Chapter 5
Using a Research-Based Learning Environment's Appropriation, as the Context for a Professional Development Intervention in ICT Integration in the Classroom

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Introduction

Concerns are often voiced in the literature about the limits of ICT implementation in classrooms, and different kinds of barriers obstructing high-quality ICT implementations have been pointed out (Bekcer 2000; Ertmer 2005). The point here is that even when teachers embrace technology, their current practices, their beliefs, or the context of their work become obstacles toward achieving the potential that technology can offer (Cuban 2001; Eteokleous 2008; Player-Koro 2012). Professional Development Training Programs have been the main means to address challenging aspects of ICT implementation that pertain to teachers, but their design is still a challenging problem. Even under quite favorable conditions, teachers' practices turn to be very recalcitrant and the quality of ICT implementations to be

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P. Anastasiades and N. Zaranis (eds.), *Research on e-Learning and ICT in Education*, DOI 10.1007/978-3-319-34127-9_5

limited (Karasavvidis and Kollias 2014). That motivated us toward experimenting with teacher professional development work that explores new designs.

Research in teacher professional development has brought forth important dimensions and best practices (Avalos 2011; Desimone and Garet 2016; Postholm 2012). In a recent review, Desimone and Garet (Desimone and Garet 2016), based on research data from US schools, reaffirm (Desimone 2009) minimum features that teacher professional development should secure: "activities that are focused on subject matter content and how students learn that content," "opportunities for teachers to observe, receive feedback, analyze student work, or make presentations, as opposed to passively listening to lectures," "content, goals, and activities that are consistent with the school curriculum and goals, teacher knowledge and beliefs, the needs of students, and school, district, and state reforms and policies," "activities that are ongoing throughout the school year and include 20 h or more of contact time," and "groups of teachers from the same grade, subject, or school participate in PD activities together to build an interactive learning community." However, they point the difficulty in supporting teachers to master inquiry-oriented instructional techniques (or to improve their skills in reflective practice). In her overview of ten years of research in professional development in "Teaching and Teacher Education," Avalos (2011) points to the importance of reflection processes, often through involvement in research, for teacher professional development and the power of teacher colearning culminating in workshops that support collaboration and joint projects. Moreover, "to move from colearning through talk to colearning through observation and feedback is necessary as well as effective." Finally, she points to the revision of the "master role" of the teacher educators in various studies toward more egalitarian patterns of participation. Finally, Postholm (2012), reviewing studies in teacher professional development, points to the importance of formal continuing education courses and lectures but also the importance of learning at school. With respect to learning at school, organizational support should include support of professional learning, teacher involvement in cooperating activities, and cooperation with external resource persons, space for teacher autonomy, while individual teacher involvement should lead into thus becoming self-regulated in their own learning process. Moreover, teacher trainers should contribute their knowledge while interacting in the teachers' arenas.

The above review of the teacher professional development literature gives helpful guidelines toward designing professional development interventions. In the current research, we focused on these aspects of professional development that emphasize teacher autonomy, teacher reflection, and teacher development into self-regulation. For this reason, we turned to the theoretical formulation of transformative learning provided by the work of Mezirow (1997a, 1997b, 2003, 2009) and his guidelines with respect to effecting transformative learning.

"Transformative learning is the process of effecting change in a frame of reference" (Mezirow 1997b). Frames of reference (or meaning perspectives) are the structures of assumptions through which we understand our experiences. Mezirow (1997b), and they are comprised by habits of mind (or meaning perspectives) and points of view (or

meaning schemes) (Kitchenham 2008). Habits of mind work as entrenched presuppositions that filter the way the learners interpret the meaning of experience and are difficult to change while points of view are feelings, attitudes, and value judgements referring to particular situations of which we have conscious awareness and are easier to change. There are distinguished (Baumgartner 2001; Mezirow 1997b) four components in the learning process suggested by transformative learning: experience (a challenge that sets the process going), critical reflection (the learner faces assumptions and beliefs that are brought up in the process and examines them), reflective discourse (the learner constructs the new meaning through discussions with others about the assumptions or beliefs), and action (where learner makes further decisions about necessary changes). Mezirow (2009) has also proposed a sequence of steps that to a certain degree describe the path of transformative learning

- "a disorienting dilemma;
- self-examination with feelings of fear, anger, guilt, or shame;
- a critical assessment of assumptions;
- recognition that one's discontent and the process of transformation are shared;
- exploration of options for new roles, relationships, and action;
- planning a course of action;
- acquiring knowledge and skills for implementing one's plans;
- provisional trying of new roles;
- building competence and self-confidence in new roles and relationships; and
- a reintegration into one's life on the basis of conditions dictated by one's new perspective."

Therefore, the goal of this research has been to design, implement, and assess a professional development intervention that would combine Mezirow's steps of transformative learning with good practices provided by the review of the literature in teacher professional development. With respect to the participants of the intervention, the goal was to bring forth and reflect on habits of mind that have not previously been open to reflection. Mezirow (Kitchenham 2008) distinguishes three types of reflection: content reflection, process reflection, and premise reflection. Since premise reflection (the reflection on hidden assumptions) is the kind of reflection related to changes of frame of reference, our design aimed toward supporting this kind of reflection.

In our design, a primary school teacher, a primary school teacher consultant, a junior researcher and a senior researcher formed a working group (WG) that adapted, implemented, and assessed a research-based learning environment (RBLE). The RBLE was a science education environment supported by ICT and produced by a foreign research team (it is described in what follows as a Foreign Research-Based Learning Environment or FRBLE). A learning environment, like a literature text, is embedded in a system of similar artifacts in its own cultural environment. Actually, the moves that translation theorists describe relative to the process of translation (Steiner 1998) are similar to the ones experienced in learning environment adaptation in a new cultural context. After the first moves that refer to the translator been attracted by and then aggressively approaching the artifact, there comes the third move where "there are

innumerable shadings of assimilation and placement of the newly acquired ranging from the complete domestication… to the permanent strangeness and marginality of an artifact such as Nabokov'v 'English language' Onegin" (Steiner 1998 pp. 314–315).

In our case, it is this extreme pole of "permanent strangeness and marginality" that we tried to realize by insisting to appropriate the FRBLE—although coming from a different tradition in science education—staying as faithful as possible to both the form and the content of the initial FRBLE. The challenge of implementing the FRBLE consisted the extended "experience," the disorienting dilemma in Mezirow's terminology, that prompted critical reflection and reflective discourse from the part of the members of the WG. Since what was to be done (content reflection) was already specified in the FRBLE and the way to be done (process reflection) was open just to the questions of clarification, the main reflective activity referred to seeing the larger view of what is operating within the WG's value system (premise reflection) which according to Mezirow is conductive to transformation in the meaning perspective (habit of mind) (Kitchenham 2008).

Our design combined also good practices found in the professional development literature with good practices on how to create conditions for transformative learning. There was a small group setting, and in particular, the WG was comprised by both researchers and teachers who had previously worked together, creating curricular material according to the participatory design paradigm (Kensing and Blomberg 1998) in the CoReflect Project. This feature is in accordance with creating a "safe, open, and trusting environment" (Baumgartner 2001). Moreover, the fact that the FRBLE was designed according to a different science education tradition than the one espoused by the researchers in the WG helped in relinquishing authority and position power from the side of researchers (Baumgartner 2001).

Method

The research reported here was possible thanks to the authors' participation in the European collaboration project "Digital Support for Inquiry, Collaboration, and Reflection on Socio-scientific Debates" (CoReflect www.coreflect.org). During this project, the participating mixed teams of researchers and teachers had to design and implement inquiry learning environments centered around socioscientific issues. The environments were supported by STOCHASMOS (www.stochasmos.org), an authoring tool for the creation of web-based learning environments supporting students' scientific reasoning through scientifically authentic investigations. Part of the project work included the translation and adaptation of each learning environment in a different language and educational system and its subsequent implementation and assessment (Kyza et al. 2014).

Participants and Setting

The participants in this research were a senior researcher, a junior researcher, a primary school teacher, and a primary school teacher consultant. They comprised the working group (WG). They interacted with the foreign working group (FWG) who authored the FRBLE (the FWG was comprised by a senior researcher, a Ph.D. student, and a school principal). The WG's main theoretical influence in science education was the conceptual change paradigm (Vosniadou and Maison 2012) and the consequent directions with respect to science teaching (Duit and Treagust 2012).

The WG organized its work along the following phases. These phases were on the one hand dictated by the flow of work in the international collaboration and on the other hand by the steps of transformative process described by Mezirow (2009):

1. The WG interacted with the FWG about the FRBLE, while the FWG was designing it—the FRBLE was not yet available to the WG. There have being two face-to-face meetings as part of the Coreflect collaboration meetings. Notes were taken during these meetings and e-mail exchanged after the meetings. At this time, we expected a mild disorienting dilemma
2. The WG got the FRBLE (implemented in STOCHASMOS) and the teacher guide for the FRBLE. In this phase, the "disorienting dilemma" took new intensity leading to the registration of negative feelings and the realization of a clash of assumptions between the FWG and the WG. The WG collected questions to be addressed to the FWG from all its members, through e-mail exchange and an f2f meeting where notes were kept. These were sent to the FWG, and feedback was provided by the FWG (acquiring knowledge and skills for implementing one's plans)
3. Subsequently, there has been a virtual meeting of the WG in which the main open issues were discussed and decisions were taken about the final form of the adapted environment. This meeting was recorded. This was a very important event. Not only emotions and frustrations could once more been aired, but there could take place recognition that one's discontent and the process of transformation are shared, critical reflection on assumptions and exploration of new roles and relationships in the group.
4. Once the translated and adapted FRBLE was ready—through the work of the WG—the FRBLE was implemented in a fifth-grade classroom and the intervention was assessed using the tools provided by the FRBLE. Moreover, the lessons were also observed by the junior researcher, and e-mails reflecting on the implementation were exchanged. Finally, after the implementation, the members of the WG exchanged mails referring to their observations from the implementation of the FRBLE and their reflections (assessment of assumptions; explorations of options for new roles; relationships; and action)
5. While the project was still going on, there was discussion among the members of the international collaboration about producing a collaborative article on the process of adaptation of FRBLEs. The process of writing the successive drafts of the current article was extended in time (more than 3 years), and during this

time, many issues came forth and were recorded in the exchanged e-mails (critical assessment of assumptions; exploration of options for new roles, relationships, and action; and provisional trying of new roles).

Research Questions

The goal of this research has been to design, implement, and assess a professional development intervention that would combine Mezirow's steps of transformative learning with good practices provided by the review of the literature in professional development. With respect to the participants of the intervention, the goal was to bring forth habits of mind that have not previously been open to reflection. We therefore were interested in recording habits of mind that referred to both teaching with ICT and teaching in general that surfaced in the reflective discourse of the group and in assessing limitations in our professional development design measured by means of Mezirow's theory.

The research questions that we posed were as follows:

What points of view and habits of mind related to the implementation of inquiry environments supported by ICT in the WG's local context were brought forth through critical thinking and reflective dialogue?

Did the particular process of FRBLE adaptation bring forth new opportunities and capacities for learning for the participating members?

What signs of inefficiency of this process of teacher professional development have been recorded?

Data Sources and Analysis

Data sources included notes (from the meetings between the WG and the FWG and the f2f meeting of the WG), e-mail exchanged between the members of the WG, and the transcripts of the virtual WG meeting.

The questions of Phase 2, which came both from e-mail exchanges and notes from f2f meetings of the WG, were categorized according to what was the type of information request (clarification, questions about the rational, questions about the context, indirect suggestions of change) addressed to the FWG and then they were assigned to steps in the sequence of transformative learning provided by Mezirow. They were also assessed according to the type of critical reflection that they supported. Mezirow (1997a) analyzes the critical reflection of assumptions (premise reflection) into narrative critical reflection (bringing forth the participants' own experiences in a narrative form and relating them to the transformation that they face), systemic critical reflection (which refers to taken-for-granted cultural influences), therapeutic critical reflection (examining one's problematic feelings

and related consequences), and epistemic critical reflection (when one reflects on the history behind being predisposed to learn in particular ways).

With respect to the rest of the data sources, there was used summarizing content analysis (Mayring 2004). The two researchers and authors of this article concentrated on concerns and affordances voiced by the WG members with respect to the FRBLE and its implementation in the Greek context and on comments on the learning dynamics of the WG. They then gradually developed the categories that better expressed the issues in the data sources. However, this category formation was led by consideration of the steps of Mezirow's transformative learning and the types of Mezyrow's premise reflection. Therefore, there was used a combination of inductive category formation and structuring content analysis (Mayring 2004)

The results of the summative assessment questionnaires provided by the FWG to assess student motivation and student knowledge gains are reported in this research as factors that influenced the learning trajectory of the WG, so the details of the relevant instruments do not interest this research.

The FRBLE

The FRBLE (Van der Meij et al. 2011) was designed within the paradigm of learning by design and was addressed to fifth- and sixth-grade students. It consisted of 8 two-period lessons. The students had a mission: to construct a prototype of a house in the moon. The students were guided toward breaking the initial challenge into (predetermined) subchallenges and were scaffolded toward organizing and transforming their knowledge and toward following a principled design process. However, there was limited concern about the misconceptions that students might have with respect to the scientific concepts involved. This feature of their design was in strong contrast with the theoretical priorities of the WG. During these lessons, the students were searching in the STOCHASMOS database, constructing 3-D artifacts, negotiating over resources, and reflecting on the process and content of the lesson.

Results

Phase 1: Concerns Emerging in the WG and FWG Interaction Before the FRLBE Material Was Available

The initial information that was provided relative to the FRLBE ensured that no hard constraints of the Greek educational context were trespassed. At this stage, most "foreign" aspects of the FRLBE were experienced as quite attractive and potentially educative for the members of the WG: a learning-by-design activity

which had also a significant part of hands-on construction work and was using new didactical techniques. The fact that the national culture of the FWG was strong on engineering and design and that the FWG in particular had experience with this type of design increased the credibility of the expected FRLBE. The notes kept in the meeting of the two groups show, however, a mild "disorienting dilemma" as the WG members were finding difficult to imagine how the goals stated by the FWG could be realized in 8 two-term periods: The conceptual goals were addressing many physics concepts that are known, in the conceptual change literature, to be hard to learn.

Phase 2: Questions Addressed by the WG to the FWG once the FRLBE Material (Implementation in STOCHASMOS and Teacher Guide) Were Available

Upon receiving the full FRLBE curriculum materials, the members of the WG realized the disorienting dilemma in a much sharper sense: "How could a credible source provide us with such, from the WG's theoretical perspective, ineffective design?" Moreover, with respect to ICT use in the FRBLE, the WG assumed that the STOCHASMOS digital environment would carry the weight of bringing in new information producing cognitive conflict toward the change of misconceptions. In the FRBLE however, STOCHASMOS was the carrier of questions suitably attributed to particular actors (scientist, engineer, astronaut) aiming to support inquiry. In their e-mail exchanges, the WG members expressed their fears that the FRBLE might not be up to the expectations of the curriculum and that the students would feel uncomfortable with the environment.

However, the decision to stay as close as possible to the FRBLE design (the plan of action) was pushing WG members toward trying to understand the gap between them and the FWG. There appeared arguments supporting the FRBLE design, claiming that the FWG group focused on supporting students toward reorganizing knowledge that the students already had, for the most part, so that this knowledge would be applicable to practical problem solving. Although this did not eradicate emotions of unease on the part of the WG, it made it easier to go on with the collaboration. We categorize this as an instance of epistemic critical reflection since it questions the reasons of the WG's preference for the conceptual change approach to science education. On the other hand, the expectation of strong information content in STOCHASMOS led to systemic critical reflection.

The decision to implement FRLBE as faithfully as possible to the specifications provided led furthermore to extensive use of the step "acquiring knowledge and skills for implementing one's plan." This was expressed through the large number and the variety of questions that were asked to the FWG. 49 questions were collected and addressed to the FWG group. Table 5.1 shows the questions categorized in groups by the researchers.

Table 5.1 Categorization of questions addressed to the FWG by the WG

Type of question (# of questions)	Examples
Requests for Clarification: (24) of the goals of the FRLBE and the connection between goals and assessment tools (8) or of the specific ways that didactical methods are to be implemented (16)	"Do we have a mapping between the questions in the knowledge questionnaire and the goals stated?" "Are 10 min (sometimes 5 min) enough for the presentation of ideas and for critical exchanges?"
Questions about the source context: (16) How did specific directions for the teacher and the students played out in reality on the FWG context (9) Exploration of cultural differences between the WG and the FWG broader culture that might be relevant to the implementation (7)	"Did the issue of air leaks and air pressure immerge at all?" "How familiar are children in your country with water recycling, water conservation etc.?"
Indirect (reasoned) pleas for change through (5) Additional content (rational: provision for unintended directions that student investigation could take) (3) Variations in the schedule provided by the teacher guide asking whether in that case the fidelity to the designers' intentions would be trespassed. (2)	"The phases of the moon do not appear at all in the content. How come?" "Is it OK if in the case there is no collaboration among schools we do two classes per week?"
Questions about the rationale behind didactic methods proposed in the teacher guide (4)	"In many instances you not only ask for information/knowledge from the students but also their feelings, their evaluation. Please comment on this choice"

The majority of the questions (28 questions: first and last category) are indicative of the WGs purpose to stay faithful to the FWG's design principles and are in concert with "acquiring knowledge and skills for implementing one's plan." These are questions that promote a deeper understanding of the FRBLE and its rational and therefore help follow the details of the FWG's intentions.

The questions in the second category express the WGs desire to understand the grounding of the FWG design in the FWG's context and indicate thus the openness to new experience that characterizes transformative learning. These questions addressed aspects of general culture (e.g., student experience with negotiations through family life and school life), school culture (e.g., what is OK to be discussed publicly in schools), and teacher culture (e.g., the degree of detail that is expected from a teacher guide). They also addressed specific instances of the design asking concrete details about the way it would run in a Dutch school. They correspond to "exploration of options for new roles, relationships, and action," and through the requested narrative, the FWG could provide means for narrative critical reflection to the WG.

Finally, the questions in the third category express concerns about the design, but they come through as implicit suggestions leaving the center of control to the FWG.

Phase 3: The Virtual WG Meeting

During this virtual discussion, there emerged both points of interest and appreciation, referring to new learning opportunities for the participants, and points of concern.

Points of interest and appreciation that were voiced were the existence of educational goals that were not well represented in the Greek curriculum (e.g., learning to negotiate about limited resources), the new didactical approaches (e.g., learning by design), and the new didactical techniques (e.g., silent writing, scaffolding questions tailored for learning by design). The use of STOCHASMOS as a carrier of well-situated questions that supported the inquiry was experienced in an ambivalent way: both as a point of interest and as a point of concern.

The points of concern that were voiced in the virtual meeting focused on educational goals, students' responses to limited new content, and possible obstacles that could hamper the implementation (see Table 5.2).

Since the limited content was such a strong point of concern for the WG, the WG went for a very minimal change, adding a tab in STOCHASMOS that could work as a security fuse. This tab had additional information that would not be initially accessible to the students. However, if the teacher would feel really hard-pressed by the students, he could make it available.

The concerns were also opportunities for bringing forth divergent views among the members of the WG having to do with the role of content in an inquiry supported by ICT and with student motivation. Although the participants were based on their predictions in different sources (scientific literature, practitioner's experience), the foreignness of the new environment intensified the sense of "recognition that one's discontent and the process of transformation are shared." In particular, the teacher was excited for the prospect of "provisional trying of new roles."

After the meeting was recorded, the researchers heard it again and extracted the main themes that emerged (the ones mentioned above). These themes were further used to support continuing interaction in the WG by e-mail, through a process of reflection and discussion that centered around two main issues: the FWG's lack of concern with students' misconceptions and the minimal presence of new factual knowledge.

At this point, one could say that two important habits of mind of the WG were brought forth: (a) working with rich new content as an essential part of teaching with ICT, instantiated in a variety of specific meaning schemes referred to all the specific cases where teacher–student interaction was mediated by rich content and (b) understanding new and counterintuitive "truths" as the essence of significant learning instantiated in a variety of specific meaning schemes where students come to see things in a completely new light. However, it should be noted that in the

Table 5.2 Concerns voiced in the virtual WG meeting

Concerns	Questions that express the concerns
Concerns about the educational goals of the FRBLE	Is the FRBLE lowering the standards of a good science lesson because it is not concentrating on misconceptions? (In the FRBLE design there was limited new knowledge provided or opportunities for cognitive conflicts)
Concerns about students' possible responses to an environment organized around limited new content	Will the students feel unease with so little content knowledge provided? Will the students loose motivation and feign that the task is impossible since not enough content was provided? Since there is too little content, what will happen if students start to ask difficult questions that are going beyond the knowledge presented in the teacher guide and are potentially difficult for the teachers themselves?
Concerns about possible obstacles that would block the flow of the lesson	Since the design has a repetitive structure, will students be bored? Since there is both a theoretical section and a construction section in the same 90-min period, will the students ask critical questions that the teachers will be obliged to side step in order to move on with the construction phase of the activity? Is the FRBLE design taking for granted cultural knowledge that is not available to Greek students?

dialogue of the group, these issues were coming to the surface and were reflected upon, only to hide afterwards under the more pressing issues referring to the implementation in the classroom. This is probably an expression of lack of experience among the participants and especially lack of experience of the senior researcher with respect to guiding the process of reflective dialogue.

Phase 4: Formative and Summative Assessment of the Learning Environment

While the intervention was running, there were coming to the WG, through the e-mail interactions with the teacher, data of narrative kind that were undermining the ideal of the conceptual change oriented lesson: (a) The students found the FRBLE motivating and found enjoyment in the application of everyday problem-solving skills and (b) the students were doing incremental changes in their design based on criticism from their fellows which was leading to improved

designs. Finally, the additional tab, carrying extra information in STOCHASMOS, was never used.

The summative assessment, which was based on the assessment instruments provided by the FWG, found that students enjoyed participating in the implementation of the FRBLE and expressed willingness to participate further in similar activities. Moreover, there was definitely learning going on, though it was not centered on the deep understanding of science concepts against prevailing student misconceptions.

The success of the FRBLE and the unfoundedness of the concerns about the possible obstacles of implementation (see Table 5.2) was a source of reflection for the WG expressed in the e-mails exchanged in the WG. First, it challenged the expertise of both researchers and teachers, in foreseeing the results of the implementation of the FRBLE in the context of their cultural environment, and thus brought forth a habit of mind related to feeling an expert on the students of one's culture (systemic critical reflection). Second, it increased the value that the WG members assigned to the FWG's goal: to organize better and more effectively the knowledge that students already had towards achieving practical ends. Therefore, a Greek habit of mind emphasizing the educational goal of "students not been taken in by simple appearances" (misconceptions fitting well on this pattern) was highlighted against a concern for knowledge reorganization toward practical effectiveness expressed in the FRBLE (epistemic critical reflection). Although the teacher reported feelings of stifled initiative from having to follow strictly the directions of the FRBLE, working with the FRBLE created also the opportunity for "exploration of options for new roles, relationships, and action" since he repeatedly was asking about how the FRBLE was actually running in the source culture.

Phase 5: Further Reflection Toward the Written Report of the Work

During the long process of writing the successive drafts of the current article, the members of the WG brought forth important issues related to this professional development experience.

First teachers' and researchers' relationship was put on a sharper relief since different dimensions were brought forth that differentiated among the two subgroups: moral responsibilities felt toward the students, professional agendas, attitudes toward the official curriculum, and differences in skills. They can be recognized as instances of "exploration of options for new roles, relationships, and action" and "acquiring knowledge and skills for implementing one's plans." Second WG members steadily commented on the realization of their overreliance on factual information and its connection with the use of ICT. Third, they realized that some WG members were bringing points of view that were novel for other WG

members and were shaking the sense of a secure knowledge base that the other WG members might have till then.

Finally, teachers and researchers found themselves at the end of the implementation in a process of still pondering on troublesome features of the FRBLE implementation in the classroom: Were the goals of the FRBLE of high enough quality? What combination of activities would make the design optimum? Why does it feel so difficult to combine the goals of the national curriculum with these "foreign" goals? Are there contextual reasons that make it so hard? How is one to balance the attractiveness of the new goals with the respect older goals still have? Rather than detecting a new equilibrium, we detect a state of openness that is valuable from the point of view of transformative learning.

However, it should be noted that the WG itself did not persist in time aside from accompanying the writing of the article. Although lessons taken from the implementation of the FRBLE were reintegrated to the lifeworld of the members of the WG, the same did not happen with roles related to the collaboration between teachers, teacher consultants, and researchers. These roles did not reintegrate into the participants' lives since the WG did not extend into or got absorbed by an extended joint community of teachers and researchers. The demise of the WG in the long ran had as a consequence that the realizations that were achieved were difficult to embed in everyday school reality.

Discussion

Successful high-quality teaching using ICT in the classroom is still a sought-for goal, and teachers are a central part for the achievement of this goal (Ertmer 2005). Professional development is a principal way to affect teachers, but the changes that are needed are quite significant and thus motivated us to explore a professional development design influenced by Mezirow's theory of transformative learning (Mezirow 2009).

This design focused on intensifying premise reflection. Teachers and researchers agreed to implement what went against their habits of mind, discuss their concerns, observe carefully the distance between point of views rooted in their habits of mind and reality (in the assessment phase), and be open and interested on the details of the FRBLE implementation in its source culture.

What points of view and habits of mind related to the implementation of inquiry environments supported by ICT in the WG's local context were brought forth through critical thinking and reflective dialogue?

The main habit of mind that was brought forth relative to ICT repeats what is known from the literature: That ICT ideally is thought as a carrier of high-quality information or visualization (Karasavvidis and Kollias 2014). However, this is connected to the centrality given to factual information in the Greek educational system as presented below.

Another habit of mind relevant to ICT use, especially in the context of science education, is that the use of ICT should be strongly related to the debunking of misconceptions in science education.

Did the particular process of FRBLE adaptation bring forth new opportunities and capacities for learning for the participating members?

The combination of the data provided by the different sources reveals that this "adaptation with minimal change" experience created an opportunity for transformative learning for the participants in the WG.

First, they realized that content is indeed a main organizing factor in the Greek classroom, and its minimizing has repercussions in raising anxiety about various other educational aspects: classroom management, teacher workload, student interest, and initiative.

Second, they realized that educational goals that are closer to everyday practical efficiency than to the achievement of the esteemed knowledge of the discipline raise anxiety among teachers and researchers who are focused on the conceptual change paradigm. Kyza et al. (2014), working in a very similar context (being partners on the same project), report similar concerns being prevalent in the Cypriot educational system, leading in their case in changes of the learning environment they were adapting, in order to be implemented.

Moreover, by challenging the teachers' and researchers' "expertise about what works for the students of their own culture," there are created preconditions for more close observation of what actually goes on in the classrooms and interest to learn further about the FWG educational culture with respect to: everyday knowledge, educational goals, and educational practices.

What signs of inefficiency of this process of teacher professional development have been recorded?

In retrospect, although the intervention led to a lot of reflection and many of the steps mentioned in Mezirow's account of transformative learning were taken, the more advanced steps "provisional trying of new roles," "building competence and self-confidence in new roles and relationships," and "a reintegration into one's life on the basis of conditions dictated by one's new perspective" were not explored in depth, especially with respect to the roles and relationships between teachers and researchers. Moreover, the bringing forth of the different issues of critical reflection was not a steady companion of the WG's work but was surfacing and disappearing in the WG discussion without being fully dealt with. As a result, the whole process was protracting in time, extending over many e-mail exchanges over a rather long period of time. We think that a proper discussion of the issues that were later on realized would have to address priorities in the dominant educational science paradigm in Greece, priorities in the science education curriculum, and issues related to the place and prestige of technical education (the FRBLE's hands-on character and practical bend was making it susceptible to relevant habits of mind) in Greece (Patiniotis and Stavroulakis 1997).

Though a truly transformative approach would go through such deeper questions, the centralized nature of the Greek educational system and the tradition of limited common ground between teachers and parents would undercut such

reflection by way of its impracticality for teachers. Furthermore, criticism of the main trends in science education in Greece might put the researchers in conflict with the trend in their domain. Though censorship of the relevant issues was not a conscious decision, cognitive dissonance theory (Akerlof and Dickens 1982) predicts that people avoid entering in mental paths that force them to see inconsistencies that are difficult to be practically addressed.

However, using a "strict" application of an FRBLE as a means for transformative learning, even if executed by a group with no prior experience, gave quite fruitful results. This design is also in agreement with recent ideas in the cognitive science literature. Cognitive science literature points out the difference in the manner experts and novices solve problems (Chi et al. 1981). Recently, the importance of highlighting the relations and patterns of surface features for scaffolding learners to attend deeper features in a situation has been proposed (Chi and VanLehn 2012). In our case, we saw that the "experience" of adopting the FRBLE led WG members to observe carefully the surface features of the implementation, ponder through, reflect and discuss their relations, and finally search for the deeper rational of the design. Therefore, the process created the opportunity to make apparent the deeper features of the situation while at the same time bringing to the fore habits of mind that usually are left undiscussed.

Conclusions

It may be reasonably argued that there are many drawbacks in the use of adaptation of an FRBLE, for reasons of professional development in ICT integration in the classroom, in the way suggested here. The participation of researchers makes quite difficult the scaling up of this approach. Moreover, we just reported results for one such researcher–teacher collaboration, and finally, there is perhaps a sense of treason to the best interests of the local students since the local WG reservations may turn out to be well founded. However, these considerations should not stop us from seeing the important gains of this approach even when implemented by a group with no prior experience in transformative learning methodology.

An additional and deeper point of concern, as we argued in the discussion, has to do with the limited deployment of transformative learning through the current methodology. Such learning depends on the cooperation and open dialogue between teachers, researchers, and probably parents. However, this form of dialogue needs less centralized control, more opportunities, and administrative protection of teacher initiative and the building of traditions of cooperation between teachers, researchers, and parents so that discussing the more challenging habits of mind is realized as meaningful by the participants. This is a formidable leadership challenge for educational leaders (Konidari and Abernot 2006). We therefore think that although the current results are additional indications for the potential of cooperation between teachers and researchers in the context of a well-selected task, they also point to such strong educational leadership challenges.

We can also connect the current research with the relevant literature of adapting FRBLEs. Kyza et al. (2014), working in a similar context, explored the possibility of principled adaptation while leaving more freedom for change, based on the interests of the target WG and the prevalent views of the target educational system. However, we think that the process of adaptation followed in this research provides stronger opportunities for teacher learning since it allows for implementing a process of transformative learning. It is therefore close to ideas having to do with avoiding teachers' mistreatment of RBLE's (Brown and Campione 1996) through organizing the work of professional communities who are focused on improving teachers' practice in accordance to (Thomas et al. 1998).

Acknowledgments This work was funded by the "Science in Society" Initiative of the Seventh Framework Research Programme (FP7) of the European Community, under the CoReflect grant (217792) coordinated by the Cyprus University of Technology. Opinions, findings, and conclusions are those of the authors and do not necessarily reflect the views of the funding agency.

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