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INTRODUCTION

CSCL is a new and important educational paradigm. A number of pilot studies and more extended interventions have been based on it. Reviews of the instructional implementations have shown not only the potential of the paradigm but also certain restraining factors (Lipponen, 1999; Stahl 1999). The factors that restrain the establishment of successful CSCL environments have been categorized into: technological, organizational, and pedagogical.

We participated in a European project (Project ITCOLE no IST -2000-26249) aiming towards the development and dissemination of a free, modular, knowledge-building environment to support collaborative learning, especially aiming for primary and secondary education in various European countries. Since the project included a significant number of implementations of CSCL designs in Greek classrooms it provided the opportunity to observe the potential and the constraints that exist when trying to integrate CSCL activities in the Greek educational system. We worked with Synergeia, one of the two software developed during project ITCOLE.

In designing the projects the researcher team has followed certain principles related to organizational and educational goals.

The principles that are related to organizational goals were aiming towards avoiding the well known pitfalls of a) teachers never developing ownership on the interventions and therefore abandoning the new methods once the researchers had left and b) students and teachers considering the new practices as a kind of "mock lesson", since they do not follow the norms of the usual classroom. For these reasons teachers were encouraged strongly to integrate Synergeia as part of their normal curriculum and to not present it as one more extracurricular activity. Moreover it was them who had the right of introducing designs of activities, selecting which activity sequence would finally take place in the classroom and setting its final form. The researchers had two roles: the advertising role of presenting the software and the educational principles they were proposing and the role of consultant to the teachers.

The principles that are related to educational goals that the research team promoted were: a) Supporting the active learner by transferring more learning responsibilities to the students themselves b) Supporting the development of a learning community by putting understanding in the centre and fostering the collaborative effort of the students themselves c) Selecting thematic areas that are recognized by the teachers themselves as demanding preferably because of the need of conceptual change for the young learner. These different themes were integrated around the theme of "collaborative model building". Collaborative construction and improvisation of models is an important candidate to concretize CSCL designs because this activity effects extensive use of explanations among students makes their explanations salient and helps orient their discussion towards understanding. However the teachers were not obliged to structure their activity along the lines of collaborative model building.

During the dissemination of the Synergeia software 276 students and 11 teachers from different schools and grades participated on various subjects. The selection of schools and teachers was done in an informal way based mainly on teachers' own interest to work with us and the schools that participated were in the majority quite ordinary public schools with average technical facilities. In Greece there have been major initiatives towards introducing ICT in education. There has been support for pilot projects but also training of mentors proficient in introducing the use of ICT in different disciplinary areas of both primary and secondary school, and recently there has been completed an extended project for securing basic ICT literacy for all teachers in primary and secondary education. These projects combined with the positive advertisement of the importance of ICT for the future work and life in general and for education in particular have lead to a general positive attitude of the teachers relative to the introduction of ICT in schools. At the same time the vast majority of teachers report that they do not know how they can integrate ICT in the normal curriculum.

The goals of this paper are:

a. To report on some very positive signs that we have detected while implementing CSCL designs. These are:
   - The positive attitude by both teachers and students for the instructional designs that included Synergeia
   - The development of a stronger sense of community between researchers and teachers
   - The change of the participating teachers trust for students' collaborative work and their willingness to experiment themselves with designs that give more initiative to the students
   - The change in the classroom climate in general and the significant learning results that we got from the more carefully designed Synergeia projects
b. To report on points that from our data seem inhibiting towards harnessing the potential of CSCL designs in Greece:
   - Teachers' misunderstanding of the function of prior knowledge in learning
   - Teachers' lack of reflectivity on the malleability of their role in the classroom, particularly with respect to gradually giving away or taking responsibilities and with respect to the norms of the classroom
   - Students expectations about the learning in natural sciences and mathematics which are strongly influenced by transmission views so that they do not develop metacognitive knowledge that would allow them to manage less guided learning

METHODOLOGY

General view

As presented in the introduction our interventions were part of the normal curriculum of the schools that collaborated with us. Teachers had to fight their way with the heavy demands for content coverage that the Greek curriculum puts upon them in order to find the time sections for a freer inquiry of some school subject using Synergeia.

In the dissemination phase of Synergeia there participated 11 teachers, and 276 students carrying out 14 short projects. The projects covered diverse thematic topics (Language, French as a second language, mathematics, physics, environmental education, technology, using information sources). The projects lasted from two to six hours each and the number of participating students was around 25 each time. Most of the schools were public schools with no special technical infrastructure and the teachers were not the top ICT using teachers in Greece. The participating students belonged to grades extending from the fifth to the tenth.

The students usually worked in groups of two or three. Each group had one account in the Synergeia software and one PC available. With the exception of one cross national project the students of each project were physically in the same room during the project.

The teachers who accepted to participate in the ITCOLE project listened to lectures by the researchers, participated in workshops with other teachers and finally collaborated with the researchers in designing the interventions and improvising with them. In addition to the workshops there were many telephone and e-mail contacts. The researches pointed to the special usefulness of Synergeia in supporting the passing of learning responsibilities to the learners themselves, developing learning community cultures and in discussing about models where students would express their initial understanding and work towards improving on it. They also introduce the participating teachers to relevant literature.

Data sources

We used a variety of data sources: teacher interviews at the first stage of the ITCOLE project (first encounter of the teachers with the software), teacher interviews and questionnaires after the completion of the projects (at the final stage of the Synergeia project), student questionnaires after the completion of the projects, the notes that students have written in the data bases, video tapes and audio tapes of selected groups, the assessment of the participating teachers about the quality of the projects and students involvement.

An important source for the data that we report has been the teacher interviews after the completion of the ITCOLE projects. The questions in the interview scheme were divided in two parts. The first part comprised of seven questions referring to the project in general. These questions were referring to the teachers' roles, the positive and negative evaluation of the implemented designs of the teachers and if and how student initiative and collaboration in higher-order work has been promoted. In this set of questions we tried to capture the teachers' experiences in the project, how it was connected with the usual school curriculum and what specific changes it would entail for their further pedagogy either with or without ITCOLE software. The second part was comprised by two questions where teachers were asked to report whether their participation in the project had lead to changes in their understanding of learning and teaching and reflected changes of reaching practices.

From the various questions of the student questionnaire here we report only on the data referring on whether students enjoyed working with Synergeia, whether they would like to work more in school with it and how they would describe the experience of participating to the interventions to somebody else.

Four case studies

The cumulative assessment of the projects through the data sources reported above can give a general view of what seems feasible in the current Greek classroom with the use of tools like Synergeia. However in order to see what is a realistic expectation for the near future we decided to compare the implementation of CSCL designs by teachers knowledgeable in modern learning theories with the implementation of CSCL designs by teachers with a lot of practical experience (many years in the teacher profession) but not knowledgeable in modern learning theories. We expect that this comparison will reveal points that need attention so that we set proximal reasonable goals for the average Greek teacher who does not have a good command of modern learning theory.

Two of the designs were in the thematic area of mathematics and two in the thematic area of Physics. For each thematic category we examined one project by a teacher with low knowledge in learning theories (practice-teacher) and one project by a teacher with high

knowledge in learning theories (researcher-teacher). One of the practice-teachers has extensive experience in the use of ICT in teaching mathematics.

Finally the more detailed examination of the researcher-teacher projects give us a better view of the potential of designs that use Synergeia but also of the current challenges even for teachers with a lot of practical experience and with a high level of knowledge in learning theories.

As a result of a common agreement between researchers and teachers in all the classrooms the teachers agreed to leave the students free in expressing their opinions and to not give them the correct answers themselves. The teachers should direct the discussion in more indirect ways. We will see later that this common agreement played out in different ways for the practice-teachers and for the researcher-teachers.

Case study 1: Public lower secondary school (7th grade 13-14 years old) Mathematics (Practice-teacher has, 15 years teaching experience)

The goal of this intervention was that students would construct rules for the procedure that needs to be followed to change the arithmetic value of a specific quantity when we change the units in which it is measured. Initially students were asked to construct rules for these transformations in the specific cases of Length, Surface, Volume, Mass. Then they were asked to construct rules for the general case. The teacher estimated that this challenge was within the proficiency of many students in the classroom. The goal of the students was to construct propositions expressing the rules and not a model of the process. There participated 32 7^{th} grade students dispersed in four classes of the same grade in the context of additional lessons to support weak students. The students were working in groups of two. Each group had one account in Synergeia and one computer available. The students used Synergeia for 4 hours. In three of the classes the work with Synergeia was followed by one hour of work in the classrooms where and students were separated in groups to discuss about the above questions. Each group had at least one student who participated in the Synergeia project. Then one student from each group (who was different from the student who worked with Synergeia) presented the opinion of the group to the class and the class discussion concluded the activity.

Case study 2: Public lower secondary school (9^{th} grade 14-15 years old) Physics (Practice-teacher, 10 years of teaching experience)

The goal in this project was to support students in using reflectively the difference between everyday terms and technical terms in Physics. For this reason the students were given two phrases expressing the motions of a train and a car in everyday language. However the phrases were constructed in such a way that they were not acceptable when seen as "talk by Physicists". There participated 27 9^{th} grade students for a total of 2 hours. The students were working in groups of two or three. Each group had one account in Synergeia and one computer available. The students were first asked to comment on whether they thought that the initial phrases should be expressed in a different way in a Physics course. They could also see what other students answered on this question and comment on the opinions of their fellow students. In the second lesson the students were given certain hints about how Physicists use the concepts that were involved (velocity and acceleration) and they were asked how they would now answer to the initial challenge.

Case study 3: Public lower secondary school (9^{th} grade 14-15 years old) Mathematics (Researcher-teacher, 6 years of teaching experience)

The goal of the intervention was that students would understand that the set of real numbers is dense through the use of the "official model" (the number line) and "unofficial models" (the models constructed by the students themselves) for representing real numbers. There participated 16 9th graders from an urban junior high school. The students worked in the school computer lab having one computer for every two students. Each group was composed by students of different level of mathematical understanding, yet its members were expected by their teacher to be able to collaborate as equals. Each group of two students had a single account in Synergeia. There have been five meetings: Four 45-minute sessions and one 20-minute introductory session. There have also participated 14 more students in groups of two who worked in the classroom with paper and pencil and had also 4 45 minute sessions following roughly the same ideas. The succession of activities set by the teacher for the four one-hour lessons is presented through the following table.

L	**Theme of the lesson**	**Initiating question, presented by the teacher**
1	Express prior knowledge about the number line	What do you know about the number line? Describe it as best as you can. Read the answers of other students and comment on them
2	Construct a model of the set of real numbers	We often use the term "the set of real numbers" Suppose someone tries to understand what we mean by that. Could you draw a picture to help him understand?
3	Compare the "official model" (number line) with the intuitive representations of the set of real numbers (comparison of the two models)	We have been talking about two different representations of real numbers: A "formal" one, which we usually use at school, and a second one, which was proposed in our discussion and you seem to find adequate. Could you find a solid reason why we should prefer the one over the other?)
4	Connect features of the geometrical line (between two geometric points there always is another point) with features of the set of real numbers (between any two rational numbers there always is another rational number)	Imagine that you can become as small as a point of the number line. Then you could see other points really close. Suppose that you are on the point that stands for number 2.3. Can you define what point is the one closest to you? Describe in words or by drawing a picture

Case study 4: Public higher secondary school (10th grade 15-16 years old) Physics (Researcher-teacher, 25 years of teaching experience)

The problem presented for inquiry is the well-known (in Physics instruction) "coin toss problem". The problem refers to a coin that is tossed straight up into the air, moves upward, reaches its highest point and falls back down again. The students are offered different options for the possible direction and magnitude if the total force on the coin (7 possible answers). They are asked which choice is the appropriate when the coin is moving upward after it is released and when the coin is moving downward. Research shows (Thornton 1994, Mol, in preparation) that most students answer based on the (faulty) intuitive assumption (prior knowledge) that the force is proportional to the velocity. More specifically both before and after traditional instruction success rate is below 5% in question 1 and bellow 20% in question 2. There participated twenty-six 10th grade students. The didactic sequence combined two traditional lessons ("traditional" component) with three CSCL lessons using the software

SYNERGEIA (the CSCL component). The two traditional lessons followed the first and the second CSCL lesson respectively. The CSCL component was part of the computer science course and was presented to the students as a new way to learn through collaboration. The students worked in groups of three and each group had one PC available. Before our intervention all students had some contact with formal mechanics taught in the traditional way. During the CSCL lessons the students wrote down their opinions on questions 1 and 2 in the SYNERGEIA database, justified them, read and commented on the opinions of other groups and on texts uploaded for consideration by the teacher. They also reported how their opinions where changing in time and why. The teacher suggested to the students to collaborate, to express freely their opinions, to see the answers of the other groups through SYNERGEIA and comment on them. At some points he asked the students to discuss their opinions face-to-face in the classroom. In the "traditional" component of this design no mention was made for the CSCL component. Following the normal curriculum students worked on the problem of "free fall" which is relevant to question 2 in the "coin toss problem".

RESULTS

The profile of the participating teachers from the interviews at the start of ITCOLE project

The initial profiles of the Greek teachers that participated in the research are similar to what we know from more extended research about Greek teachers: They appreciate ICT as a major forming factor of the modern society but are not sure about how to introduce them in classrooms. Although the Greek curriculum seems to give them a lot of freedom various checks (the opinions of parents, peer pressure from other teachers, traditional attitudes of principals, lack of security in taking pedagogical decisions especially for high school teachers) make them feel that the curriculum does not allow them the time for deeper examination of the subjects they teach, and for confronting misinterpretations from the side of their students.

All participating teachers were familiar with the use of computers. However they had not clear ideas on how computers could be instructionally useful. Moreover they generally feel that the introduction of ICT increases the danger of loosing control of the classroom. The Greek teachers feel strong that they (and not the students) should decide what is to be learnt and how it is properly learnt, in a particular topic. Finally they are afraid that students can be a source of diversion for their fellow students either motivationally or content wise (through their erroneous understandings).

The participating teachers felt very strong about the importance of collaboration between students and the lack of collaboration in Greek schools –even though they shared the above mentioned fears that are relevant to collaborative settings-. In this respect the idea of community of learners was attractive to them. Among the various dimensions of building a community of learners, teachers in Greece were mostly in favour of emphasizing different points of view as a resource for collective reasoning. However, they had great difficulties with the following issues:

- Thinking about roles, shared practices, norms and how they can be negotiated in classrooms. That is they were not proficient in the concepts that would help them to manage the social dynamics of the collaborative environment.
- Keeping the tasks planned for the students as flexible as possible to allow for different learning trajectories and freedom of inquiry.

Most of the teachers thought that the current curriculum makes it impossible for them to adapt the principles of community of learners in the everyday life of classrooms.

Relative to their attitudes about researchers, teachers expected the researchers to bring them ready software and to provide them with clear enough directions to realize an activity that would work efficiently in the classroom. The researchers were also considered a source of clever "fixes" and not resources for deeper engagement. The teachers do not expect conceptual tools and methods of interpretation that can support them to

a) Analyze meaningfully current situations in the classroom and

b) Find ways to achieve the deeper goals that are mentioned in the national curriculum

Answers to interviews and questionnaires after the completion of ITCOLE project

In the teacher interviews the teachers comment on the progress in the technical ICT infrastructure in the Greek schools. Moreover Synergeia is assessed very positively for its user friendliness. However the majority of the teachers still consider that their most salient role in the intervention as it actually played out in their classrooms was technical assisting. This final remark agrees with an image of teachers who feel uncertain about how to act in a pedagogically efficient way in the new environment.

In the organizational concerns the Greek teachers mention issues of organization at the

- national level, having to do with the difficulty to make Synergeia projects compatible with the current national curriculum
- school level, having to do with the difficulties of time scheduling the access of the computer room by different classes at the right time,
- Class level, having to do with careful preparation of each lesson, to cover for different learning trajectories. In the positive side (of making the life of the teacher easier) there is mentioned the easy sharing of information through Synergeia.

Many teachers found in the implementation of SYNERGEIA designs in their classrooms a way of getting a deeper understanding of their profession and of understanding the pedagogical principles that they are hearing of in various trainings they have been in. For example they realized in practice that students can collaborate meaningfully and effectively towards an academic goal that listening to the opinions of other students on academic issues is motivating for students, that listening to other students' opinions is not as dangerous as they thought for students' learning. Teachers find that the nature of the software forces them to think about organizational issues that they don't have to in the traditional classroom.

We have categorized the comments the teachers made based on the main dimensions of the Greek research team interests: Community of learners, Active learner, Use of prior knowledge-conceptual change

Community of Learners- Collaboration: All teachers estimate that collaboration is very badly represented in the Greek classrooms and highly appreciate the Synergeia as they saw it to help them in practical ways towards supporting collaboration. They found that during the ITCOLE project, their students collaborated successfully, that collaboration was motivating for the students and that it helped students to create richer products and to realize the possibility of alternative opinions. However teachers do not reflect on their social roles in a concrete way. They had no strategies about developing and maintaining learning communities.

Active learner- Student initiative: All teachers in introducing Synergeia in their designs have agreed to loosen their grip on the "Feedback" in the sequence Initialization, Response, Feedback with which they usually work in their classrooms. They accepted that students would take much of the Feedback function and indeed some of the Initialization too. However they kept a tight control on what is to be learnt and in setting the timing of the project

although in their interviews and questionnaires they report that they want to transfer more responsibilities to students and use more group learning. There is a distinction here between "practice-teachers" and "researcher-teachers" as we will present more carefully in the four case studies. Researcher teachers were more aware of other ways with which they could manage the classroom. Moreover in the interviews their role and the degree that they kept responsibilities on themselves is an object of reflection. This is not the case for "practice-teachers". They saw their pedagogical role as mainly providing emotional support for the students to express freely their opinions and to become familiar with alternative opinions. In both cases however a significant finding is that the participation in the project has made teachers feel more trust about what students can do by themselves.

Prior Knowledge- students' alternative conceptions: As the project progressed most teachers came to appreciate the opportunity that it gave to students to express their alternative opinions and to come to know and comment on each other proposed explanations or models. However for "practice-teachers" they saw this as part of their emotional support to students to not be afraid of doing mistakes and of their effort of making the lesson more interesting. On the other hand the researcher teachers, who have a better understanding of the function of prior knowledge, were very interested in making students express their explanations and models and used them as starting points for further discussion.

Although it is well known from the literature about Greek teachers that they are afraid of the loss of control through the introduction of ICT, the participating teachers not only reported that they feel more comfortable about students collaborating but also that they now feel bigger trust to the students about what they can succeed by themselves.

Finally teachers' answers show a changing relation with researchers:

- Teachers enjoyed collaborating with researchers and report on that
- Five teachers became members of the CSCL community on their own initiative (however it is teachers who have a longer contact with ICT in education.)
- Teachers felt that in participating in the project they were getting pedagogical expertise. The principles they were getting in various training courses were becoming concrete

Answers to student questionnaires

From the answers of the students in the Lickert scale questionnaires we conclude that most student enjoyed working with Synergeia in the projects and would like to see more classes performed in that way (in a 5 point Lickert scale the students answer in the average 4 in support to the thesis that they would like to use SYNERGEIA for more time in the school). The students gave generic positive comments when required to describe to others their experience with the project (i.e. It was a beautiful experience; It was a very useful experience) and showed a certain sensitivity for the modalities through which the activities were carried out, and collaboration was particularly relevant (i.e. It was nice to use Synergeia; it helped me to understand, in a better way, moreover, I understood that I could make a better work collaborating with the others.).

Rough analysis of the data bases

Comparison of students' notes to teachers' notes shows that the latter were scarce relative to the former. In the majority of the projects teachers had minimal participation in writing notes. Although students knew that their teachers could read (and were reading) their notes, there was a sense that the Synergeia space belonged to the students themselves. Teachers preferred the traditional means of classroom presence. In the case of researcher-teachers there

was more participation from the teachers in the data base and this provides an opportunity for the teacher to model ways of arguing and commenting. Although such high level notes were presented by teachers they did not actually operate as models within the constraints of the current interventions. Another characteristic of the researcher-teacher classroom data bases is that they have less social comments and the ones they have are more integrated to the inquiry. This is an indication that the researcher-teachers can have a more tight temporal control to the didactic sequence. Although they do not put extreme demands on students they are able to assess the value of the opinions that are presented by students and suggest new questions that keep them focused. In the researcher-teachers classrooms very few notes have social character. It looks as if the researcher-teachers have followed a more tight temporal control that was keeping the students focused. On the other hand it is an indication that even in the researcher-teacher classrooms the teacher keeps to himself the higher-order organizing duties.

Case studies

Case study 1: Public lower secondary school (7th grade 13-14 years old) Mathematics (Practice-teacher, with 15 years teaching experience)

The teacher assessed students' performance by monitoring them while working with Synergeia, by comparing the answers of students who participated in the project with students of the same classrooms who did not and by assessing student performance in the final written exams at the end of the year. He reports that he is very much satisfied with the student performance and he has decided to participate in the European ITCOLE web-community (http://www.euro-cscl.org/site). He also compared the performance of students in the class where no final face to face discussions took place with the classes where it did and found superior performance of the latter.

Moreover, both from the comments in the data bases and from discussion with the students, teacher comments that students gain a more positive attitude towards collaboration. However there was no support for students to develop control of the situation. Students had to do a lot of things in the sense of answering lots of questions. The questions were successive in the sense of the formal structure of the subject but were not successive in a psychological sense as happened with the researcher-teachers. In the student questionnaires many students comment that the lesson with Synergeia helped them see mathematics with a more positive light and that it helped them learn to collaborate with their fellow students. They also express their interest to collaborate with students from other schools through Synergeia.

With respect to classroom management the teacher gave the students a lot of questions so that they had enough work to do. However there was also freedom to look at other opinions. He also encouraged the students when they were on the right track. In the interview the teacher does not refer to his role and the way in which it could gradually change.

Case study 2: Public lower secondary school (9th grade 14-15 years old) Physics (Practice-teacher, 10 years of teaching experience)

Student product performance was assessed by the teacher of the class. He found that the students were working successfully and that they were getting involved individually in a deep way with the physical problem. By monitoring the students' answers in the data base we see that the initial problem causes students to rewrite the sentences using more technical terms. However they cannot distinguish the velocity and the acceleration in a clear way. When provided with some hints of the proper relations between velocity and acceleration only few students make an effort for a better statement. There are a lot of notes that express agreement

or disagreement with opinions that have been stated without going deeper into justifying the agreements or disagreements. There also exists an increase in social talk. The teacher sees that students are interested in reading each other opinions and discussing among themselves and does not mind that the written opinions are not that deep.

Students participated in the classroom in ways different than in their normal Physics classroom. They worked more among themselves and the centeredness of the teacher has diminished. Both teacher and student questionnaires show that students enjoyed collaborating and would like to work more in Physics in this way. The teacher was very satisfied for the participation of the students and the students said that they felt they learnt through this activity. In the interview the teacher is satisfied with the way the lessons went. He gives emphasis in the students working in the Physics classrooms in ways similar with what they will face at work: emphasis on collaborative work, work with computers, and work towards solving problems. Students get accustomed into working in small groups. He is very interested in applying new ways of collaborating and learning because he now has a higher trust on students' ability to work collaboratively. Through his work with the researchers he has now more interest on how students think. In his interview there is not reflection about his role and the ways in which this role could gradually change.

Relative to classroom management the teacher left the students quite free. He was helping them when asked, encouraged them to keep trying and offered positive feedback when they were approaching a proper answer. We think that like the previous teacher, this one too does not have the expertise on the nature of prior knowledge to guide the students in detail. He selects a more hands-free stance than the previous teacher.

Case study 3: Public lower secondary school (9th grade 14-15 years old) Mathematics (Researcher-teacher, 6 years of teaching experience)

The Pre test showed that indeed students judge about the structure of rational numbers influenced by presuppositions that are more appropriate for natural numbers (1, 2, 3,) and by the representational approach (fractions or decimal representations). Only 10% of the students are aware that there is infinity of numbers between any two rational numbers.

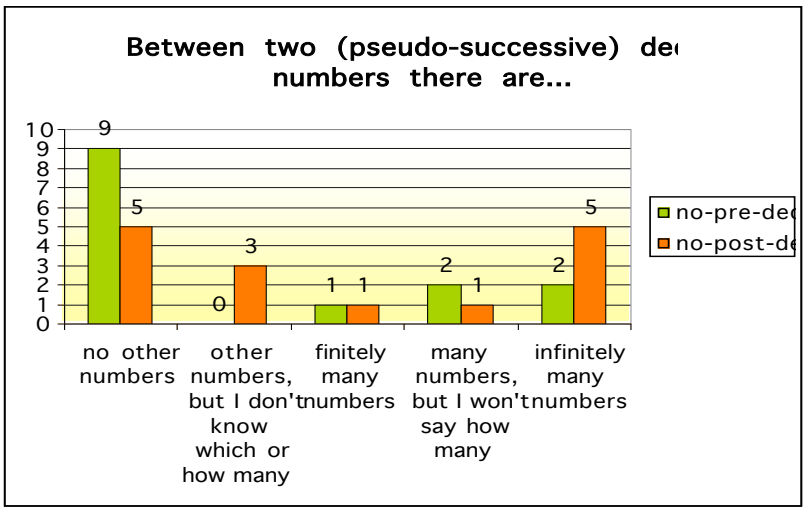

Figure1: Difference between pre and post tests in the experimental classroom

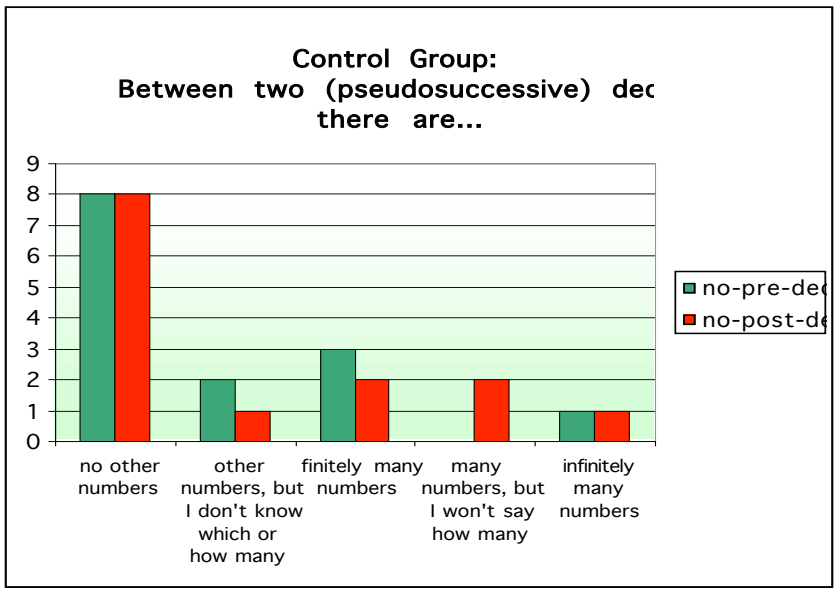

Figure 2: Difference between pre and post tests in the control classroom

Both the notes that students wrote in the knowledge building space and their drawings show a gradual deepening of the understanding of the nature of numbers (from natural to real numbers) in accordance to the design of the project.

Although there has been progress in the experimental classroom that we do not see in the control classroom, our enthusiasm is tempered by the fact that the students in the different groups have great difficulty in properly justifying their opinions and do not develop really deep written dialogues among themselves. Moreover some students recognize that through the activity their opinion about real numbers changed. However when asked if they have learnt something through the activity they answer that they have not. This is an indication of beliefs about what valuable mathematical knowledge consists from, so that can affect their learning decisions (will they put time in changing their opinions about numbers if they think that this is irrelevant to learning mathematics?).

In their questionnaires the majority of students report that they enjoyed working with Synergeia.

In her interview the teacher puts emphasis on the opportunity students have in discussing in a deep way about mathematical concepts and in some cases understanding that they have different understandings and talk about them. The teacher is concerned about her role in the intervention, about the responsibilities that she kept and those that she gave to the students. She is aware of the need to better organize and prepare for the lesson. Moreover teacher's comments on the data base show a sensitive follow up of the students' alternative understandings of the nature of the real numbers. This makes it possible for her to introduce new questions and to keep them focused. However she also gets to be more vulnerable to the management problems that develop as different students do different choices. She tries to deal with this through a summarizing role at the beginning of new lessons at the cost of straying away from the initial goal (the stated goal of the intervention was the understanding the "density" of real numbers but the design strays towards multiple representations of the relationships of various subsets of real numbers). With respect to managing the classroom the teacher participates in the discussion without providing information or assessing relative to the content but pointing to needs for clarification or inconsistencies, proposing new directions for the inquiry, prompting students to propose examples to think about the "linguistic forms"

that they propose (the representations that they use), to propose arguments. However, as noted before, she provides the summarizing.

Case study 4: Public higher secondary school (10th grade 15-16 years old) Physics (Researcher-teacher, 25 years of teaching experience)

While working in the first SYNERGEIA hour of the intervention, 70% of the students gave the intuitive answer for questions 1 and 2. None of the students gave the scientifically correct answer in either of our questions. By the third SYNERGEIA hour 70% of the groups were right in both answers. The differences with the percentages reported above are striking.

However videotaping groups of students working shows us the operation of constraints:

Three students, one of whom has a better understanding of the concepts involved, are arguing about a question without being able to construct convincing arguments. Through a questionnaire given to them we know that according to these students epistemological beliefs knowledge is something given to the students by the teachers. The teacher intervenes trying to help them think deeper about the way we can construct new knowledge.

Teacher (he was listening without being noticed all this time): I notice that there is a difference of opinion here.
Student: Yes
Teacher: How does one decide in such a case?
Student: We all tell our opinion and we end up somewhere.
Teacher: By majority vote?
Student: Through an experiment.
Teacher: What experiment would you do here?
Student: We would throw it high
Teacher: You would throw it high. And what would you measure?
Student: In this case we cannot measure.
Teacher: How do scientists decide?
Student: I am not sure. They are based on their knowledge.
Teacher: What do you mean? What about those that first found out?
The discussion ends there.

In another instance a student says to his fellows
Student: I am sure about H (the answer they have put in question 1). But about B (the answer they have put in question 2), I cannot **remember**, this is the issue

These instances indicate that students' beliefs about the source of knowledge may inhibit them from taking responsibility of the learning process and developing metacognition needed to manage the process.

In his interview the teacher puts emphasis on the development of deeper student thinking. He is concerned about how such pedagogy can be integrated in the current form of the Greek educational system. He is reflective of the role he played in the classroom and he speaks about choices he made about the degree of control he had and the kinds of interventions he made in the classroom. He is thinking seriously about organizational issues, about the different trajectories that the course can take due to the interests of students. However he would like to have a tighter time control on the students so that he is surer that they stay constantly focused. He appreciates the learning potential of collaboration (while other teachers may appreciate the social potential both in getting students more sociable and in getting them to be more motivated). He is concerned with both letting the students free to express their opinions but also with the depth of thinking that is involved.

DISCUSSION

The changing teacher-researcher relations

As can be seen from the comparison of the relative answers in questionnaires and interviews at the beginning and the end of ITCOLE project, the attitude of the teachers towards the researchers change in the direction of a possible mutually beneficial community. There are various reasons that may have contributed in this direction:

a) Although the teacher get no direct financial gains the proof of participation in a university project can be useful in administrative promotion b) ICT in education gets bigger and bigger visibility, it is a central priority for the ministry of education and therefore it is relevant to future professional gains c) the contact with the researchers is motivating. The researchers bring forth new perspectives. These new perspectives are brought forth in a concrete situation (the design of activities that are going to actually be implemented in the classrooms) and lead to interesting problem-solving interactions between teachers and researchers. d) The software is user friendly for the teacher and is easy to be learnt e) the software is user friendly for the student. Its application under many different designs has shown that students find it easy to collaborate and work at acceptable levels of discipline (We know that this is a very significant concern for teachers (Vosniadou et al). f) teachers report that the software has helped them experiment in a concrete way with pedagogical principles they learn about in various professional training classes.

The positive attitude by both teachers and students for the instructional designs that included Synergeia

The interventions were in generally very well accepted by both teachers and students. Contrary to the reports that Greek teachers feel that the introduction of ICT in schools is very difficult the teachers who collaborated in ITCOLE had a feeling that they could master this technology in the classroom. The teachers also report that the students learnt through participating in the projects. Finally most students enjoyed collaborating with other students and feel they have learnt.

There are some indications that technical problems become less significant as constraining factors as both technology becomes more user friendly and the teachers become more digitally competent. This means that the organizational and pedagogical factors get to be more prominent. Although the research teachers have clearer results of success than the practice teachers the research teachers are more critical relative to the achievement of their intervention and more conscious of the need to improvise.

The change in the classroom climate in general and the significant learning results that we got from the more carefully designed Synergeia projects

Did we transform the way students work in the Greek classroom?

Yes. The students are quite happy with their lessons. ICT is used. Discipline does not come out as a big problem. Students are reading and commenting on each others' opinions. Certain indications of better understanding especially for the more carefully designed researcher-teacher projects have already been reported. All these are indications of difference.

The change of the participating teachers trust for students' collaborative work and their willingness to experiment themselves with designs that give more initiative to the students

We saw that teachers both feel more trust for their students and they feel that through software like Synergeia they can experiment with new pedagogical ideas in a concrete and fruitful way.

Challenges

- It is difficult to engage students in deep discussions.
- It is difficult to transfer to students sufficient responsibilities so that they mange the process of learning themselves. At this moment there are rare suggestions from students having to do with what to learn and how to learn it.
- Students seem to be burdened about beliefs about the source of knowledge that constrain them when working in the new learning environments.

Hewitt reports having achieved classrooms where "with minimal teacher guidance, students collaboratively pose problems of understanding, invent and debate theories, engage in research, and general strive to make intellectual progress in key curricular areas". (Knowledge Building Community; Scardamalia and Bereiter, 1994). We cannot claim something close to that.

Teachers' understanding of the function of prior knowledge in learning

In our design the participating teachers differed in their expertise in learning theories. Practice teachers had significant teaching experience but no deep knowledge of learning theories. The researcher-teachers (although novices in ICT in education and in CSCL) had a researcher-level contact with learning theories. Our data suggest the conjecture that although both practice teachers and research teachers try to avoid intervening by providing content, the research teachers have a deeper understanding of the nature of prior knowledge and this helps them to appreciate more the different opinions that students express and to manage more effectively the discussion in the classroom. Where practice-teachers see "false statements" that are useful only because of affective reasons (students get more trust to themselves, students get more motivated), or because they allow other students to play the traditional role of the teacher as validation authority the researcher teachers see efforts to explain, to model, to represent, they develop more trust to the process of learning without continual monitoring of the product.

Teachers' lack of reflectivity of their role and the ways in which this role can gradually change by giving away or taking responsibilities and by affecting the norms of the classroom

Researcher teachers are more aware of the need to change their role and they use this concept in order to monitor their performance. However they also do not manage to realize what they preach in the classroom.

Teachers managing the organizational demands of the new situation

The researcher-teachers report that the varying learning trajectories of the students put higher demands of having prepared for the various direction that the inquiry may take. For example in the case of Case 3, students' answers lead to a secondary theme that emerged on the side of the primary theme of understanding the "density" of rational numbers. The secondary theme was, understanding the structural relations between rational numbers and

known important subsets (natural numbers, fractions, decimals). In Case 4 students introduced arguments related to the second law of Newton and the formula W=mg in the case of gravity although this was not the main issue of the inquiry.

Students' expectations about learning in natural sciences and mathematics are strongly influenced by transmission views so that they do not develop metacognitive knowledge that would allow them to manage less guided learning

We think that the examples in case 4 are indicative of the ways expectations about knowledge can constrain deepening of the discussion. Most probably students cannot arrive to an advanced epistemology by themselves no more than they can invent Newton's laws by themselves.

CONCLUSIONS

1. Promoting the use of CSCL through the use of Synergeia and under the constraints of the principles of the Active learner, Collaboration with emphasis on Understanding, and Expression of Prior Knowledge is already enough to lead to interesting lessons that engage the students and rekindle in teachers the interest for experimenting with alternative ways to do their lessons.

2. Teacher training should give particular attention in developing into teachers a deeper understanding of the function of prior knowledge and of the concept of role especially with respect to gradually giving away or taking back responsibilities. Both are crucial for the proper management of the social dynamics of the new learning environments.

3. Open problems:
   - How to design environments that lead to students with a constructive epistemology in order to participate more fully in the inquiry
   - How to support a deepening of the dialogue among students. We think that unless we guide teachers into addressing the issues presented in point 2 we are far from even beginning to deal with these two last issues because both seem to demand very careful orchestration and guidance from the side of the teacher.

4. Issues of time and Synergy

Time is needed for teachers to understand and manage and reflect upon the issues of point 2. But as they do so and they improve their lessons they are both doing a better lesson and they start getting a different kind of feedback from their classrooms that presents now a new challenge for them towards improving. This is a vertical time component and a vertical synergy. The horizontal time component and the horizontal synergy has to do with other teachers operating under the same principles and teachers collaborating and exchanging experiences.