# Systemic theory in classrooms: Results from the CL-Net and the ITCOLE projects.

Vassilios P. Kollias and Stella Vosniadou
Cognitive Science and Educational Technology Laboratory,
National and Kapodistrian University of Athens

**Abstract**
The goal of this article is to show the usefulness of systems theorizing for revealing the dynamics of classrooms where instructional designers introduce pedagogical innovation. The model of Learning as Expanding [Engstrom (1987)] is used to make salient the structure of the classroom. Then data from two European projects aiming at pedagogical innovation are used to make concrete those categories that are often overlooked by teachers but are important to take into consideration from the point of view of instructional design. Evidence is presented that teachers overlook categories such as *division of labour*, *norms* and *tools*. Then, using a systemic template developed by P. Senge and his associates [Senge (1994)]: "Shifting the burden", it is argued that this lack of attention can explain malfunctions observed in the classrooms where the projects were implemented.

**Keywords**
Social systems design, Instructional design, Systemic templates

## 1. Introduction

The recent social changes towards an information society have raised the standards for education, both for the general public and for future specialists. New didactical methods have been proposed and new tools are available from the expansion of technologies of representing, computing and communicating. These methods emphasize the increased responsibility of the learner in learning and the development of the proficiency to learn in many different environments [Vosniadou (2001A)]. In this new situation teachers feel particularly insecure with respect to loosing control of their classrooms [Vosniadou et al 2001B]. The situation is aggravated by the development of assessment instruments both in specialized subjects and in more general skills that need deeper learning and understanding of the material taught than is usually the case [Bransford, Brown and Cocking (1999)].

Since in these new learning environments the place left for student initiative allows a degree of complexity that precludes micromanagement, we use systems thinking to help us organize concepts in the classroom environment so that we can identify the problematic areas that need to be addressed from the point of view of Instructional Design. More specifically the goals of the present paper are the following:

a) to use Engstrom's approach of "Learning as Expanding" [Engstrom (1987)] to make salient the categories that determine the activity inside the classroom.
b) to use data from two pedagogical interventions with software that supports computer supported collaborative learning and new practices of teaching science in primary and secondary school classes [Kollias, Vlassa, Mamalougos and Vosniadou, (2000); Kollias, Vlassa and Vosniadou, (2001); Deliverable 7.2 ITCOLE project] to demonstrate the importance of the categories.
c) to use Senge's "Shifting the burden" template to understand how certain teacher decisions can inhibit the fulfillment of the expectations for the designed environment.

## 2. Theory

### 2.1 Engestrom's "Learning as Expanding"

This model is theoretically driven by activity theory and has been applied in various settings related to both work and education (Cole and Engestrom, 1997). Figure 1 shows the basic categories of the model.

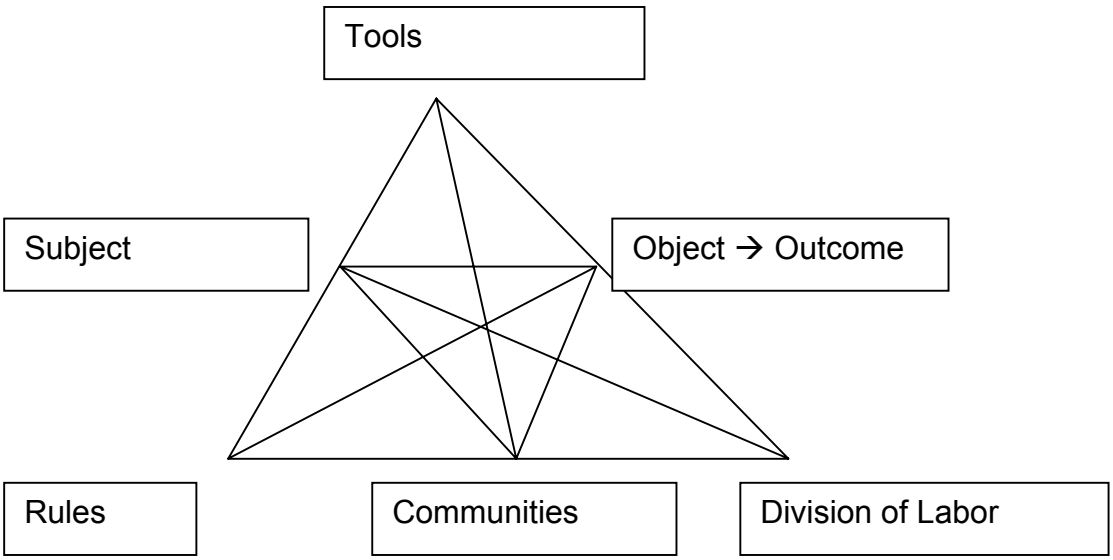


Figure1: Categories involved in the "Learning as Expanding" model

In the general form of the model, the *subject* refers to the individual or subgroup from point of view the analysis is performed. The *object* refers to the problem space at which the activity is directed and which is transformed into *outcomes* with various *tools*. The *community* comprises of multiple individuals and groups who share the same general object. The *division of labor* refers the kinds of roles that exist and the way they are apportioned. The *rules* refer to the explicit and implicit regulations, norms and conventions that constrain actions and interactions within the activity system. The totality of the model represents human "activity".

In Engsrtom's view all these categories exist in a constant dynamical interaction. Any change in a category introduced by an innovation causes tensions that have to be played out towards a new state of dynamical equilibrium. In this aspect the model can be useful from an instructional design point of view in planning classroom innovations. However this model does not examine in detail the ways in which this transition can be locked into malfunction. For this reason we use the model presented in the following paragraph.

### 2.2 Senge's systemic templates

A group led by P. Senge [Senge (1994)] in the Sloan School of Management has gradually developed principles to manage organizations towards becoming "learning organizations" able to compete and to support human development in the information society. Lately the same principles have been used in treating schools as learning organizations [Senge (2000)].

Among the different disciplines that comprise this approach we will concentrate here in "systems thinking". Inside this discipline there have been specified certain systemic templates that can describe malfunctions in organizations. We are going to show that one of those: the "Shifting the burden" template is very efficient in describing how the effort to implement pedagogical innovation can be inhibited. Figure 2 presents the basic characteristics of this template.

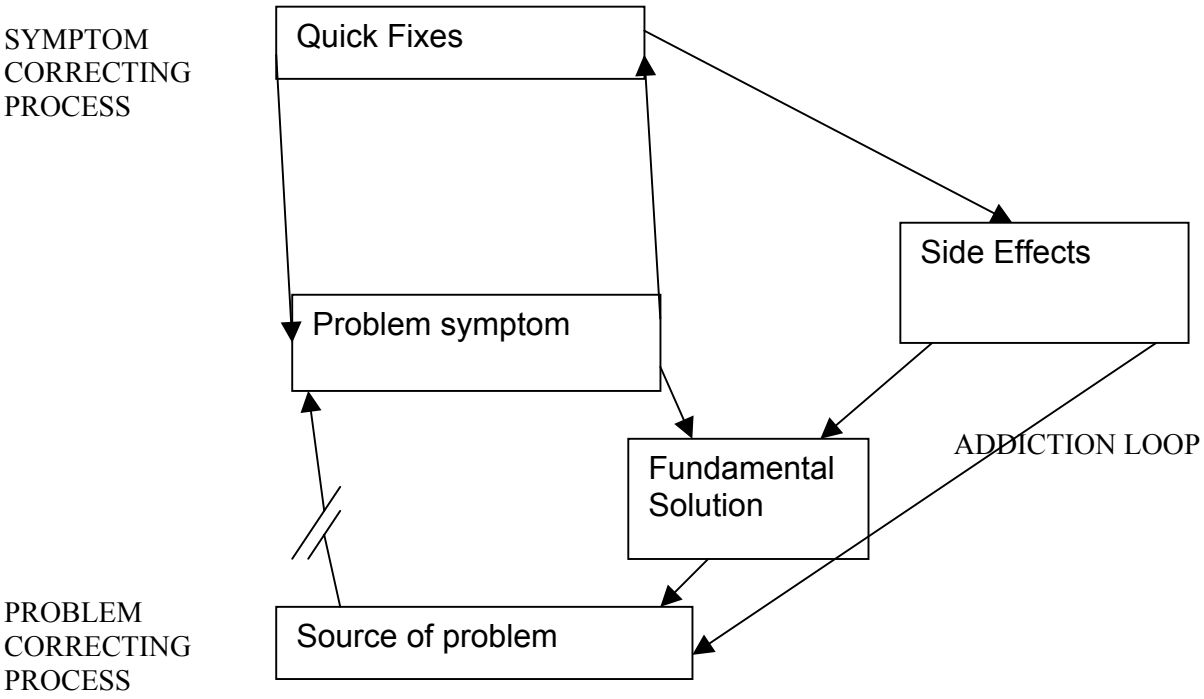


Figure 2: Basic characteristics of the "Shifting the burden" systemic template"

In this template a certain problem symptom is quite salient. The people responsible for management rush to correct by a quick fix and this action brings some immediate relief. However as time goes on the problem aggravates. This is because no proper care is taken to deal with the source of the problem and because the quick fix has as side effect the lowering of salience of the source problem.

## 3. Methodology

The Cl-Net and the ITCOLE projects are both pedagogical interventions that aim towards implementing Computer Supported Collaborative Learning environments. They are both multinational European projects supported by European Community funds. The researcher teams collaborate with teachers in particular schools. The students are provided with software that is specially designed to support collaboration: Web Knowledge Forum and SYNERGEIA respectively for the two projects. Web Knowledge Forum was a multimedia data base that supported asynchronous discussions. SYNERGEIA is a software that has both tools for synchronous and asynchronous collaboration between students and support for sharing various files (texts, video, images etc.). Every participating research team was free to realize their own pedagogical intervention designs.

The Greek research team has followed in both projects principles for designing activities that have been developed from previous research [Vosniadou, Ioannides, Dimitracopoulou and Papademetriou (2001C)] and are in accordance with the demands of the information society [Vosniadou (2001A)]. These are:

•Focus on difficult subjects from the normal curriculum that demand students to change their theories
•Let students express their prior knowledge
•Ask students to build models that explicate their understanding
•Support students to collaborate efficiently
•Pass learning responsibilities to the students

In the case of the Cl-Net project the researchers designed a computer supported collaborative learning environment centered around a project. The project was to build a model of the hot water heating

system in which there was required some independent work and presentations in the whole class. In the case of the ITCOLE project the research team supported the teachers' own efforts to design computer supported environments in the classrooms.

Moreover in the ITCOLE project, http://www.euro-cscl.org/site/itcole/, the software used (SYNERGEIA) was under the process of development and the teachers were providing feedback in developing it. The models and technology developed in this project are to be tested and disseminated throughout the European education landscape free of charge in order to help in building a coherent and unified network of participants that supports sharing of expertise, content, practices and tools. The ultimate goal is to build a network spearheading the use of collaborative learning technology by utilizing pedagogical best practices.

Different sources of data were used for the two projects. In the case of the Cl-Net the students were videotaped as they were working in dyads in front of their computers. The students' comments in the database were analyzed as well as the discussions teachers and researchers in which the former were introduced to the design of the activity by the latter and expressed their views. In the case of the ITCOLE project, the teachers answered questionnaires in which they expressed their pedagogical opinions and practices. The teachers gave also interviews in which they expressed the difficulties they were facing in implementing the new environments.

## 4. Results

The categories suggested in the "Learning as Expanding" model allow us to contrast between the traditional learning environments and the learning environments that we are designing.

Table1: Comparison of traditional and modern learning environments

| **Traditional learning environment** | **Modern learning environments** |
|---|---|
| In the traditional learning environments the classroom is perceived as a primitive *community* composed by individual students. The individual students are the *subjects*.<br><br>The *outcome* of the activity is assessed in ways that do not have good correspondence with the stated object of the activity: Students are assessed on reproducing texts and algorithms although the stated outcomes are developing deep understanding.<br><br>*Norms* in the traditional learning environments are usually kept implicit and no open discussion is done about them. The same holds also true for the *distribution of labor*. The roles of teacher and student stay pretty much fixed among different classes and keep the higher responsibilities of planning and assessing at the hands of the teacher. | In modern learning environments the classroom opens up to broader influences. Thanks to the modern information and communication technologies the students may have access to web pages supported by scientific and professional societies and get acquainted with open issues and the methodology through which they are addressed. Therefore students are now operating in a broader *community*.<br><br>Attention is given in our interventions to have students working in various communicational environments and participating in different processes so that the *subject* can also be a dyad (when students work in dyads in our environments and dyads sent comments to one another), or a group of students (when each group has to offer its own proposal as to how the hot water heating system works).<br><br>In our environments we take care to have close contact between the stated intended *outcomes* and the tools by which they are assessed.<br><br>There has also been change in the *norms* and the roles (*distribution of labor*). Discussion among students is no more prohibited, but rather it is prized, given that it promotes the goal of the activity. Moreover students take over assessment and planning responsibilities that used to be part of the role of the teacher only. |

| | |
|---|---|
| Finally traditional classrooms are usually limited in the availability of tools both for getting information and for constructing models. | Finally students are empowered by software (access to internet and simulations) that makes access to information and modeling easier and to software (WebKF, SYNERGEIA) that supports students' collaborative inquiries. |

It is clear from Table 1 that the introduction of new learning environments brings a lot of changes. These changes are not easy to be implemented especially because of the inertia of old norms and roles in teachers and students. The following example taken from one of our classes helps us clarify this statement.

> *Two students have claimed that inside the hot water heating system the water becomes stream. Another group of students remembers that when the class visited the heating system of the school the technician told them that the hot water leaves the boiler at 75C. They therefore write a comment on the database stating that it is impossible the water to become stream.*

Already we see in this example a lot of changes: students express publicly their own explanations about a mechanism (change of norms: traditionally an incomplete opinion stated by students should not be left uncontested by the teacher for long, lest the students take it for true.). They also use information from other sources, assess their fellows comments (change in the division of labor: this is traditionally done by the teacher). Finally students are expected to answer themselves in a principled way to other comments (change in division of labor and roles: in traditional environments students should not speak among themselves. Moreover it is not their work to sort things out but the teacher's)

> *While the students argue about what to answer the teacher comes by and they explain to him the situation.*
> *Teacher: So you should say that "you are right, it is not this that happens but it is that that happens"*
> *Student1: Oh No! An error!*
> *Teacher: They have been good to you, they helped you with this comment. You must also thank them, because in this way they help you.*
> *Student1: OK this is not necessary (both students laugh)*
> *The teacher leaves*
> *Student1: What a nice discussion (ironic)…*

The answers of Student1 to the teacher's suggestions are indicative of the norm of the traditional learning environment where success is measured according to the number of correct answers given. Within this context, thanking other students that made clear that they erred is incomprehensible and accepted only as a joke. However since new learning environments give emphasis on taking advantage of others' comments, and use them to change opinions and grow to a deeper understanding, a different norm about errors is essential.

Then the discussion of the students in their dyad proceed as follows:

> *Student1: Let us first see the question. In this question… You are…*
> *Student2: In this question you are right because…*
> *Student1: We will not say why, we cannot tell you why…*
> *[they start and stop many times]*
> *Student2: We cannot answer to you because … we did… probably…*
> *Student1: No*
> *Student2: You are right*
> *Student1: You are right…you are right because…no…eh…we simply stated our opinion but we did not know if it was right or wrong*

The new learning environment has given the students new roles. They are the ones who have to sort out things. However we see here that students interpret the situation in new ways. It still counts to not be found wrong. They solve this problem by suggesting a different way to construe the situation: it is about expressing opinions and not about claiming that they know. Such a position solves the social problem of saving face at the expense of bypassing the intended problem of understanding deeply the way the heating system operates.

In an environment where the teacher accepts to delegate the role of assessing truth her own work becomes more subtle: she has to work with the students on the principles along which assessment will be done. However, the data we have from teachers questionnaires and from the analysis of the joint designing session with teachers show that teachers feel very uncertain about commenting about different roles, different rules, or learning processes in the classroom. Moreover teachers do not use such concepts to mediate their discussions when they design interventions. Many times they find incomprehensible and disturbing the theories that students propose to explain phenomena. These results were found both in the feedback that teachers gave in the project Cl-Net to the designs presented to them by the researchers and in the designs that they had formed themselves and discussed with the researchers in project ITCOLE.

Using the "Shifting the template" template we have detected how the lack of these concepts to mediate teachers' pedagogical decisions in the classroom led them to decisions ("quick fixes") that lead to unintended problems. Table2 presents such problems, the quick fixes, the unintended consequences, what we think are the real problems that need solving, and ways that the quick fix harms more in depth corrective actions. These are important components of the "shifting the burden" template.

Table2: Use of "shifting the burden" template in classrooms where new learning environments were implemented

| **Original problem symptom** | **Quick Fixes** | **Undesirable Impacts** | **Fundamental solutions** | **Addictive side effects of quick fixes. (Side effects that undermine the viability of fundamental solution)** |
|---|---|---|---|---|
| Students express opinions that are incorrect from a scientific point of view. | The teacher rushes to set the truth straight so that students do not get misled. | Very limited discussion. | **New division of labor**. The teacher supports students to improve in the process of acquiring understanding and does not provide ready answers. | By continually taking the lead the teacher supports the students to concentrate in whether their answers are correct or not and not on the process of improving them. |
| Students do not collaborate. | The teacher asks them to exchange ideas and comment on what each other writes. | Students are afraid that their ideas will be stolen and others will take the good grade that is due to them. Superficial collaboration. | **New norms** in the classroom: Students are assessed on their proficiency to take advantage of other opinions to improve their own and to discuss various sides of an issue. | Students get used to accept as "collaboration" a very superficial expression of it that does not include real understanding. |

In the environments we have implemented we documented that students got involved into expressing their prior knowledge and constructing explanations based on it, take initiatives related to the process of inquiry, collaborate to design a common product, progress in the ways they assess their level of

understanding. Although all these are very promising they do not really have great motivational import for the teachers. Although teachers appreciate them they do not know how to integrate them in the system of the classroom and how to assess relative value when they compare them with other measures that they are more accustomed with. They do not know on what grounds to order in significance, and thus such signs are lost among many other similar ones. Since teachers have a crucial role in modern learning environments these are issues that need to be addressed in teacher training

## 5. Discussion and Conclusions

Systemic analysis can help us to analyze learning environments in a deeper way and to design more effective learning environments. Based on the examples reported systems' thinking can moreover be used to:

- Guide research in determining the issues where research is needed to further comprehend what goes on.
- Personnel development: to guide teacher training decisions.
- Educational policy: to specify changes in schools that can really have leverage.

### References


Bransford, T.D., Brown A.L., and Cocking, R.R. (1999). *How People Learn: Brain, Mind, Experience and School*, National Academy Press.

Cole M. and Engestrom Y. (1997). A cultural-historical approach to distributed cognition, in *Distributed Cognitions: Psychological and educational considerations,* (G. Salomon, ed), Cambridge University Press.

Deliverable 7.2, (2002). *Intermediate Field Test Report*, ITCOLE (IST project 26249).

Engestrom Y., (1987). *Learning as Expanding*
http://lchc.ucsd.edu/MCA/Paper/Engestrom/expanding/toc.htm

Kollias, V., Vlassa, M., Mamalougos, N. and Vosniadou S. (2000). Study of the metacognitive and collaborative characteristics of a networked learning environment in *Proceedings of the 2nd Greek Conference: The technologies of Information and Communication in Education,* (V. Komis, ed.), Patras

Kollias, V.P., Vlassa, M and Vosniadou, S. (2001). Design and evaluation of a CSCL environment for the learning of science, In *Proceedings of the first European conference on computer-supported collaborative learning: European Perspectives on Computer-Supported Collaborative Learning*, (P. Dillenbourg, A. Eurelings, K. Hakkarainen eds.), Universiteit Maastricht, March 22-24.

Savory A., (1988). *Holistic Resource Management*, Island Press.

Senge P. (2000). *Schools that Learn*, Nicholas Brealey Publishing.

Senge P. (1994). *The Fifth Discipline Fieldbook*, Doubleday.

Vosniadou, S. (2001A), *How Children Learn*, Educational Practices Series, The International Academy of Education (IAE) and the International Bureau of Education (UNESCO)

Vosniadou, S. and Kollias, V. (2001B) Information and Communication Technology and the Problem of Teacher Training: Myths, Dreams and Harsh Reality*, Themes in Education,* 2:4, 341-365.

Vosniadou S., Ioannides C., Dimitrakopoulou A. and Papademetriou, E. (2001C), Designing learning environments to promote conceptual change in science*, Learning and Instruction*, 11, 421-429