. Centralised purchasing and management is becoming increasingly popular with regard to ICT service for schools generally and so the only question remaining is how to finance such a step. Given the price of economic isolation and the need for balanced regional development, the question remain, can the Irish educational community afford not to take the necessary steps to put in place a broadband service that serves the needs of all Irish pupils and not just those in large cities?

Written by Sally Reynolds and Anneleen Cosemans, ATIT, and drawing extensively upon the evaluation work of Dr. Aidan Mulkeen, National University of Ireland, Maynooth.

For further information  
Please contact Sally Reynolds  
Email: [Sally.Reynolds@atit.be](mailto:Sally.Reynolds@atit.be)  
Telephone: +32 16 284040



## **VI. Designing the School of Tomorrow: The Things To Come**



## The Future of Schools from a European Union Perspective Selecting, Analyzing and Disseminating the Most Innovative Approaches Towards the School of Tomorrow

---

*Henrik Hansson*

*Institute of International Education/Department of Education  
Stockholm University, Sweden  
Henrik.Hansson@interped.su.se*

*Scott Hall*

*Institute of International Education/Department of Education  
Stockholm University, Sweden  
scott.hallblt@pub.malmo.se*

### **Abstract**

What can we learn from EU-school projects about the future learning approaches? The European Union has invested massively in ICT-projects promoting innovative use of the new technologies in school settings. The aim of the project Schoolforesight, with partners in Bulgaria, Estonia, Greece, Rumania, Czech Republic and Sweden, is to select and reflect on the best projects done so far. These projects will be popularized and presented at the EU science week the autumn 2004, reaching more than 10 000 students in five countries. This article describes and discusses the Schoolforesight project and the selection process of innovative EU-projects showing the way towards tomorrow's school. A number of best cases will be presented and discussed in a European, American and global context. The future school is both a question of what is possible and what is desired. Different scenarios might be preferable depending on local context, history, language e t c or are we all moving into the "global classroom"?

Keywords: School of tomorrow, Information and communication technology, EU-projects, student perspective, innovative projects.

## 1. Aim and Background

The EU-funded School-foresight project aims to publicize the different visions for the “intelligent school of tomorrow” unveiling, particularly to school students, new horizons that are created thanks to the contribution of scientific and technological achievements from various EU-projects. In particular ongoing or completed projects in or related to the 5th or 6th Framework program in the area “School of tomorrow”. The total budget was 14 960 Million euro for the activities in the 5th Framework program of the European Community for research, technological development and demonstration activities, 1998 – 2002 [1]. The focus areas of the 5th framework program were [2]:

- Quality of life and management of living resources
- User-friendly information society
- Competitive and sustainable growth
- Energy, environment and sustainable development
- Confirming the international role of Community research
- Promotion of innovation and encouragement of participation of SMEs
- Improving human research potential and the socio-economic knowledge base
- Improving the socio-economic knowledge base
- Joint Research Centre

The 6th Framework program is currently in operation, 2002 – 2006. The seven areas of priority of the 6th Framework program are, quote from the official EU-site [3]:

1. Life sciences, genomics and biotechnology for health: a) The new picture of health Genome sequencing, including of human beings, is bringing new prospects for molecular biology and genetics which are as yet difficult to gauge, b) A European priority Research in the field of post-genomics and biotechnologies for health not only meets the expectations of European society but also the hopes of developing countries where health conditions must not deteriorate any further.
2. Information society technologies (IST): a) The ‘all-communicating’ world Our domestic appliances, our environment and our health, our way of working and learning... The information and knowledge-based society is immersing us in an ‘e-civilisation’, b) The age of ambient intelligence. How research is helping to create an intelligent and interactive environment which places the human being at the centre of developments in information technologies.
3. Nanotechnologies and nanosciences, knowledge-based multifunctional materials and new production processes and devices: a) The nano revolution. Mastering the arrangements between atoms to form nanosystems is leading to applications which herald a new and innovative age of technology, b) A critical need for a European dimension. A concerted European approach is essential to achieve the major fundamental and

applied research effort needed to make the most of the opportunities of the 'nano' age.

4. Aeronautics and Space: a) Onward and upward. Safety, profitability and sustainability are the three leitmotifs of aeronautics research. Europe possesses real potential in this promising field, as it does in space research, b) Striving for excellence. Public and private research combine with particular effectiveness in the aeronautics and space sector.
5. Food quality and safety a) The paradox of progress. The agri-foodstuffs sector is subject to increasingly stringent regulations, standards, monitoring procedures and quality control. Yet recent years have brought some dramatic failings in the form of BSE, dioxins, listeriosis and salmonella, b) From the farm to the fork The spotlight on the Union's responsibility at every stage of the agri-foodstuffs chain and future research prospects in this field c) Communication: a challenge and a duty Consumer concerns about food safety and their level of confidence in the information provided on the subject are a major challenge for European politicians and scientists.
6. Sustainable development, global change and ecosystems: a) Earth in the balance. Sustainable development is crucial to humanity's future. This is why it is a vital dimension of the work of scientists and researchers in all fields, b) Time to decide. Energy and transport – the two most strategic elements of sustainable development – are a priority sector within the Union's scientific policy, together with (strategic) research on global change.
7. Citizens and governance in a knowledge-based society: a) The return of the human sciences. The contribution of human and social sciences in fields as diverse as health, information technologies or the environment. Plus the new light they are shedding on multidisciplinary research, b) How can progress be controlled? Restoring relations between science and the citizen, between research and society.

The School-Foresight project is a one year project that began in January 2004. It is coordinated by Q-plan in Greece and consists of the following partners Q-PLAN S.A., Greece [4]; Ellinogermaniki Agogi, Greece [5]; Institute of International Education, Stockholm University, Sweden [6]; S.C. IPA R&D, Engineering and Production for Automatisation, Romania [7]; Center for Prospective Studies at the Technical University of Sofia, Bulgaria [8]; Alfa-Omega Communications Ltd., Estonia [9]; and Gymnázium F.X.Saldy, Czech Republic [10].

## 2. Methodology

Projects were selected in two scientific and technological domains: 1) new learning approaches using information and communication technologies (ICT) and 2) Eco-efficient technologies in intelligent school buildings. This paper describes the selection of only the first category.

The selected projects will be popularized with posters, radio, TV and demonstrations to more than 10,000 secondary school students in Bulgaria, Estonia, Greece, Rumania and Czech Republic this autumn in conjunction with the European Union Science week. Students in the

five countries mentioned are also invited to participate in a contest – writing an essay about the school of tomorrow from their perspective. The winners will receive their prizes at the science week.

The first step in selecting the target group of about 15 innovative projects was search, find, read and interpret the available information online with the following criteria as “filter”: 1) The project has received money through the IST (Information Society Technologies) area of European Union research funding, 2) the project is directed toward secondary school students and/or secondary schools, 3) and the project can in some way be seen as promoting the “School of Tomorrow” through some sort of pedagogical and/or technological innovation.

The main source of information at the start was the published reports cataloged on various European Union eLearning project websites. In particular the site [www.elearningeuropa.info](http://www.elearningeuropa.info) was used, because of the amount of information available [11]. Other published information was used in conjunction with this site. Even searching using Google was needed in order to put all the pieces together for some projects and to realize their value to the project.

The first screening consisted of more than 800 projects, out of which 60 projects were selected for detailed further studies. After being selected using the three criteria above the projects were looked at closer to insure their relevance to School Foresight. At least a second source was used to verify the information about the projects. This checking also allowed for a closer reading of the project’s details. The 60 projects were categorized in thematic areas like science projects, language projects, etc. After they were organized this way a rating of either 1 (first rated) or 2 (rated number two in the category) was given to each project. Looking at the projects in this way allowed us to see the projects next to each other and clear divides were created in the different thematic areas. The projects given a 1 were considered the next level of selected projects. The 60 identified cases were then narrowed down to 35 cases.

The next step of the research was taken on two fronts. In this process their specific websites were visited, when available and other databases of information were reviewed to gather further information. For each of the 35 projects catchy headlines and short descriptions were created. This gave the project partners something they could read through and comment on in a meaningful way. The intension here was to have all project partners contribute to an open dialogue about the value of each project. In the end we relied mostly on Ellinogermaniki Agogi for selection help.

At the same time this was going on a questionnaire was sent to EU-officials with a central position in project management and with deep knowledge about the projects in order to consult them about innovative cases. The replies from experts in the different European Union countries associated with the European Schoolnet gave certain projects more value and also revealed others not included in the original list of projects. The value of these responses is in the fact the people contacted are experts in their national education departments. Beyond the European Schoolnet some of the School Foresight partners have been involved in the pool of projects. Their experience at a national level, as well as a direct project level, makes their opinions valuable.

To continue beyond the 35 project selection a weighting system was devised. The areas graded

were innovation, attractiveness to secondary students, help with understanding, learner support, and independent learning. The first 3 mentioned were given double weight compared to the other 2. A table was created for each project and the different contributing members weighed the projects based on the readings available on the projects. Although the weighting was used to measure the projects and establish which would be most suitable, a more holistic approach was used. It was decided among the different project partners that the criteria was good but may not allow certain projects with real value to be selected. The analogy of the decathlete and specialist sprinter was used. A decathlete will have no problem scoring well in many different types of areas. A sprinter, even the best sprinter, will have difficulty doing well in another event. For this reason certain projects were given more weight even though they may have scored low on the weighting system described above. The Institute of International Education sent 14 letters and on Ellinogermaniki Agogi sent 11 letters. The reason for this direct contact was we needed to cooperation of the projects to include them in the School Foresight project. Projects that would not cooperate, or would not provide information to us about their project would be eliminated from the selection. From the e-mails there were 14 replies. E-mails were re-sent to the project coordinators. After about 2 weeks. In many cases all project partners were sent the e-mail. This proved effective in a number of cases. From the 14 project replies phone interviews were conducted.

The list of 22 projects was in theory quite a good list of projects from the 5th and 6th framework funded projects in education for secondary education that have made a contribution to the school of tomorrow. The human reality of our work has come out again. While all have been contacted many did not bother to reply. Some very innovative projects like Imutus music project would have been a good addition to School Foresight. They were unable to provide the necessary information needed to participate. Their exclusion has only affected our results slightly. As mentioned before, traveling around for to gather the needed understanding of the various projects would have helped this type of problem. The problem could be written off to a lack of social presence. It is easy to dismiss an e-mail but in person or even in a phone interview it is easy to be understood as well as convey information easily.

The phone interviews involved a pre-set list of question. The idea was to have the person contacted identify certain details about the project that may not have come out from reading the websites and other written information. Thirteen interviews were conducted over about 3 weeks. The interviews were recorded and transcribed later. This contact proved invaluable to the project selection.

In the various discussions different details and issues were highlighted. In one case a new project was found due to the project we selected being outdated. In other cases the details of the project made it clear it would not be suitable for the School Foresight project. 12 projects have been settled and agreed upon by the different project partners. The final selected projects for the School Foresight science week, in no particular order, are in the appendix.

The projects selected were then grouped in themes: 1) Science projects 2) Language projects 3) Collaborative Learning / Teaching and Online Content 4) Culture and Personal / Social Education and 5) Mobile Learning. In the following section the projects are described more in detail.

### 3. Results

In the assessment of the new learning approaches using information and communication technologies projects different themes emerged allowing for projects to be categorized. The five themes are Science, Language, Collaborative Learning, Personal and /Social Education, and Mobile Learning projects.

**Science.** The science projects combine technology and pedagogy to excite students learning different fields of science. The project Lab of Tomorrow is one such example. In the project science is been taught through the everyday experiences and objects. The project has created a number of ambient technologies. These technologies allow students to explore and learn different complex science concepts. Joining these new technologies and pedagogical innovations enhances the learning process. One of the technologies developed is a football with various sensors built into it. Students use the ball to test reaction times or measure pressures exerted by kicking the ball. The project has also created a series of cameras to map the trajectory of the ball. The film and forces on the ball can be used to practically teach and allow students to explore concepts before explained in textbooks and were difficult to demonstrate in meaningful ways. Another exciting aspect of the Lab of Tomorrow project is the different technologies students can wear to measure heart rate, temperature and position. The pedagogy employed is one of sharing results and experiences with students in the same school and in different countries. Allowing for true inquiry into the concepts allows for deeper learning. Finally the project exposes science to students in a real way and may attract them to the field in the future. [12]

Exodus, teaching science with robotic telescopes, and Coldex, collaborative learning and distributed experimentation, are other exciting examples of science projects being promoted by School Foresight.

**Language.** The great number of language projects in the initial pool of projects highlights the importance given to multilingualism and mobility in the European Union. One such project identified by the School Foresight project is called Fluent. Many language and technology projects have a focus on written text and reading comprehension. Fluent is a project employing technology to learn how to speak languages. One of the aims of the project is to provide a means of teaching or learning any one of 11 European languages through the interaction with a computer and specifically designed technologies. Internet and a CD-ROM have been developed to allow students to learn correct pronunciations when learning a new language from the start. The design allows for students to work independently or in the classroom setting. The tool is split into 3 modules all designed for maximum learning and ease of use for the students. While pronunciation is the most obvious innovation, Fluent strives to be a rounded language learning tool to motivate and ensure success for its students. [13]

**Linc** is another aiming for life without dubbing across Europe. Linc's approach is focused on meaningful exercises with the CD-ROM and connections to the Internet for further learning. Linc provides motivating lessons for learning language and understanding cultures. Lessons are based on real news clips taken from the different countries. Language learning is done through discussions in class about the news footage. Students go through the material in their own time and use class time for discussion and reflection in the target language. Students

spend time studying by looking through video clips from news and other programs. The student's written and spoken language learning is monitored by a tutor/teacher online or in person. Language learning is conducted in a meaningful, adult way. First words are heard during the news extract and looked up by the student. Different vocabulary exercises allow for new vocabulary to be practiced. Vocabulary is also presented in written sentences and listening exercises. Students use the new words in written and listening exercises to help mastery.

**Collaborative learning.** One trend the research has uncovered is secondary school projects focusing on collaborative learning and teaching. Basically using communication technologies to collaborate or share experiences across different themes or all together in multi disciplinary type projects. One such project is called School+.

School+ is a platform for learning. An innovative educational approach is used to engage students in meaningful activities. The outcomes of the activities can be varied. The learning environment system is based on a number of state-of-the-art technologies. The educational approach has been designed to promote high order thinking, creativity, and teamwork that use a range of ICT tools. On aspect of School+ is the reusability and diversity of the platform. Instead of being an ICT tool meant for a specific purpose, School+ allows the user great flexibility. This flexibility will allow this tool to be widely used, thus changing how schools work. School+ can be seen as a complete computer-based learning system accessible 24 hours a day. [14]

School+ is only one of a number of collaborative learning and teaching projects. There are three other examples of collaborative learning and teaching types of project identified by the School Foresight project. Agroweb aims at innovating approaches to facilitate interdisciplinary work and collaboration. The European SchoolNet has also made many contributions to this area. The School Foresight project has identified ZAP as relevant and exciting for promotion to secondary school students. Finally the WebTV for Schools project addresses TV program for students by students on the web.

The last project in this area is called Hero(dot)eNews. Students are asked to share the experiences from their own community in Hero(dot)eNews as well. The focus of this project is citizenship and learning about environmental issues by sharing your local situation with the greater European community. Students acts as journalists writing reports about their local environmental issues, potential solutions, or related issues. Their articles are posted on the platform and discussions are conducted around the different issues. Bringing the real to technology in this Aristotelian approach allow students to become participants as learners and teachers. This shift is another challenging the bounds of current school systems. Time is needed for this type of project. The scope is multidisciplinary. The marriage of ICT and environmental learning has been well developed in this project. It is attractive and innovative project in the collaborative learning area of School Foresight.

**Personal and Social Education.** Victec is the project representing this theme for School Foresight. The project has developed a prototype of a virtual graphical drama for anti-bullying education. In a role play type of scenario one interacts with empathetic characters. These characters are able to react to your responses and discussions. The result is an emergent narrative, or a story that develops as it is being told. The project is innovative and attractive for

a number of reasons. The fact that ICT is being used to develop the area of personal and social education is notable. The application of this ICT innovation in this area could carry over to other aspects of the theme, like drug awareness, and sex education. Vitec makes the focus of the activities emotions and attitudes not simply knowledge. This is something that the innovations in the Vitec projects have allowed possible. [16]

**Mobile Learning.** New technologies have made it possible to be in touch when and where you need to be. The saturation of mobile phone use across Europe has put people together in new, dynamic ways. New ways of using these technologies for teaching purpose are being developed. As these technologies come down in price and the units themselves become more versatile the possibilities are being exploited. Anytime anywhere learning is no longer fantasy but a reality needed to explore from a structural and pedagogical position.

MoTFAL is a project identified by School Foresight as innovative and attractive in the area of mobile technology. Combining students exploring the environment, either a historical place or natural area, they are always connected to the internet to access information. The different things they observe can be photographed and shared with others in the same class or posted to be shared with many classes from around the world. Technology is being exploited to connect students to students, students to information and intimately students to rewarding learning experiences. This deductive learning approach has been tested in two schools in Greece and Spain. The project contributes to the school of tomorrow in a few unique ways. Some technologies are expensive and in turn access is blocked to many people. In MoTFAL the school is providing the technology and structure so the students can benefit. The technology and even access to Internet is out of the reach of many. The school in this projects acts as a central point where technology and infrastructure are connected to many. IN the project mobile technology is explored as a component in education. The attractiveness and innovation is well balanced and the MoTFAL is an excellent example of the types of projects contributing and pushing the school of tomorrow in a real way [17].

#### 4. Conclusion

The projects selected for promotion by the School Foresight during Science Week 2004 are attempting to represent the best examples of new technologies incorporated into secondary school education. In the broadest sense the School Foresight is highlighting these projects to show what is possible for the school of tomorrow. The twelve projects are the result of many different multinational consortiums across Europe. These networks of secondary schools, universities, and private firms grow with each of the successful collaborations. The reality for many of the projects identified in the School Foresight project is they are projects that work and are used today. In this way they are not really viewed as the school of the future but of what a school of the future could be. To allow these projects and others like them to be incorporated into schools many things may need to change in the future. School structures, relationship between students and teachers, and technological infrastructures all may need to change in some way or another if the vision of the school of the future that can be seen from these projects will be realized.

## 5. References

- [1] <http://www.cordis.lu/fp5/src/budget.htm> (retrieved 2004-04-22)
- [2] <http://europa.eu.int/comm/research/fp5/key.html> (retrieved 2004-04-22)
- [3] <http://europa.eu.int/comm/research/rtdinfo/en/special-fp6/index.html> (retrieved 2004-04-22)
- [4] Q-PLAN S.A., Greece <http://www.qplan.gr> (retrieved 2004-04-22)
- [5] Ellinogermaniki Agogi, Greece <http://www.ellinogermaniki.gr/> (retrieved 2004-04-22)
- [6] Institute of International Education, Stockholm University, Sweden. <http://www.interped.su.se> (retrieved 2004-04-27)
- [7] S.C. IPA R&D, Engineering and Production for Automatisation, Romania. <http://www.ipa.ro> (retrieved 2004-04-22)
- [8] Center for Prospective Studies at the Technical University of Sofia, Bulgaria. <http://www.tu-sofia.bg/Bul/index.html> (retrieved 2004-04-22)
- [9] Alfa-Omega Communications Ltd., Estonia. <http://www.alfa-omega.ee> (retrieved 2004-04-22)
- [10] Gymnazium F.X.Saldy, Czech Republic. <http://kojot.gfxs.cz/web/> (retrieved 2004-04-22)
- [11] [www.elearningeuropa.info](http://www.elearningeuropa.info) (retrieved 2004-04-22)
- [12] <http://www.laboftomorrow.org> (retrieved 2004-04-22)
- [13] <http://www.eurofluent.net/> (retrieved 2004-04-22)
- [14] <http://www.school-plus.org> (retrieved 2004-04-22)
- [15] <http://www.exodus.gr/imutus/> (retrieved 2004-04-22)
- [16] <http://www.victec.org/> (retrieved 2004-12-18)
- [17] <http://www3.ellinogermaniki.gr/ep/motfal/> (retrieved 2004-12-18)

### Appendix . The twelve selected projects – title, theme, countries involved and URL

| Title                    | Theme                           | Countries involved                                                                                         | URL                                                                                                                                                        |
|--------------------------|---------------------------------|------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Selected Projects</b> |                                 |                                                                                                            |                                                                                                                                                            |
| Lab of Tomorrow          | Science                         | England, Germany, Austria, Italy, Greece                                                                   | <a href="http://www.laboftomorrow.org">http://www.laboftomorrow.org</a>                                                                                    |
| EUDOXOS                  | Science                         | Greece, Austria, Italy, Spain                                                                              | <a href="http://www3.ellinogermaniki.gr/ep/eudoxos/htm/index.htm">http://www3.ellinogermaniki.gr/ep/eudoxos/htm/index.htm</a>                              |
| Coldex                   | Science                         | Germany, Chile, Sweden, Spain, Portugal                                                                    | <a href="http://www.coldex.info">http://www.coldex.info</a>                                                                                                |
| Fluent                   | Language                        | Italy, Denmark, Sweden, Spain, Belgium, France, England, Netherlands, Norway                               | <a href="http://www.eurofluent.net/">http://www.eurofluent.net/</a>                                                                                        |
| Linc                     | Language                        | Belgium, Denmark, Finland, Sweden, Netherlands, Hungary, Italy, Estonia, Czech Republic, Lithuania, Poland | <a href="http://www.uia.ac.be/linc/linc.html">http://www.uia.ac.be/linc/linc.html</a>                                                                      |
| School+                  | Collaborative Learning/Teaching | Finland, Greece, Israel, Czech Republic                                                                    | <a href="http://www.school-plus.org">http://www.school-plus.org</a><br><a href="http://web.udges/tiec/orals/c2.pdf">http://web.udges/tiec/orals/c2.pdf</a> |
| AGROweb                  | Collaborative Learning/Teaching | Germany, Austria, Greece, Denmark, Portugal                                                                | <a href="http://www2.ellinogermaniki.gr/ep/agroweb/">http://www2.ellinogermaniki.gr/ep/agroweb/</a>                                                        |
| ZAP                      | Collaborative Learning/Teaching | All                                                                                                        | <a href="http://www.eun.org">www.eun.org</a>                                                                                                               |
| WebTV for Schools        | Collaborative Learning/Teaching | Denmark, Finland, Greece, Austria, France, Germany                                                         | <a href="http://www.students-webtv.com/index.php">http://www.students-webtv.com/index.php</a>                                                              |
| Victec                   | Personal and Social Education   | Spain, England, Greece                                                                                     | <a href="http://www.victec.org/">http://www.victec.org/</a>                                                                                                |
| HerodoteNews             | Collaborative Learning/Teaching | Austria, England, Finland, Romania, Bulgaria                                                               | <a href="http://www.zgis.at/e4news/">http://www.zgis.at/e4news/</a>                                                                                        |
| MoTFAL                   | Mobile Learning                 | Greece, Spain, Hungary                                                                                     | <a href="http://www3.ellinogermaniki.gr/ep/motfal/">http://www3.ellinogermaniki.gr/ep/motfal/</a>                                                          |

## Looking at the School of the Future

---

*Costas Tsolakidis*  
*University of Aegean, Greece*

### **Abstract**

Information and communication technologies are changing society. Education resisted as last conservative bastion but technology is penetrating and overflowing fast. The implementation of technology is taking place in a varied rate and manner. With existing technology there are new trends and methods that are gaining grounds in everyday life and in school practice. At school cross curriculum approach is gaining ground and in a more theoretical level the belief that knowledge can be gained from other sources as libraries, museums, archives and galleries. Finally virtual reality and games incorporating state of the art technology since they are deployed the market promise to bring a substantial change in the way teaching can be less boring and more adventurous. Training and a culture for technology could make the transition easier and more beneficial.

### **1. Advances in technology**

Information and Communication Technologies (ICT) have invaded dynamically in every aspect of contemporary life. In almost all organizations one can find nowadays departments that operate aiming to develop or to make wider use of ICT applications at the organisation's benefit. ICT are a substantial part in every system that bring about important and fast changes in work, at home, in economy, in civilization and in social integration. Inevitably they affect lifestyle at a increasing speed and gradually have also a considerable impact on the society's values by introducing new parameters and new issues to many activities. Their dynamic character and their significance are so high that some figures related to their uses have become indices of social and economic growth (e.g. number of personal computers per 1000 inhabitants, number of Internet connections, number of sites developed and experts on relative fields/professions per population unit). Some scientific and professional fields have been altered in a dramatic way by means of ICT such as medicine, (drugs, artificial limbs, DNA study, trans-

plants etc all directly or indirectly affected by ICT) communications (Internet, mobile phones, satellites etc) and others but not education.

## **2. Education and Technology**

Education, a fast growing of sector of social and economic activity that relates today's effort to tomorrow's quality of life, is definitely sieged by ICT. Everybody is aware of that:

Education specialists have already answered positively to the introduction of ICT in schools accepting that advantages are so many that they worth most problems related to ICT. Nevertheless, surprisingly enough, apart from the initial move of introducing computers and internet to schools there is no general strategy for further developments. Constructivism seems to favour ICT and this is important since it provides a well accepted theoretical backing for ICT in education. Yet something is missing.

Education will gain from technology. This statement is possibly correct but to what degree? How far is technology going to affect school? Will there be any school in the future? Will there be classes, curricula and modules? Will things in education change dramatically with the application of technology in school?

## **3. The Discussion**

We are doing the following discussion having in mind the contemporary – existing technology.

We assume that in the near future technology will develop not in a linear but in an accelerating but foreseeable speed. That means that it is difficult to predict or realize the extent of nonlinearities that may occur. However if one wants to make analogies, in the past societies have many times experienced the dramatic extensive effects of such nonlinear developments (for example the evolution from electronic valve to transistor to integrated circuit and from copper wire to optical fibres). In the next paragraphs some points of well known methods and technologies will be discussed. It is anticipated that these methods will have a great use and effect in the school of the future.

## **4. Scaling Issues of ICT in Education**

In order to have a sense of the magnitude and the speed of the deployment of ICT in education one has to examine some parameters, as they are reported below:

In assessing the dimensions of change, a time parameter should be taken into account. ICT have been introduced at schools but not simultaneously in every country and not in every school. Their introduction has gone through controversies, doubts, different attitudes and stances, syndromes of technophobia and weaknesses of ICT technology itself. All these seem to belong to the past. The introduction of ICT in education from now on is only a matter of policy, time and money. Those who decide to introduce ICT can now catch up much faster

than before since they have in front of them equipment and programmes which are friendlier in use, very efficient in operation. In the same sense, the technological environment will be much different, probably friendlier.

Since technology is not equally used in different societies, in assessing the dimensions of change, a space parameter should be taken into account. In the United States ICT is already used in education extensively, in Europe it is used up to a far lesser extent and in Third World countries it is almost not used at all. If we assume that the technological stages of the United States now are similar to the technological stages that the third world societies are going to meet some years later, then the present state of ICT in the USA's education can be considered as the target that the whole world tends to reach. This is a reference to a benchmarking method of assessing the situation.

Yet, development does not necessarily mean that all countries will follow the paths that present societies have followed. In the same way as the growth in some countries occurred without going through an industrial revolution, it is expected that each country may follow alternative ways for social and technological advancements.

It is necessary to find a threshold between what constitutes a big or systemic change –i.e. one that signals the beginning of a new era- and what may be considered as a small-scale development that simply improves an already existing system. For instance, is distance education a dramatic change in teaching?

## 5. The Challenge of Individual Subjects: Cross-Curriculum Approach

Adaptation of education to the new social, cultural, and economic reality and improvement of educational quality are main challenges of any educational system. Therefore educational change should be continuous, although sometimes it follows the pendulum model.

Interdisciplinarity, in the sense of a cross curriculum thematic approach is a new way of organising the curriculum aiming to address individual subjects in an integrated sense. According to such an approach, as an example, one can teach the subjects of mathematics, geography and language along the axis of a single project. According to the theory of constructivism, such an approach helps pupils to develop their own knowledge in a holistic and integrated way which seems to be closer to reality.

Cross curriculum thematic approach, as we have experienced it up to now, represents teaching a methodology and not the subjects it tackles. It is applied as a pilot method rather than as an indispensable part of the curriculum. An interdisciplinary application, usually in the form of a “project” and most of the times as an isolated part of a strongly cohesive traditional curriculum has not many chances to show its potential. Many parameters difficult to handle are hindering their extensive use as time, teacher's acquaintance with the subject and evaluation. Cross curriculum approaches are better handled with the use of ICT, since ICT are “multidisciplinary in themselves”. ICT help along many directions such as collection of information, calculations, writing, drawing and presenting. They help in the designing organising, managing and evaluating a multidisciplinary project.

Cross curriculum approaches are used a lot in the Multigrade schools, the “forefathers” of our contemporary school system. The reason for it is the different organisational scheme that is followed in these schools. Could these multigrade interdisciplinary teaching approaches based heavily on ICT be considered as grandfathers for something new?

This point seems to be a really interesting source of inspiration and, of course, a field for experimentation. Futurists envisaging the future school can work out an interdisciplinary curriculum based extensively on ICT as an appropriate teaching model for the school of the future.

## **6. The Challenge of the Third Person Experience: Virtual Reality**

Up to now all knowledge of humanity is stored and transferred using alphabets and other symbols. In the era of new technology not only the sound and the view (images and video) of reality can be conveyed, but also an integrated system of representation of first person experiences; virtual reality (VR). First person experiences are direct; do not require the use of symbols (such as language, letters and numbers) and they are subjective. On the other hand, third person experiences are indirect, require the use of symbols and provide the point of view or the beliefs of the one that conveys knowledge. As an example, seeing a movie is a totally different experience than having someone/something describe to you that movie. In theory, VR places the user in a synthetic 3D environment without restrictions -same or completely different from reality- where he/she is free to select his/her own path, to freely explore anything, whenever and whichever way he/she likes, to manipulate time and space. Thus, the user has first person experiences and creates reconstructions of the real world that she/he encounters. Learning in such an environment is definitely a dynamic process determined by the user who sets the aims and changes them at will and the outcomes of the training process differ from individual to individual. In addition to all the above, VR can also provide third person experiences if we choose to limit what the user can do in the synthetic environment.

The technical and financial parameters of VR are favourable now and since offers a totally new environment for teaching experiences and skills unheard off in the past, it will be used extensively in the school of the future.

## **7. Games**

A new fast spreading entertainment for students and young people are games and these form a new way to interact with technology. They carry important clues to interact with technology because they require cooperation and interdependence.

Young people play online not only for communication purposes or in order to find information but also because there are online activities which may be characterized as emotion-rich. Following the last 30 years diffusion theory, it seems likely that sophisticated simulations and virtual worlds will be the next innovative panacea in education. Smart and very friendly interfaces with the appearance of a well known actor, a dog, a friend and so on are expected to give personalized messages to the happy recipients of the new technology. Games are related to VR in many ways so there will be fusion between the two technologies.

It may well be that these games will be the effective and attractive teaching schemes of the future.

## 8. The End of the School Monopoly on Knowledge: Other Sources of Knowledge

Reports have shown that Archives, Museums, and Libraries have a great impact on culture as well as on personal and societal level of knowledge. No one doubts that it is difficult to talk about them in an aggregate way, since each Museum and Library has its own aims and its own way of operating. However we all agree that all of them can be considered as important tools for public knowledge at the service of scientists, researchers, teachers and students or anyone who visits them. The traces of their activities justify their function and define their uses. However how many can visit them? In the new era of Internet and Communication, electronic Archives, Museums and Libraries have a lot to offer to education. Most important they can reach those who have access to ICT and their contents can be available as authorised and organised information to students and educators.

By means of such electronic museums, archives and libraries, ICT users learn how to approach new fields of information, evaluate and select information, get material at a distance (archival, photographic, museum and bibliographic), comprehend structures, handle general educational programmes, convert the new coming information elements into knowledge and productive ideas and reach intellectual maturity. This is not easy: It requires attention and high level of collaboration between teachers and students, but it opens new ways in knowledge and promotes educational attitudes and methodologies.

The ICT era signals the end of the school's monopoly of knowledge. School as producer of knowledge has already entered in a "market" that becomes more competitive as time passes. It will survive if it differentiates its roles with respect to knowledge but also to teachers care and communication.

For the school of the future, administration will be a minor user of its communication infrastructure.

## 9. How Can We Participate in Shaping the Future?

Technology is developing and this evolution up to now was irrespective of the needs of education. If education was to use technology, it had to adapt to it. It is important however for education to take an active role: Education has to define its needs and ask for purposed-built technology and for made-to-measure applications. We have seen some cases along these lines, one is the less-than-a-hundred-dollar computer that is negotiated between people of education and technology nowadays. Such an active role requires:

1. Research in educational technology and development of new applications that will make teaching more effective;
2. Research in education that will develop new theories, methods and strategies and will lead to a systemic reshaping of the curriculum;
3. Political will for this change and brave decision as to what is to be included in the curriculum;

4. Teacher training in ICT, so as to discover the capabilities of technology, to get familiarised to them and to fully exploit their capabilities.

#### 10. Conclusions

If we ask pupils (and teachers) we shall reach the conclusion that today's school is boring, especially if compared with other fields of life. The future's school, relying on ICT, can become a place where students work, play and learn while engaged in much more enjoyable activities.

Our overall opinion: Technology broadens our horizons and gives us an option. We have to redevelop new strategies and new plans to use it. But before that we need to develop a culture for technology through knowledge.

Technology has a great potential: It is like a language. All of us have to learn it, to master it, to communicate and to create using it. We have just started living with technology and we have still a long way to go.

Technology is like the wind. Education should open its windows, let the wind come in and develop sails that will exploit technology in a sustainable way and explore the ever sustainable knowledge.

### 11. References

- Clegg E., 2004, "Into the future", Threshold Magazine, Summer 2004  
Education and Technology: "Future Visions", 1995, September, OTA-BP-HER-169  
Thornburg, D., 1997, "2020 Visions for the Future", <http://www.tcpd.org/thornburg/handouts/2020visions.html>  
Tsolakidis, C., 2004, "ICT in Education: the Dawn of a new era or the development of an accessory?", International Symposium on Advanced Technologies in Education, Kefalonia, Greece, 4-6 July

## Virtual Observatory : The D-Space Project

*Elena Tarlaki,  
Head of Research Programs Division, OTE  
99 Kifissias Ave., 15124 Athens, Greece  
etarlaki@ote.gr*

*Information sharing is critical because intellectual assets, unlike physical assets, Properly stimulated, Knowledge and intellect grow exponentially, when shared.*

*James Brian Quinn - HBR 1996*

### Abstract

The aim of D-Space project is to deploy a virtual science thematic park that will connect schools, universities, science museums and parks with a network of robotic telescopes around the world. It is an eighteen months' validation project, co-funded by eTEN, with the ambition to provide a real service to the potentials users, supported by a viable business model. The offered service will give the opportunity to remotely located users to perform observations by using the robotic telescopes of D-Space.

### 1. Introduction

It is well known that all great ancient civilizations were particularly interested in a unique resource of knowledge: the sky. The sky, with all its planets, has always fascinated the mind of the people, has always been a driver for the search of scientific truth. This ancient need is originally conveyed in the D-Space project, by the full deployment of the contemporary technological solutions. On top of this need, the advancement towards the knowledge society, depicts e-learning as a tool that has to be developed as well, evolving the way of learning towards a more informal self-controlled one, making real the dream of lifelong learning. The aim of D-Space project is to deliver a real, viable financially, service, by deploying a virtual science thematic park, that will connect organized scientific communities and individuals with

a network a robotic telescopes, around the world.

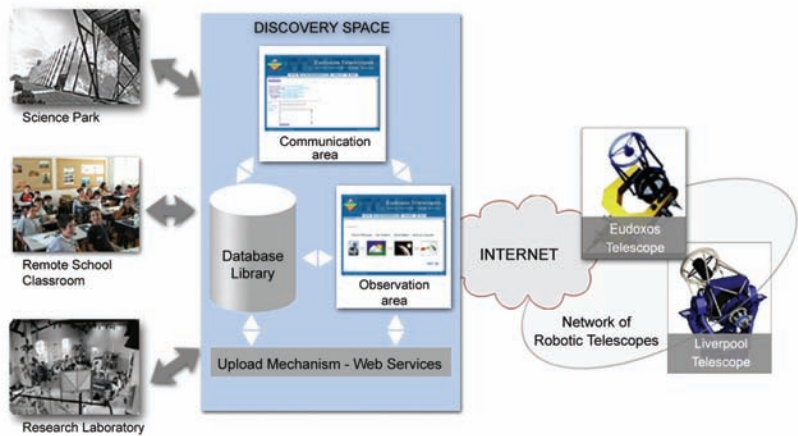


Figure 1: Overview of D-Space system.

2. D-Space Approach

D-Space has its foundations to the EUDOXOS platform, which was developed in the EUDOXOS project [1]. The interface and all associated tools are web-based. The service is currently running for a hundred schools from different European countries. The schools are connected to the telescopes and are performing day and night observations facilitating the five telescopes of the participating observatories. Namely, there are two telescopes in Kefalonia (Greece), the Liverpool Telescope, which is the largest robotic telescope in the world and is located on the island of La Palma in the Canaries, and two telescopes in Herstmonceux (UK).

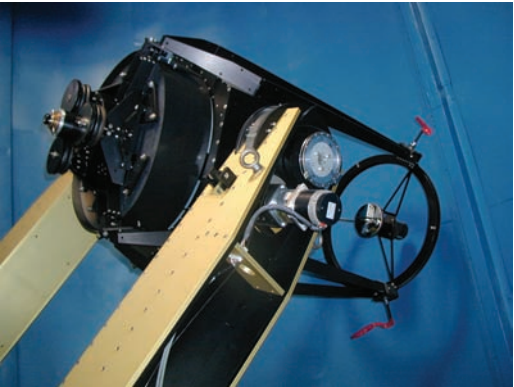


Figure 2: Andreas Michalitsianos Telescope, located on mountain Eudoxos of Kefalonia island

It is apparent that D-Space is based on a distributed system with observatories distributed across the globe. Each observatory hosts at least one telescope server to store information that is local and relevant to each telescope at that observatory, including telescope properties, schedule, and availability. This information is stored in a virtual telescope object. There is also a main D-Space server that hosts the D-Space platform, the scheduler and the polling and updating agent. The last one communicates with the robotic telescopes.

D-Space platform has four key components, namely the Web services, the Communication platform, the Observation Area, the Upload Mechanism for managing the telescope resources and the Resources Database/Library. The access to the tools requires registration. The user information will be stored securely in the Database and will be available only to authorized persons. Users have to log on for each session. Registration will avoid the use of persistent cookies and will allow the system to identify the unique individual using the telescopes at that moment in time, as at school and even in a home environment, multiple users share a single computer. User preferences will be stored in the Database.

The web-based services offered by D-Space platform include: registration and authentication services for all users, profiling services based on the registration and the authentication services, and customization and personalization services.

The D-Space Consortium is comprised of different market stakeholders, each of them conveying its expertise and commitment for the successful delivery of an integrated D-Space service. Namely, OTE S.A. [2], the largest provider of telecommunication services in Greece, is D-Space coordinator. OTE is currently collaborating with Ellinogermaniki Agogi (EA) [3] and the Research Foundation of Kefallonia (RFK) [4] in order to create an advanced communication system (including satellite link through DVB-RCS platform utilization<sup>5</sup>) for the EUDOXOS observatory. OTE has great interest in deploying such advanced services over wired and wireless broadband networks for Greece and the Balkan area in general. Q-PLAN S.A. is responsible for the Market analysis and the development of the Business Plan. TELEFONICA I+D [6] will provide the broadband services for the data transfer from the telescopes to the users. TELEFONICA has great interest in the specific case not only for deployment in the Spanish market but also for exploitation in Latin America (through the collaboration with ESO). The Telescope Technologies LTD [7] has pioneered the manufacture of large fully automated (robotic) telescopes using state-of-the-art systems developed for some of the world's largest and most sophisticated conventional telescopes. It has brought this endeavor to a successful conclusion with the manufacture and delivery of four 2m telescopes which are the largest robotic and most advanced technology telescopes of their class in the world. Ellinogermaniki Agogi (EA) is a private educational institution which introduces advanced technological applications in real school environments. The group is mainly working on the determination of the implementation parameters, on the pedagogical evaluation and on the validation of the proposed applications. Ellinogermaniki Agogi is the main pedagogical partner in the EUDOXOS project and coordinator of the school network. The group has also designed and developed the EUDOXOS platform on which the D-Space system will be based. Ellinogermaniki Agogi is closely collaborating with the Research Foundation of Kefalonia which runs the EUDOXOS robotic telescope which will be used during the pilots. The consortium includes two science centres, the Research Foundation of Kefalonia and the Observatory Science Centre at Herstmonceux, which are connected to the telescopes of the D-Space service in order to give the opportunity to their visitors to perform real observations. The MENON Network will coordinate the validation study of the D-Space service by extending the trials of the system to a big number of users across Europe and by setting up the

D-Space User Group. Finally, the dissemination and marketing strategy of the project will be supported by the involvement of the European Physical Society which represents over 80,000 members and physicists through its 38 national member societies.

The D-Space project main objectives include:

- a. Feasibility study of the operation of a network of remotely controlled robotic telescopes.
- b. Extended market survey for the estimation of the size of a target market and market potentials.
- c. Extended validation phase of the D-Space service in real environments.
- d. Feasibility study of the business case for the stakeholders involved.

The potential customers are divided in four major categories; educational institutions (e.g. schools), research institutes, scientific museums, (e.g. science centers and parks) and wider public (individuals). It is foreseen that the main target market will be formal learning institutions – schools and universities - and informal learning establishments (science centers and science parks), all over the world. The end user in this case will be a student, an educator or a researcher. Additionally, the end-user might be a visitor of the science centers and parks. The user will be provided with the services by the affiliated institution and he/she will be able to make astronomical observations through the use of remotely robotic telescopes during the teaching and learning procedure or in the framework of his/her research. The visitor of the science parks will have the chance to experience unique phenomena and to be involved in playful learning activities.

More precisely the user has the potential to use the following services:

- On-line access to the network of the robotic telescopes (on-line or scheduled requests)
- Access to scientific data and resource archives (data and images)
- Access to a central data archive, making use of a common archive and distribution system
- Access to educational material and interactive tools (allow for data representation and analysis)
- Access to teacher resources (e.g. professional development materials, lesson plans)
- Student-centered materials (e.g. data library, communication area, student's magazines)
- On-line training courses at different levels (for school students, for university students, for the wider public)
- Information on specific events (e.g. transit of Mercury or Venus)
- Participation contests (the contests will cover the levels of all targeted groups of users, e.g. scientific contests, best science project contests for students, best photo contest)

for the wider public)

- Participation to conferences, workshops and summer schools (the users of the service will have the opportunity to visit the observatories during different events)

The framework of the D-Space services is developed on two axes: formal and informal education. On one hand, in formal education, an important purpose of the service is to improve science instruction. The participating classes could control the telescopes 'live' via internet. Also, they can order their own observations in a preferred date, while the images, which are delivered, will be calibrated and analyzed by the students using simple image-processing software. In elementary education, the school teachers could develop creative, hands-on interactive astronomy lessons over the internet using D-Space network of robotic telescopes, to meet the needs of school curricula. These would be suitable for small-group collaborations and would include automated image acquisition service and/or observatory control as required to complete the lessons, plus the use of copyright material on the D-Space web site. In university education, the telescope network will be used to improve the quality of science instruction at the university level, while offering to the students the opportunity to realize their own projects and to gain experience in carrying out independent scientific research. Astronomy (or other closely related fields) students and faculty can use the D-Space service for teaching practical astronomy laboratory techniques and research astronomy courses (that is, a minimum of related theoretical background is required). Essentially, (due to the nature of telescopes) optical observational techniques can be taught.

In parallel, D-Space will offer on-line astronomy courses to users (individuals or groups). The theoretical background of such courses could be covered through lecture notes that professional astronomers collaborating with the consortium would create and assign readings of textbooks in libraries or on the Web. Scientifically, through the robotic telescopes network it will become possible to perform time-intensive projects, where a series of measurements and observations are necessary, which otherwise would require enormous efforts from the professional astronomy community.

On the other hand, in informal education, the service will offer to users from all over the world, the unique opportunity to control professional astronomical observatories in real-time for self-directed astronomy studies or personal enjoyment. Using the Internet, private users would gain full control of the virtual observatory, commanding its robotic telescopes and cameras to capture images of the sun, moon, planets, galaxies and other deep sky celestial objects in real-time much like a professional astronomer. Images can also be obtained using automated requests, without having to control the telescopes directly, which is a convenient way to acquire multiple images during late night hours. In this way, the requested data will be taken on the next clear evening/day and returned via email. The private users will have to first sign-up with our service for a fee (per hour or per night) in order to control the various (one or more) telescopes, or in order to request specific object images. Once they have purchased the credits, they will be able to book observing time or make specific image requests. Upon agreement, there will also be provision for refunding if the requested observing cannot be performed on time (e.g. due to instrument problems or unfavorable weather conditions).

### 3. Conclusion

D-Space's ambition is to contribute to the education process by inspiring and motivating young people to pursue careers in science. It aims to engage the young participants in sharing the experience of exploration and discovery. In parallel, D-Space will enhance awareness and understanding of the scientific and technological advances of contemporary society, without omitting to link them to the history and evolution of the human mind and society, where there exist the roots of modern astronomy. Nevertheless, D-Space will be considered as a success, in case that it will manage to provide a real service to the potential users, supported by a viable business model.

### 4. References

- [1] <http://www.ellinogermaniki.gr/ep/eudoxos>
- [2] <http://www.ote.gr>
- [3] <http://www.ellinogermaniki.gr>
- [4] <http://www.rfk.gr>
- [5] <http://www.ea.dias.gr>
- [6] <http://www.tid.es>
- [7] <http://www.science-projects.org>

## WEB TV for Schools

---

*Caroline Schleiss*  
*DIGITAL-BROADCAST-CHANNEL (DBC)*  
*Switzerland*  
*[schleiss@digital-broadcast-channel.com](mailto:schleiss@digital-broadcast-channel.com)*

### **Abstract**

The today's multimedia facilities allow multiple and interactive communication. It is possible today to have of course access to a dedicated internet community multimedia channel. Due to the unlimited technical possibilities, the community will be able to create, upload, animate and manage alone the content.

### **1. Introduction**

The today's multimedia tools and channel allow multiple and interactive communication. Internet is not only a transmission pipe, but offers numbers of new possibilities that one has just to choose and to apply.

Let's have a look at the existing example of that community channel: the Web TV for Schools, created in only 24 months in cooperation with the Ellinogermaniki Agogi team and managed by the schools themselves.

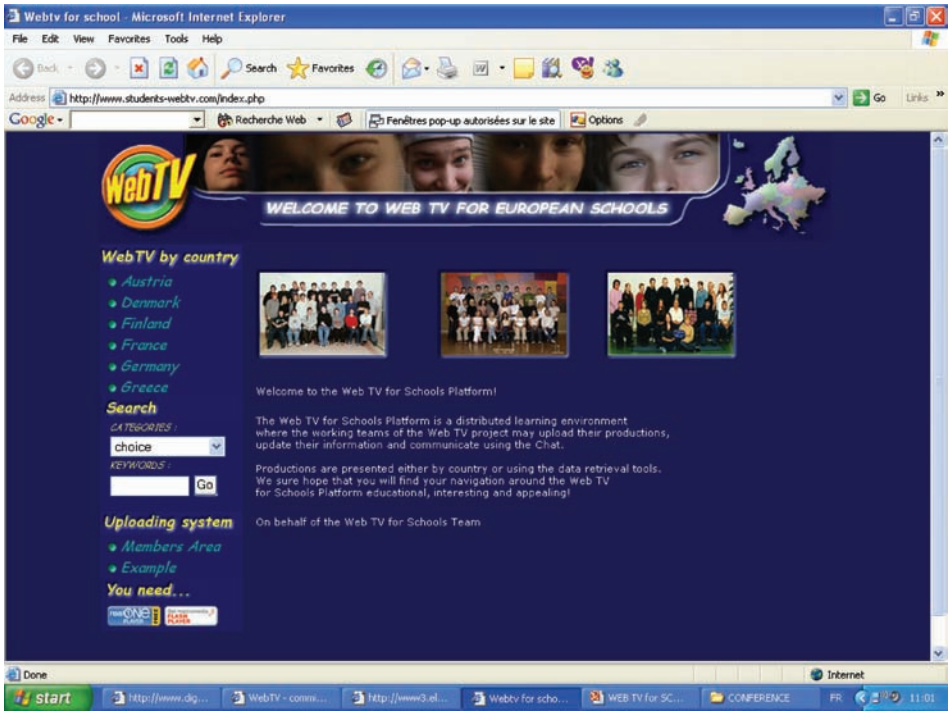
### **2. The channel**

It's a dedicated channel, realized for schools from 6 European countries, which have the possibility to create each their own content and to exchange with the other partner countries. Especially interesting is, in addition to traditional radio or traditional TV or compared with a current website, the easy accessible interactivity of that platform through specific interfaces.

The multiple segments of the channel can be active on open and/or privative mode.

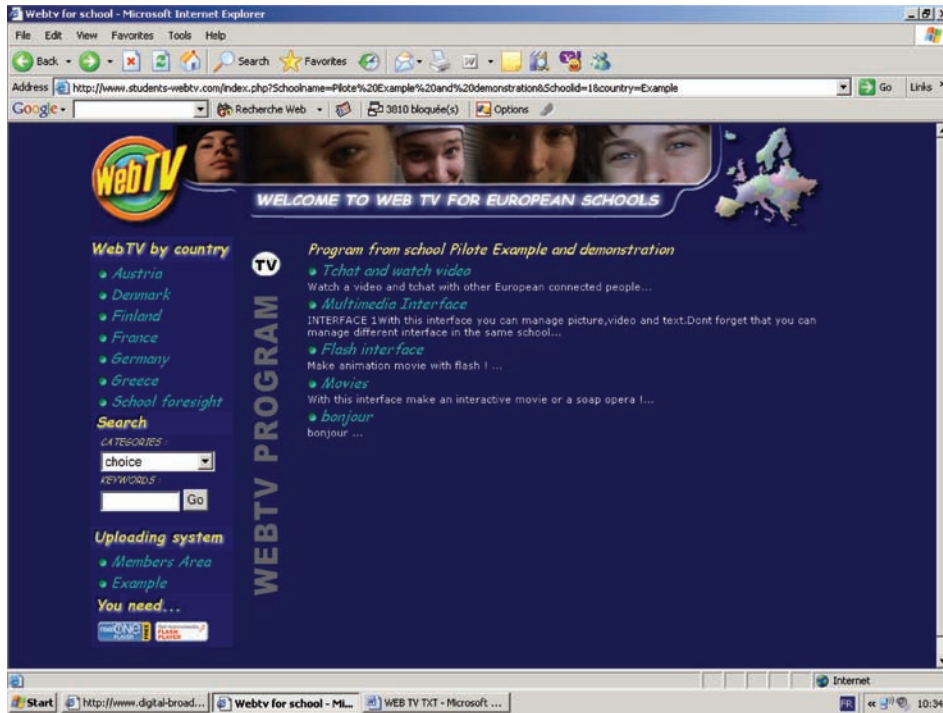
The general access is free for public, but there are also restricted areas protected with access codes for managers, teachers, tutors, etc. Even the channel itself can be shared or dedicated to a specific group's communication.

3. TV channel's home page



This is the general access gate leading through the links to the next public parts of the channel and/or to the restricted areas like the member access page, where the user has to identify himself to be authorized to continue.

#### 4. Interfaces :Examples



Behind this page, when the user is identified, he has to decide the action he wants to undertake.

Between these interfaces, he has to choose the presentation's model for the student-created content:

- Chat with visualization of a video
- Multiple visualization (photo, video and text)
- Flash interface
- Video with interactive shot action.

The interface's construction leads the user easily through all the uploading process with simple clicks to fulfil the content's uploading.

The content can be created by:

- Students (entertainment, culture)
- Home work (graded or not)
- Teachers (lessons, exchanges)

Content produced by the students represents a playful method to:

- learn communication,
- learn cooperation within a production team
- learn to accept spectator's criticism
- enlarge knowledge
- use contemporary tools from the “blank paper to the wave and the screen”

Content produced by the Teachers might be:

- Interactive lessons plans (for free access)
- Interactive communication between teachers
- Live and/or on-demand audio exchanges (free or restricted access)
- Dedicated Radio-TV channel, with thematic programs and animations

The technical transmission facilities are the existing ones, adapted to the specific educational program, following the local and financial possibilities of the interested communities.

## **5. Conclusion**

In conclusion, it is possible today to have access to a dedicated internet community multimedia channel, with unlimited technical possibilities. Besides the concrete functionality definition and the adapted channel and server creation, the necessary tasks to take into account are comparable to any traditional media production:

- Editorial tasks,
- Audio or audiovisual production
- Encoding
- Uploading
- Live programs.

## **Bridging the Digital Divide: Web-based E-Learning for Medical Practitioners in the Developing World**

*Theodoros N. Arvanitis, Evi Chryssafidou*  
*Dept. of Electronic, Electrical & Computer Engineering*  
*University of Birmingham, United Kingdom*  
*t.arvanitis@bham.ac.uk, e.chryssafidou@bham.ac.uk*

### **Abstract**

This paper presents our experience in organizing e-learning seminars for medical practitioners in Bangladesh, in the context of the 'E-health & Learning' project, an European Union funded initiative. The work consisted of three important research phases: i) a needs analysis regarding the Bangladeshi clinicians' views, attitudes and practice concerning Evidence Based Medicine (EBM) and Information and Communication Technologies (ICT), ii) the broadcasting of web-based video streamed medical seminars, and iii) the delivery of self-directed web-based asynchronous lectures with an interactive content structure. The work explored the feasibility of web-delivered distance learning short courses focusing on EBM. This paper reports the observations and findings from the educational needs analysis of medical practitioners in Bangladesh and some findings on their learning experiences, based on the implementation of an accessible and affordable e-learning technology solution.

### **1. Introduction**

The use of advanced information and communication (ICT) technologies has transformed the arena of education, from the level of primary school to the level of professional training. We are witnessing a rapid development and deployment of educational technology innovations that advance our social and economic development goals for a global society of equality and prosperity. In our information-intensive and knowledge-based world, there still exist many challenges in bridging the divide in educational opportunities between those who have and those who have not. Despite this divide, efficient transfer of educational innovation, through the appropriate use of ICT can support the educational needs of the citizens, at all levels, in

countries of the developing world. In this paper, we are examining the use of accessible and affordable web-based e-learning technologies for the professional training and educational development of medical practitioners in Bangladesh and evaluate their success in bridging the gap between the developed and the developing world.

Limited continuing medical education in Bangladesh, isolation of the healthcare practitioners, and their growing need to acquire skills for accessing and critically appraising web-based medical literature make the use of information and communication technologies more and more relevant. The e-Health & Learning (e-HL) project, an EU Asia IT&C funded research and development effort<sup>1</sup>, has actively promoted the idea of accessing web-based medical guidelines and medical literature as part of the medical practice, in developing countries such as Bangladesh. The project aimed to train healthcare practitioners to keep themselves informed about new diseases and treatments. The paper explores the feasibility of web-delivered distance learning courses on Evidence Based Medicine and discusses proposed indicators of educational effectiveness in the different types of web-based seminars.

## 2. The Context of the e-HL project

Practicing EBM requires a positive learning attitude, use of information and communication technologies (ICT) to access relevant medical guidelines, reviews and primary literature, and relevant critical appraisal skills [1]. The 'E-health & Learning' project activities included the organization and diffusion of a series of seminars on diagnosis, therapy and prevention of relevant to the Bangladeshi population diseases or other medical conditions. These seminars attempted to raise awareness about EBM. The seminar themes were accompanied by simple ICT skills training, including accessing and using medical databases, improving practitioners abilities for critically appraising medical literature, and allowing the asynchronous communication and information exchange between European medical experts and Bangladeshi medical practitioners.

The 'E-health & Learning' project has been developed in three phases:

- i) Collecting information about Bangladeshi clinicians and their professional education needs: A needs analysis phase focusing on Bangladeshi clinicians' views, attitudes and practice concerning Evidence Based Medicine (EBM) and ICT, which until now remained unexplored.
- ii) Delivering the continuing education medical seminars via video streaming, available at the project's Web portal ([www.ehealth.bham.ac.uk](http://www.ehealth.bham.ac.uk)).

---

<sup>1</sup> e-Health & Learning (e-HL), contract reference ASI/B7-301/97/0126-71 – ALA 97/0126, is a 17 months project co-funded by the European Commission (EuropeAid Co-operation office) within the Asia IT&C programme, 'Liaise with European IT&C Initiatives and Programmes' component. The project was completed in June 2004 and was coordinated by the Università Cattolica del Sacro Cuore, involving three additional partners from UK and Bangladesh, namely The University of Birmingham (UK), The Bangladesh University of Engineering and Technology (BUET), and the Sustainable Development Networking Programme (SDNP) of the Bangladesh Institute of Development Studies.

- iii) Finally, the planning and implementation of asynchronous web-based self-directed e-learning lectures, build with an interactive content structure in mind.

In following sections, we describe our experience and findings of the collection of educational needs phase of the project and discuss the observations and lessons learned from the seminar and web-based self-learning phases of the research work.

### 3. Background

In Bangladesh, as in many other developing counties, medical practitioners often operate in relative isolation, dealing with diverse health care needs, poor health care infrastructure for diagnosis and treatment, and limited number of specialists. There is a great difficulty in retaining specialists in non-urban areas. Tertiary care hospitals are mainly concentrated in urban areas, where large segments of the population have no access due to high levels of poverty and lack of state-provided social security. Barriers in accessing continuing medical education (CME) are raised by the remoteness of major academic centres, especially for rural physicians, the limited time owned to practice responsibilities, and the cost of the CME training [2].

Many of these problems are related to the extended private care system in Bangladesh and the lack of public national healthcare structures. According to an earlier report, published in 1995 [3] there are 24,000 medical graduates in Bangladesh of which only 8,500 are working in Government health services. According to same report, the Government has never, or until the time of the WHO publication, felt the necessity of vocational training for general practitioners who are providing health services to eighty percent of total population. Despite these difficulties, progress is being made towards the development of the discipline of family medicine in Bangladesh [3]. According to a later study, irrational and inappropriate prescribing was observed in both graduate and non-graduate medical practitioners in rural Bangladesh [4]. An opportunity to meet some of the needs of Bangladeshi physicians, based in both rural and urban communities, could be pursued in web-based continuing medical education (CME). Videoconferencing is found to be an acceptable medium for the delivery of continuing medical education, with encouraging findings as to participants' satisfaction [5]. With regards to knowledge transfer though, when compared to conventional lecturing, interactive videoconference does not usually produce significantly higher results in knowledge acquisition [6]. However, for shorter videoconference sessions, of around two hours, there have been findings of increased immediate and long-term knowledge [7] [8]. Furthermore, it is noted that courses of continuing education, specifically designed for interactive videoconferencing, significantly increased post-test knowledge [9]. Most of the studies conclude that videoconference is an acceptable medium for delivering CME [10]. The circulation of handouts prior to the videoconferencing sessions can increase the value of the delivery, while participants reported examples of changes made in their practices as the result of the CME programs [10]. 'Videoconferencing has the potential to bring the benefits of small-group, practice-based learning to many physicians; however, strict attention to videoconferencing techniques is required. Cost is also an important consideration' [11].

#### 4. Educational Needs Analysis Among Bangladeshi Medical Practitioners

Practicing EBM requires use of information and communication technologies (ICT) to access relevant guidelines, reviews and primary literature, and relevant critical appraisal skills. In Bangladesh, clinicians' views, attitudes and practice concerning EBM and ICT remain unexplored. We conducted a survey of medical practitioners in Dhaka to investigate these and we reported some of our initial results at [12]. Here, we provide a full account of our educational needs analysis.

We randomly selected 300 practitioners from a database maintained by a consortium of diagnostic centres and nursing homes in Dhaka. The sampling method used, ensured representation from various clinical specialities. Our questionnaire assessed attitudes and practices concerning Evidence Based Medicine and the use of information and communication technologies in professional practice and continuing education. The questions were developed based on existing validated instruments [13][14]. The practitioners involved in the study were personally invited to participate in the survey. Of the 226/300 (75%) who accepted the survey, there were 157 general practitioners, 14 cardiologists, 5 clinical epidemiologists, 8 oncologists, 9 orthopedists, 17 respirologists, and 16 gynecologists. The questionnaires were hand delivered and collected on the same day, by the field researchers. Due to incomplete responses in returned questionnaires, 207/226 (92%) questionnaire sections on EBM and 224/226 (99%) on ICT were analysed. The responses were entered into a spreadsheet and data were summarised as percentages of the above denominators.

With regards to ICT, about half of the participants (118; 52%) owned a computer, 95 (42%) had never used e-mail communication and 111 (49%) had never accessed the Internet to search for information. Questions investigating how often the respondents accessed and used evidence in their practice showed that 72 (34%) never looked for evidence, 86 (42%) did occasionally, i.e. on average once a month, 18 (8.7%) checked for evidence every 1 to 2 weeks, while 31(15%) searched for evidence at least once every week.

Overall, 161 (77%) respondents believed that EBM was essential to their practice, and 172 (83%) acknowledged the need to receive more training in EBM. In assessing research evidence, 136 (65%) felt confident, ranging from slightly (42; 20%) to strongly (36; 17%). However, their confidence was not supported by an understanding of EBM terminology, e.g. 50 (24%) were not familiar with 'assessing study design', 52 (25%) with 'evaluating bias' and 62 (30%) with 'evaluating statistical tests or principles'.

According to our results, there is limited access to and use of ICT in Bangladesh. Nevertheless, the participating practitioners showed a very positive attitude towards EBM and strongly acknowledged the need for further training. However, as noticed in other surveys [15], the respondents' confidence in assessing research evidence did not reflect their ability to critically evaluate medical literature.

This questionnaire survey [12] allowed us to construct a database of medical practitioners who were, potentially, interested in participating in further professional training. A subset of 61 clinicians, who had limited ICT skills, has been identified to form the cohort of participants on the "videoconference-like" web streaming seminars delivered within the project. 23 practi-

tioners more familiar with IT were invited to participate in the final phase of the project and attend self-directed, web-based asynchronous interactive e-learning.

## **5. Web-based Video Streamed CME Courses Integrating the EBM Approach.**

One of the purposes in this project phase to appreciate the effectiveness and acceptability of interactive video streamed seminars, organised in lieu of videoconferencing, as a medium for providing continuing medical education in Bangladeshi urban and rural communities. The project, linked clinical and health informatics specialists of the Università Cattolica del Sacro Cuore (UCSC) in Italy, Rome and of The Birmingham University, UK with a small rural medical community (Community Hospital Mymensingh) and a larger urban group (Comfort Nursing Home, Dhaka) for the provision of continuing medical education.

Eight seminars were delivered to medical practitioners in Dhaka and Mymensingh. The original activity plan was to deliver the seminars via videoconference, nevertheless a series of technical limitations in Bangladesh's communication infrastructure obliged us to abandon this solution over a less technologically demanding one, the 'video streamed seminars'. The lectures were video taped and streamed to Bangladesh via the Internet (i.e. encoded into a format so that they could be viewed or download over the internet). The participants watched the seminars in a classroom specially set up for the need of a video seminar. The video streamed seminars featured the lecturer and the power point presentation accompanying the seminar. The streamed video either switched between the lecturer video sequence and the slides video sequence or the lecturer video sequence was reduced to a small square and projected over a corner of the slides. The participants were also distributed handouts of the power point presentation to make the reading of the slides easier.

Most of the seminars were structured based on the EBM approach, while more practice-based content, e.g. a seminar on the care of multi-trauma patients, was delivered in a more traditional approach. The arrangement of video streamed seminars has compromised the synchronous interactivity between the lecturer and the participants during the seminar. To moderate this effect, a live interactive "Questions and Answers" Session (Q&A) took place at the end of every seminar, using the platform of Windows Messenger (a live chat platform).

After the end of the seminar and the Questions and Answers Session, the participants were asked to fill in a questionnaire addressing issues related to the delivery, relevance, and resources (e.g. handouts) of the seminar. Their understanding of the seminar content was also informally assessed.

Overall, we have observed that the transfer of medical knowledge from European practice to the developing world, especially on issues of treatment, should be cautiously adapted to local conditions, such as limited medical infrastructure and cultural idiosyncrasy. The Q&A sessions made it possible to bring in the 'discussion room' real cases, while exposing the difficulties of applying diagnostic and therapeutic procedures that are considered as basic in European medical practice.

The seminars managed to raise awareness about EBM and many participants replied enthusiastically about the integration of the approach in the seminars. However, more work is needed to achieve a shift from the traditional paradigm that relies on textbooks and medical authority towards a practice relying on strong research findings. An initial analysis of the Q&A session showed that the seminar participants were accepting the European specialists, who were presenting the seminars, as authorities in their fields rather than asking from them, as peers, to discuss their opinion in view of precise research findings.

One of the limitations in this phase of the work was the restricted access of the participants to computer facilities. Although EBM is closely related to accessing on-line databases, it was impossible for our seminar participants to access the medical literature, mainly because of the lack of infrastructure and their limited ICT skills. Although access was granted during the last two seminars, special ICT training courses had to be organized locally.

The informal assessment of the participants, examining the understanding of basic concepts returned rather discouraging results, according to an initial appreciation of our data. Access to on-line material provided, well ahead of the seminar may have prevented this effect.

## 6. Self-Directed Asynchronous Interactive Web-based e-Learning

The aim of this phase was to compare between different modes of delivering lectures, within a distance-learning context, and explore whether a more or less 'structured' way of integrating the EBM approach is appropriate. In the 3rd phase of the project, we have created a complete package of interactive video lectures with additional on-line learning material and accessibility to EBM resources on the Internet. Given the accessibility of EBM findings over the Web (journal, data banks, medical portals, etc.) the character of learning was inevitably mediated by the interactivity of information on the Internet. Accessing this information raises quite a few interesting issues. In this phase, through the use of on-line video-based lectures and interactive on-line EBM material, we were mainly concerned with how to guide the medical practitioners through this complex and widespread professional EBM practice information and knowledge, while training them to become critical readers of EBM resources.

We used the technology of Microsoft Producer for the production of the interactive video lectures. This software application can synchronise the video of a lecture, the lecture slides and hypertext files, linking to online databases and other online learning material. Learners can then play back these files on any web browser platform (as seen in an example in Figure 1). In effect, learners can have access to all this material on the same screen, play the video in small sequences defined by the slides themes, visit the hyperlinks, and complete given tasks at their own pace. It was hypothesised that, when the seminars graphs and figures are synchronised with the video and further definitions and clarifications coming from the hypertext links, there is greater understanding of the concepts presented. The results from this phase, showed an improvement in the learning of participating practitioners. Furthermore, we found that combining the narration with screenshots demonstrating the use of key medical web-based libraries and procedures on identifying primary medical literature on-line, can also help improve the skills of learners with limited experience in searching web-based databases. However, we have

identified that the complexity of technology can hinder learning and discourage learners with limited experience of on-line resources. Further training on IT skills is definitely required.

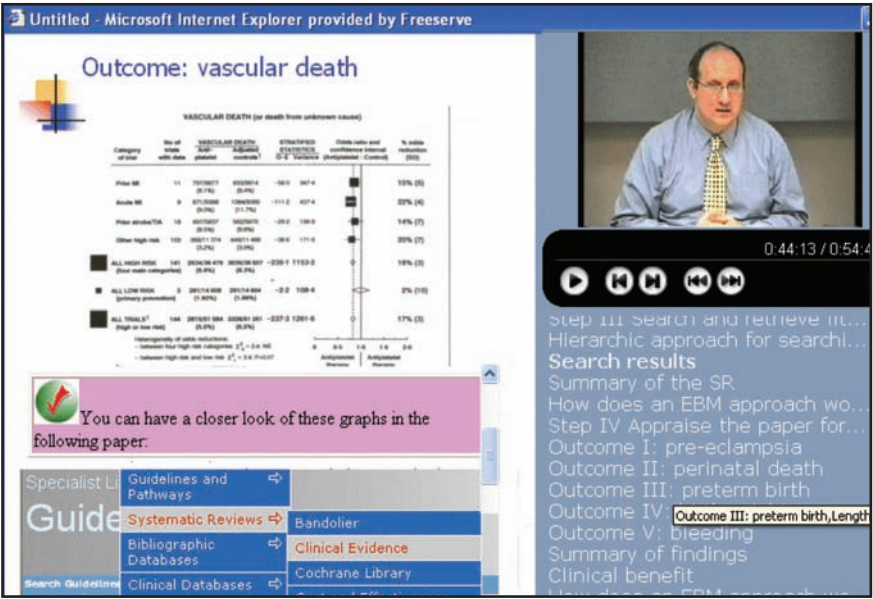


Figure 1: A Screenshot instance of a lecture on pre-eclampsia, delivered through MS-Producer.

7. Conclusion

A paradigm shift in clinical practice towards EBM can be embraced even in the poorest countries, where constraints on implementing effective health care may include lack of financial resources and political will [15]. Short Continuing Medical Education (CME) on-line courses integrating the EBM approach are expected to, at least, raise awareness about the importance of the EBM approach in developing countries, if not to provide or improve the skills for practicing EBM in everyday cases. Our project showed that the use of advanced, while affordable ICT technologies can bridge the digital divide in professional training between the developed and the developing world. The e-Health and Learning project has currently received follow-up funding (a continuation project to start in February 2005) from the same EU-Asia Co-operation initiative, in developing further the IT and health informatics skills of practitioners in Bangladesh.

## 8. References

- [1] Murelli, E., T. N. Arvanitis, 2003, "e-Health & Learning: The Bangladesh experience." *Technology and Healthcare* 11(5): 341 - 344.
- [2] Sackett, D., S. E. Straus, et al., 2000, *Evidence-Based Medicine: How to Practice and Teach EBM*. New York, Churchill-Livingstone.
- [3] WHO/Wonca, 1995, *Making Medical Practice and Education More Relevant to People's Needs*. Ontario, Canada, the Family Doctor WHO/Wonca Joint Publication.
- [4] Baqui, Q. B. O. F., S. A. R. Choudhury, et al., 1997, Prescribing pattern of graduate and non-graduate medical prescribers in rural Bangladesh. First International Conference on Improving Use of Medicines: ICIUM, Chiang Mai, Thailand.
- [5] Himpens, B., 2003, "The Pentalfa project. 4: Educational aspects." *Journal of Telemedicine and Telecare* 9(3): 171-175.
- [6] Loewen, L., M. M. K. Seshia, et al., 2003, "Effective delivery of neonatal stabilization education using videoconferencing in Manitoba." *Journal of Telemedicine and Telecare* 9(6): 334-338.
- [7] Hampton, C. L., P. E. Masmanian, et al., 1994, "The interactive videoconference: An effective CME delivery system." *J. Cont. Educ. Health Prof* 14: 83-89.
- [8] Gruppen, L. D., S. P. Hutchinson, et al., 1996, "An evaluation of the efficacy of interactive videoconferencing in residency and continuing education." *Academic Medicine* 71(1): S7-S9.
- [9] Rees, C. S. and D. Gillam, 2001, "Training in cognitive-behavioural therapy for mental health professionals: a pilot study of videoconferencing." *Journal of Telemedicine and Telecare* 7(5): 300-303.
- [10] McDowell, C. A., E. Challis, et al., 1987, "Videoconferencing CME programs to rural physicians: The University of Calgary videoconference program." *Family Practice Education* 33: 1705-1708.
- [11] Allen, M., J. Sargeant, et al., 2003, "Videoconferencing for practice-based small-group continuing medical education: feasibility, acceptability, effectiveness, and cost." *J Contin Educ Health Prof* 23(1): 38-47.
- [12] Chryssafidou, E., T. N. Arvanitis, et al., 2004, "South Asian health: what is to be done?: Skills of evidence based medicine need to be taught." *BMJ* 328(7443): 839.
- [13] Taylor, R., B. Reeves, et al., 2000, "A systematic review of the effectiveness of critical appraisal skills training for clinicians." *Medical Education* 34(2): 120-125.
- [14] Seago, B. L., J. B. Schlesinger, et al., 2002, "Using a decade of data on medical student computer literacy for strategic planning." *Journal of the Medical Library Association* 90(2): 202-209.
- [15] Awonuga, A. O., L. S. Dwarakanath, et al., 2000, "Postgraduate obstetrics and gynaecology trainees' views and understanding of evidence-based medicine." *Medical Teacher* 22(1): 27-29.
- [16] Garner, P., R. Kale, et al., 1998, "Getting research findings into practice: implementing research findings in developing countries." *BMJ* 317: 531-5.

## Mobile Technology in Education Mobile Learning Applications in Language Learning and History Education

---

*S. Savvas, S. Sotirou, E. Malliou,  
Research & Development Dept.  
Ellinogermaniki Agogi  
Athens, Greece  
savvas@ea.gr, sotirou@ea.gr, malliou@ea.gr*

### Abstract

The Ad-hoc.com project aims at the development of an innovative advanced multimedia language learning tool for European travellers who on location are willing to acquire certain language skills, in order to communicate with locals in the country of their destination. The Mobile Technologies For Ad-hoc Learning (MoTFAL) project is a joint initiative of pedagogical, cognitive science and technological experts, educators, and psychologists to research the possibilities of using mobile platforms with Internet access for educational purposes at school level. The project designs, develops, tests and evaluates a handheld learning environment based on emerging technology that facilitates in situ learning. This paper presents the basic principles of the Ad-Hoc.com and the MoTFAL project, the theoretical background of their development as well as the possibilities for their educational exploitation.

### 1. Introduction

Learning happens in various ways. Students learn in classrooms, but they also learn by exploring streams and parks, trying and failing to perform tasks, talking to friends etc. Adults learn in many of the same ways, by experience, by involvement, by talking with peers and experts, or by delving into a practical problem. All of these can be legitimate learning activities. Virtually any experience can be a learning opportunity, but often the resources to make it so are lacking. We are used to thinking of knowledge as something “stored,” “held,” or contained in a “body of knowledge.” That conception lends itself very easily to conceptions of learning as “acquiring knowledge,” collecting it from books, lectures, and other media. We are following

a different, complementary insight here, that knowledge is something active in situations and contextual in its very nature. Knowledge is something that happens rather than something that is stored and applied when appropriate. This approach is reflected in the pedagogical theory of contextual learning [1,2,3].

The idea of contextual learning is fully supported in the framework of m-learning application. In the word m-learning “m” stands for “mobile”, representing the back-stage mobile delivery technology. It is obvious that for the expansion of the idea of learning and the creation of learning schemes that are based on the effective use of motivation that arises when a student is faced with the stimuli, mobile devices with Internet access can offer significant advantages. Mobile technology actually offers the appropriate educational environment to assist learning activities both inside and outside the classroom [4]. Opposite to the limitations of working and learning only in the classroom or in the lab, mobile technology offers access to learning material regardless of location and time. In this framework mobile learning is translated into flexibility in accessing learning materials but also classmates and teachers anytime, anywhere. As Paul Harris in Goin’ mobile states mobile learning is the ability to enjoy an educational moment from a cell phone or a personal digital assistant [5].

Language learning and history education are among the disciplines that offer the appropriate framework as well as the motives for the introduction of mlearning applications in education.

## **2. Language learning independent of time and location: The Ad-Hoc.com project<sup>1</sup>**

The Ad-Hoc.com project’s [6] develops an innovative advanced multimedia language learning system that allows travellers (for business, leisure or educational purposes) to access the web through the advanced new communication applications (PDA applications, GPRS and UMTS) and acquire certain language information in order to communicate with locals in the country of their destination. These new applications allow for fast transfer of data (text, sound, picture and video) through the mobile device (phone, palmtop) of the user. The Ad-Hoc.com system serves users regardless of time and location. The system is presenting linguistic content embedded in its cultural context furthering the understanding of European’s cultural and multilingual diversity, as it is proven that the mutual understanding in the communication process depends not only on linguistic competence but also on the awareness and perception of cultural behaviour, cultural differences and similarities. The Ad-hoc.com project is mainly focused on two axes: PDA’s multimedia capabilities and short-range wireless communications technologies. Using tools like Embedded Visual Basic 3.0 and Embedded Visual C++ testing applications are being developed from scratch, to take full advantage not only of the mobility of the device but mainly of the exploitation of all multimedia capabilities, like download and reproduce audio and video files.

<sup>1</sup> The AD-HOC project is a European cooperation project (2000-2002), co-financed by the European Commission, DG Education and Culture, SOCRATES Programme, Lingua2 Action



*Figure 1: The PDA application of the AD-Hoc.com project*

The approach, which has been adopted in the framework of the project, is the scenario design method [7] as a means of defining suitable educational applications of the mobile technology. In the framework of the Ad-Hoc.com project a series of scenarios have been developed describing real life situations (Visit to a museum, at the library, at the restaurant, at the bank, during the break at the conference, admission, at the beach, at the hotel, business meeting, at the multimedia lab). Language learning information is presented through written text, audio and video. The piloting of the application is taking place in repeated cycles of learner-centered trials [8] in Greece, Italy, Austria and Germany. Each cycle includes the design, the development, the trials and the evaluation, which is the input for the next cycle in the product's development approach. The in-situ trials are not only meant for evaluation purposes but involve both students and teachers offering them the chance to provide feedback to the project and its technical and pedagogical aspects.

### 3. History education through mobile devices: The MoTFAL project<sup>2</sup>

The project MoTFAL- Mobile Technologies for Ad-Hoc Learning- [9] is a joint initiative of pedagogical, technological experts, educators, and psychologists to research the possibilities of using mobile platforms with Internet access for educational purposes at school level. The

<sup>2</sup> The MoTFAL project is a European cooperation project (2002- 2004), co-financed by the European Commission, DG Education and Culture, SOCRATES Programme, Minerva Action.

partnership develops, tests and evaluates learning schemes that are implemented on a hand-held learning environment based on emerging technology that facilitate in situ learning. The project engages mlearning applications in the field of history and science education.

The MoTFAL learning environment includes full access to digital resources, cognitive tools, knowledge visualizations, software mentors to help with learning to use devices such as digital cameras, organise and recall images and sounds of people and situations, knowledge sharing between students in different environments, contextual personal tools that change their behaviour based on where they are and the activity in progress. Students have the chance to be linked to video clips, PDF articles, and Websites.

The project includes an extended period of school-centred work. The aim is to help both teachers and students to actively participate in the development of the MoTFAL platform by giving their input and contributions. Furthermore the project proposes a student-centred approach in order to assure the maximal usability of the new tools as well as a realistic evaluation of the pedagogical effects.

In the framework of the MoTFAL project the pedagogical theory of contextual learning as well as the scenario design method gives the guidelines for the development of the educational material and the design of the educational process. In the partnership's vision the contextual learning in history education and the scenario design method offer a different approach and perspective to history teaching and learning.

#### 4. mLearning applications in history education in high school: a scenario example.

The teacher of a high school class takes the students to a field trip Parthenon for example. As they are visiting the monument the students are requested to connect to the specific area of the platform where the teacher has already uploaded the selected material concerning the history of the monument. Students are able to see pictures of the monument during the time, to see drawings of the monument. They can also have access to a video presenting how the monuments were and how it was related to the everyday life of the people living at that time. They can even find sound and video recordings of remarkable events of this specific period. Furthermore students are able to capture moments of their visit with the camera of the device and upload them to the server for future reference and also to add their comments and to continue their research by accessing web-sites.

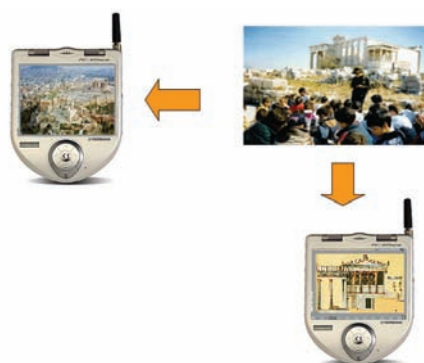


*Figure 2: Using their mobile phones and PDA devices the students of a high school class participate in an in situ history lesson.*

## 5. Conclusions

Today's ICT has significantly extended the scope for learning anywhere, anytime and the term mLearning has gained serious strength and influence in describing the future of education [10]. It is widely believed that technologies in the hand will engage young people in learning activities, start to change their attitude to learning and thereby contribute to improving their skills, opportunities and lives.

## 6. References

- [1] Lave, J., Wenger, E., 1990, *Situated Learning: Legitimate Peripheral Participation*. Cambridge, UK: Cambridge University Press, 1990
- [2] McLellan, H., 1995, *Situated Learning Perspectives*. Englewood Cliffs, NJ: Educational Technology Publications
- [3] Brown, J.S., Collins, A., Duguid, S., 1989, *Situated cognition and culture of learning*. Educational Researcher
- [4] J.Fleischman, 2001, *Going Mobile: New Technologies in Education*, Converge Magazine
- [5] Paul Harris, 2001, "Goin' Mobile" – Learning Circuits ASTD Magazine All about eLearning
- [6] [www.ellinogermaniki.gr/ep/ad-hoc](http://www.ellinogermaniki.gr/ep/ad-hoc)
- [7] Carroll, J. M., Rosson, M., 1992, *Getting around the task-artifact cycle: how to make claims and design by scenario*
- [8] ISO 13407: *Human-centered design processes for interactive systems* (1999)
- [9] [www.ellinogermaniki.gr/ep/motfal](http://www.ellinogermaniki.gr/ep/motfal)
- [10] Donna Abernathy, 2002, "@ work; Get ready for m learning" – On line teaching 4 libraries



## Moments of the Conference











