ESCALATE: The White Book

Chapter 1: General Introduction

Written by A-N. Perret-Clermont and B. Schwarz

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1.1 The objective pursued in the ESCALATE project

It is recognized that Science Education should promote understanding of scientific concepts and scientific practices instead of the acquisition of scientific facts. This general claim which is agreed upon most of educationalists, researchers and policy makers is not a trivial matter when it comes to find strategies to lead to such goals. Researchers in Science Education have claimed that argumentation may foster the acquisition of scientific concepts. However, engaging in scientific argumentation is a difficult endeavor. The use of enquiry-based strategies may provide procedures that sustain argumentative practices. However, it is difficult to design activities that combine argumentation and enquiry-based strategies. The pedagogical idea brought forward in the ESCALATE project was to bring technology to the service of education so to provide environments that make the integration between argumentative and enquiry-based strategies possible.

The ESCALATE project capitalizes on two environments that mediate argumentation and enquiry-based practices. Argumentation is enabled by the Digalo tool that has been developed in the DUNES project (IST-2001-34153), in which some of the participants in this SSA were involved. The Digalo tool provides a graphical platform in which participants may collaboratively construct an argument (on one computer or on different computers in a-synchronous mode) or participate in synchronous discussions. The argumentative map produced during the construction or during the discussion is an artifact that participants can exploit in further activities, as opposed to face-to-face discussions from which students cannot "physically" extract previous outcomes.

The second tool is in fact a series of tools – Microworlds, that fit ideas developed by constructionists, and that are alleged to enable learning through construction, bricolage, and "instrumentalizing" (transforming an artifact into an instrument, through which meaning is mediated) .Microworlds are open to manipulation, construction and de-construction of virtual objects as well as their behaviors and the relationships between them. Microworld are open for the students, allowing them to change, for example, the initial conditions of a physical phenomenon, isolate a specific factor and see how it influences a certain physical procedure, etc. In that sense, students can define the physical laws that dominate the phenomena, they can use the trial and error method to examine "what will happen if...", and they can transform the environment "so that ... will happen", etc. Microworlds such as those developed in the Learning Games project (LeGa, Greek Secretariat for Research and Technology, GSRT-03-26) that feature a 3D modeler for students to experiment and express their ideas, are available to students.

1.2 Specific objectives

If the general approach of the ESCALATE project is quite simple – the integration of argumentation and enquiry-based activities in the same environment is a difficult enterprise that necessitated an SSA project: In ESCALATE, we integrated the enquiry-based and argumentative-based approaches and use the technological tools we independently developed *in conjunction* - in classrooms and in other, informal learning environments like museums. More specifically we employed the research results of the DUNES and LeGa projects and implemented them in different educational frameworks. A well-designed learning environment was then necessary. We detailed this general

objective as a list of operative objectives:

(1) Implementing our approach to science learning and teaching, through the design of learning environments, by means of state-of-the-art of argumentation-based methods and tools, especially the ones developed in the DUNES project.
(2) Using technological tools – mainly "Microworlds"- designed to enhance science learning environments and by which students engage in representation, construction and experimentation with digital artifacts.
(3) Conducting the implementation of (1) and (2) above in the framework of several schools, science museums and other science learning environments in 5 countries: France, Greece, Israel, Switzerland and UK.
(4) Creating a "critical mass" of teachers, through proper training activities, who are capable of maintaining the argumentation-based science learning environments during and beyond this project's life.
(5) Compiling and analyzing all the data gathered and preparing a comprehensive volume describing the experience and issuing recommendations to guide the launch of similar initiatives elsewhere in Europe.

For the accomplishment of these primary goals, additional objectives were addressed, including:

- The design of "cases" to support learning activities featuring argumentative discourse in science.
- The design of computer-based educational scenarios to support enquiry-based learning combined with argumentative discourse in science.
- Training science teachers to design, animate, and evaluate argumentative activities, based on the above, in classrooms, science museums and other learning environments.

The accomplishment of the primary objective of the project – building a usable and effective learning environment that enhance science learning could not be easily measured or compared with any predefined magnitudes or criteria. The whole concept was very much a new one. We nevertheless developed measures that pointed at success or failure of the implementations in the different sites. The ways used by the different were diverse, some adopting qualitative methods, and some quantitative ones. We list here some of the ways we used to evaluate accomplishments:

(1) A first measure consists of listing the number of educational-science-activities created and implemented within the current science curriculum;
(2) Another measure refers to the number of teachers and students that used the proposed tools and methods in their science teaching and learning.
(3) We also evaluated the level of students' engagement (involvement) in solving scientific problems and discussing scientific conceptions.
(4) We evaluate the use of **scientific language**, a language that incorporates daily life speech acts (e.g., questioning, agreeing, objecting, clarifying or elaborating) with scientific speech acts (e.g., challenging, counter-challenging, refuting or appealing for different kinds of resources) by various students.
(5) In certain cases we used statistical methods to measure changes in mental models of scientific concepts before and after implementation of cases, or to measure the effect of some manipulations (such as the mediation of the teacher)

1.3 The White Book as a resource for researchers, educators and teachers

The White Book is aimed at integrating in one unified volume all the experience gathered by the partners in their respective countries, including a comprehensive account of the preparatory work, the activities themselves, the interaction with the community of teachers and an overall evaluation of the work and its outcomes. This ESCALATE White Book includes also a thorough analysis, by the partners, based on a macro-, project-wide perspective, from which useful recommendations (to teachers, educational authorities, other public and private players in the learning/teaching arena) is articulated. A member of the Swiss team visited all learning sites to observe in vivo how children learn in the new integrated learning environment and to report on differences of implementation. This White Book represents the means through which our project's heritage will be transmitted toward its further implementation elsewhere. The report, devised for unrestricted distribution, will undoubtedly constitute an important building block on the way to achieving the big impact we intend to generate in science learning all throughout Europe. This white book presents the theoretical back up of the project (chapter 2); the technological advances (Dunes-Digalo, Microworlds) on which it could rely and that have been adapted (chapter 3); and the best cases developed in the Escalate project (chapter 4). Then chapters 5 to 9 explore all the partner's experience with these cases in their respective countries, including a comprehensive account of the preparatory work: what strategies, methods, cases, have been designed, implemented, tested, then redesigned, evaluated and disseminated; how the teachers' roles have evolved during the course of the implementation; and also the participants' opinions. Attention is brought to the necessary adaptations required to meet the demands of the different realities of our European schools to implement the tools, cases and evaluations. This awareness makes Escalate a multidimensional project in which stimulating cross-fertilizations among the partners has occurred. Chapter 10 presents an integrative view of the findings, pedagogical lessons, and recommendations concerning sustainability and scalability of the project to propose a new model of Science Education in classrooms and informal settings.

The overall impression is that an inquiry based approach in the teaching of science that gives a large role to the learning of argumentation is perhaps difficult to implement in its first steps, but then very quickly releases interest (and some time enthusiasm) on the side of the learners and the teachers. In this endeavor the use of a tool that sustains the visibility of argumentation (Dunes/Digalo) is a very precious and innovative step. As well, the tool Microworld that offers simulations creates bounded environments that permitting systematic exploration and hypothesis testing by the students, an epistemic agency that they don't experience in schools usually in the learning of science. This approach has also allowed for an increase in the social exchanges between the students (group work, debates, and other forms of joint activity and social interactions).

Of course introducing such tools and teaching strategies is a complex endeavor. The close examination of each trial and experimentation in different contexts, has taught us lessons on how to proceed. Designs have to be adapted, students and teachers' scripts are transformed, learning is not automatic but the result of a careful preparation and ever present monitoring from the teachers; evaluation needs to take into new dimensions (time devoted, technological know-how, nesting in the curriculum, teachers' motivations, freedom and previous training, classroom organization, institutional support). Escalate has experienced very different opportunities of implementation of the « cases » , different

ways of doing it, different meanings attributed by teachers and students to these activities, different settings and conditions (both physical conditions and psycho-social conditions). Escalate has brought data and insights on the interrelations between the « micro » level of making cases, training teachers etc... and the « macro » level (institutional conditions, cultural and professional traditions, interpersonal relationships, image of science, etc.) that mediate the acceptance of such cases, trainings, etc., that have contributed to the difficulties and success of Escalate. The set of recommendations drawn from these experiences described in chapter 10, may stimulate « spin offs » to be born from Escalate!

General plan of the White Book

Part I: General introduction in which the content of the book is expressed, as well as general themes announced.

Chapter 1: General introduction

Part II: This part includes a theoretical background on which the ESCALATE project relies as well as a background concerning technologies and tools at disposal.

Chapter 2: Learning Science in Inquiry based environments and in argumentative activities

Chapter 3: Technologies:
The Dunes environment and Microworlds

Part III: The design of cases.

Chapter 4: The design of cases

Part IV: The description of the respective implementations and lessons learned (France, England, Greece, Switzerland (& Italy), and Israel). After a brief introduction, each of the teams will describe its experimentation(s) (chapters 5 to 9).

Chapter 5: Description of the experimentation in France
Chapter 6: Description of the experimentations in England
Chapter 7: Description of the experimentations in Greece
Chapter 8: Description of the experimentations in Switzerland (& Italy)
Chapter 9: Description of the experimentations in Israel

Part V: General reflections on the main outcomes and overall picture of the respective experimentations. This concluding chapter will also include **recommendations** for further activities integrating inquiry and argumentation based environments for Science Education.

Chapter 10: Reflections and recommendations