

Reflections and Recommendations

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10.2 An integrative view of the observation of implementation in the different sites: from dream to reality

The five R&D teams that developed and implemented cases in their five respective countries agreed on a general idea, the integration of enquiry and argumentative practices to foster learning in science. The five teams were even more specific as they also agreed in the use of graphical tools as a way to sustain e-discussions and on the use of microworlds and or other resources providing ways to obtain new evidence in order to support inquiry and feed argumentation. Implementation of theory-based ideas in educational settings is always highly context dependent. However, the diversity of the descriptions of implementations of cases is immense. This diversity has certainly a cultural dimension as will be suggested further on. However, in each of their five countries, the R&D teams implemented cases in different sites and the diversity within these sites is still extremely big. In this situation, giving general recommendations may seem an impossible mission. We suggest on the contrary that general directions emerge from the different chapters from which important lessons can be drawn. We also claim that the high diversity (intra and intercultural) point at a profound societal change in values concerning science, the nature of scientific knowledge and as a matter of fact of science education. Diversity, we suggest, points at change at a motivational-individual level and at resistance to change at the institutional level. The different solutions suggest the first, inevitably instable, solutions that emerge from a strong drive of teachers, researchers, designers and students to get rid of an epistemological burden according to which scientific knowledge originates from authority. We organize this chapter according to the general trends that arise from the different chapters.

Readiness of the institutions to science education through argumentation and enquiry

All R&D teams are engaged in educational programs in their countries. They turned to four kinds of organizations: universities, institutes for teacher training, schools and museums. In general, it appears that the educational system is far from being ready to incorporate argumentative practices and to recognize their added value. From the reports it appears that the readiness of the four countries for learning science through argumentation is not uniform. The United Kingdom and Israel seem quite ready while in other countries the organizations are less disposed to integrate argumentative activities. And indeed, the Ministries of Education in England and in Israel recently recognized officially in-service teachers programs for fostering argumentation in Science. In both countries, the official standards include both argumentative and inquiry skills 'to be acquired' One in-service teachers program in UK has already focused on argumentation in science, and one in-service teachers' program included argumentation as one of its foci. These facts indicate that the educational system is sensitive to the need to teach and learn scientific reasoning and not only to scientific facts. Of course, the educational system simplifies some of the central ideas behind argumentation and enquiry: national standards include terms such as 'argumentative skills' instead of 'argumentation' and 'enquiry skills' instead of 'inquiry processes' since institutions are expert in transforming processes in fixed procedures. This is a very good beginning although the gap between an approach of 'skill acquisition' and programs like ESCALATE that are dedicated to authentic scientific reasoning is still big. Not surprisingly, so far, no official in-service program (at least in Europe) has focused on the way the ESCALATE program was aimed to promote scientific reasoning: through (1) argumentation; (2) enquiry procedures; (3) the use of graphical tools for synchronous discussions, and (4) the use of microworlds. The main reason for the absence of official program that promotes scientific reasoning in its

complexity like with the ESCALATE project, is because practices involved in argumentation and inquiry processes in science cannot be turned to fixed procedures whose acquisition can be easily checked. In conclusion, the educational system in the UK and in Israel seems to be very partly ready to the approach suggested by our project. In France, Greece, and Switzerland, it seems that the readiness of the system is less pronounced. The educational system as a whole is not ready to embrace such a complex endeavor.

It is then natural that R&D teams attempted to introduce themselves in existing pre-service and in-service programs mostly without success (e.g., in Toulouse). The way teachers were finally recruited was through workshops (in the UK and in Israel), through projects in pre-service teachers' programs and through one-to-one interaction with a teacher that the researchers or designers knew personally (Greece, France, Switzerland). Another population with which the team cooperated was (not surprisingly) university students. These students were not exploited by the researchers. On the contrary, the ESCALATE project allowed them to ask theoretical questions on research design (in Greece) or on learning theories (in France). For university students as well as for pre-service students, ESCALATE cases allowed for understanding theoretical ideas.

Interest in the ESCALATE program

In all the occasions ESCALATE was presented to in-service teachers, pre-service teachers or to students, it convinced the audience. After all, this success is not extremely surprising. The main ideas of the ESCALATE project are that: (1) scientific knowledge is constructed by people who interact with each other; (2) this construction is motivated by a need; (3) to be acceptable, constructions are done according to scientific methods; (4) constructions are meaningful for the participants in scientific activities. These ideas are sound, and if they are illustrated by a demonstration of the implementation of a case, they stress what is missing in "traditional" learning of science in classrooms. However, as shown in the next subsection, this first enthusiasm was often tempered by organizational constraints.

Organizational constraints on the implementation of ESCALATE activities

The organizational constraints on the implementation of ESCALATE activities are multiple. First of all, the curriculum specifies the content domains to be included in the program of study for students from age 5 to 16. The curriculum is quite stiff in England and seems more flexible in Israel. It seems in general more flexible in low grades. The settings in which Escalate has been implemented by the five R&D teams are extremely varied. The situation is even more complicated: in each of the countries, the implementation has been realized in diverse ways. The different chapters that describe the experiments undertaken show several important overall phenomena, beyond the diversity we could observe.

1. All teams report on degree of primary interest of teachers, on the preparation of teachers, and on their actual involvement.
2. Primary interest is always very high. People seem extremely interested. Preparation is feasible but more difficult and actual involvement raises institutional problems. Therefore contacts are often realized at a personal level rather than as a part of a program.
3. The support of teachers in preparing activities and even in their structuring in classes is generally great.
4. The confidence of teachers in their ability to conduct and to animate argumentative activities increases as they persist in their participation in in-service

programs that integrate between activities in classes and meetings with researchers and educators

5. The diversity of tools used to evaluate the different programs is extreme. This diversity originates from a cultural shift concerning epistemology and what is valuable in science.
6. Correctness is still one of the criteria to be taken into account. However, other criteria such as coherence or argumentative level are in place.
7. We think that this diversity reflects a cultural shift in which knowledge is
8. In spite of all the problems and the constraints in the implementation of the program, the different experiments reported evidence the tangibility of the integration of argumentative and enquiry activities with the technological environment provided in Escalate. The program worked in the sense that evidence collected supported the general claim that it helped in the improvement of the scientific activity of the students.

Evaluation of participation to cases that integrate argumentation and enquiry-based practices

The evaluation of ESCALATE activities was a challenging endeavor. Each pedagogical chose the methods that suited more its traditions. The result is a plethora of evaluation methods:

1. Field observations – satisfaction, engagement, collaboration between students, role of the teacher (Rhodes, Neuchatel, London, Jerusalem-museum)
2. Collection of outcomes (explanations, arguments, etc.) by learners (Neuchatel, Lugano, London)
3. Correctness of answers in post-test (as compared to pre-tests) (Jerusalem, Toulouse)
4. Coherence of answers (Toulouse)
5. Structure of arguments in written tests (evidence used, reasons, principles, etc.) (London)
6. Focus discussion groups after implementation (Athens)
7. Evaluation of e-discussions – degree of participation, reference to peers, etc. (London, Toulouse, Jerusalem)
8. Evaluation of change in mental models (Toulouse, Jerusalem)

The variety of evaluation methods does not point at chaos but at the fact that the practices evaluated are new and rich. Two important trends should be noted. First, the evaluation of synchronous discussions appears more feasible than face-to-face discussions contrarily to intuition: Synchronous graphical discussions force students to indicate to whom contributions are directed and in what way (support, opposition, neutral). Also, the DIGALO environment provides an argumentative ontology that invites students to flag the nature of the moves they instigate (question, comment, argument, explanation). Although the congruence of the shapes chosen by students and their content is sometimes problematic and suggests that choices of shapes are often whimsical, it appears that the choices help understanding many of the moves of the students. In addition, the technical facilities provided by DIGALO enable the immediate counting of interventions and by such reference to peers provide precious data on the quality of the discussion.

A second trend concerns the analysis of the structure of arguments. It appeared that teachers were able to recognize reasons, evidence, and claims. In countries such as the UK and Israel, where the ministry of Education calls for fostering argumentation, such

evaluating tools provide ways to instill standards through evaluative tools that give clear evidence that the standards are reached.

Technological strengths, potentialities and limits

It appears that our vision concerning the collaboration between technological and pedagogical partners in designing new cases partly succeeded: for the MARBLES, THE FUNAMBULIST and HIT THE BALLOON cases. The fact that these three cases were fully implemented is in itself a very valuable achievement: It was possible to collaborate during a very short span of time to tailor cases for implementation in classrooms. This partial success shows that there is a possibility and that this possibility should be exploited in various countries. Especially at a national level, collaboration between official agencies that cumulatively tailor cases in Science Education is a possible endeavor. However, we also saw that in many of the cases pedagogical teams preferred to use other software or material tools. This preference does not point at a failure of the ESCALATE project, for example in the readiness of technological partners to provide quickly suitable tools for implementing cases. Rather, this preference points at the process that pedagogical partners undergo when presenting the ESCALATE project to educational institutions. This process is always a negotiation. The pedagogical team is always attentive to teachers' and students' needs, so that the choice of a case cannot be done unilaterally by the pedagogical team. After an agreement was reached, the pedagogical partners pondered with the technological partners whether to tailor new tools or to use existing tools. Many times, existing tools were sufficiently good for performing reasonable enquiry based activities.

The role of the teacher

The environment needed to operate cases according to the ESCALATE approach is highly complex. First of all, the teacher needs to coordinate between two activity systems (enquiry and argumentation). These two systems are quite different: enquiry based activities are procedural as students must follow a series of stages (asking a question, hypothesizing, testing, explaining); in contrast argumentation for learning purposes is conceptual, thus not procedural. The coordination between these two systems is then very complicated. In addition, the role of teachers in synchronous discussions is extremely complex: discussions are not linear since students interventions can overlap, and students can often sustain parallel discussions with different discussants. The role of the teacher within synchronous discussions is then extremely complex.

All pedagogical teams were aware of this double complexity, and provided for teachers an adequate preparation phase. However, the findings of some of the pedagogical teams seem to indicate that teachers could only partly overcome complexities. For example, in the day/night cycle, the HUJI team focused on the question of effective teaching during synchronous discussions. They showed that the interventions of teachers in synchronous discussions impaired the quality of the discussions and the subsequent cognitive gains of students in post-tests as compared to the subsequent cognitive gains of students who collaborated without any guidance. However, the HUJI team also showed that experienced educationalists that were intensively trained to moderate synchronous discussions could moderate productive synchronous discussions. The help these educationalists provided was found efficient as compared to collaboration without any guidance. An interesting finding concerns the fact that students expected mediational strategies from the part of the teachers (i.e., that help in the elaboration of ideas) over facilitating/social strategies (i.e., that encourage students to participate and to refer to

each other). Facilitating strategies were acceptable only when teachers combined them with meditational strategies.

Concerning the first complexity, the combination between the two activity systems (enquiry and argumentation) all teachers who implemented cases were supported by the pedagogical teams in designing cases and in providing help in activities. Moreover, the teachers were highly motivated. However, the incorporation of evidence collected in enquiry based activities in e-discussions proved to be extremely complicated. Such an incorporation which represents one bridge between the two systems suggests that the new practices that the project ESCALATE have a great potential but need more efforts for broad dissemination.

The last section of this chapter constitutes an integration of all observations in all the sites. Visits from site to site by the same critical eye made it possible to really compare between implementations and allowed for interesting generalizations.