Teacher Training as Collaborative Problem Solving

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Abstract

A problem solving protocol is described and then applied to a teacher training problematic situation in science and technology education. The problem consists of improving a learning community involved in education research, development and communication. Some remarks concerning the strengths and limitations of using the protocol are made in connection with action learning and collaborative work.

Keywords

Action learning, Collaborative work, Human learning systems, Learning community, Problem solving analysis protocol

Introduction

Systems can be classified in different ways; for instance, Wilson (1990) considers the following four categories: natural or physical, artificially designed, for human activities, and socio-cultural. For simplicity, we will refer to the first and second ones as physical systems and to the third and fourth ones as human learning systems. In physical systems the components and interactions are described with relatively high precision and well-organized structures; very often optimized conditions for their most efficient performance can be calculated. Usually, for these problems the statements are quite clear, the parameters defining the system are known or can be determined with good precision, and we can be rather sure when the solutions have been obtained.

Human learning systems are defined by sets of activities concerning the planning, development and evaluation of different sorts of transformations in human organizations where learning is at the core. For instance, systems concerning education, training, production, planning and management belong to this category. Practical expectations to improve the functioning of these systems by solving specific problems relate at the most to coarse descriptions and partial evaluations of how the systems work. In such cases, the problems are not well defined and the contexts change a lot; furthermore, there never is certainty that any solution is the optimum one but just the best possible one under certain given conditions. The aim is to understand concrete problematic situations with the hope of transforming them.

In this report we circumscribe to educational situations and consider teacher training as a problem in a specific human learning system of importance in science and technology education. We consider the use of a problem solving protocol to address the following problem: How can we improve a learning community of educators working in teacher training? In what follows we describe the cognitive and metacognitive dimensions of a problem solving protocol called TADIR, then we present an example of application of this protocol in order to get first and second order solutions of the previous problem and close with some considerations regarding action learning and collaborative work.

Description of a Problem Solving Protocol

The name TADIR of the proposed problem solving protocol corresponds to the five initials of its steps (Barojas & Perez, 2001). While the first four steps (T-Translation, A-Analysis, D-Design and I-Implementation) correspond to the cognitive dimension of the protocol and lead to model building, the fifth step (R-Review) represents the metacognitive dimension of the protocol and provides an evaluation of the solution of the problem. In defining these steps we took into account the procedure introduced by Checkland (1981) and presented by Wilson (1990) in the treatment of human learning systems. We shall apply this problem solving protocol to a particular human learning system: a learning community of educators working in teacher training projects.

We will understand by a learning community (LC) any group of human beings in interaction with the four fold purpose of being informed, organize communications, obtain and apply knowledge, and make transformations possible in order to learn something. Any LC is defined in terms of the transformation activities in which their members are involved in order to accomplish certain goals. Models describing the building process of any LC require both a conceptual framework and a logistic scenario. The theoretical considerations that serve to understand the beliefs, ideals, concepts, attitudes and values of the members of the community provide its conceptual framework. The working conditions of the community and its operational principles define its logistic scenario; it concerns the available technological support and the practical skills required to function under these circumstances.

In this section we describe the five steps of the protocol. In order to be more concrete, we focus on the characteristics of one LC of trainers, not on their training projects.

TRANSLATION (T): description of the elements of the system.

Explain the structure of the human learning system under consideration and answer the following questions: who belong to the system?, in what transformation activities are they involved?, for what purposes?, in what subject matters?, and with what resources?

ANALYSIS (A): characterization of the working conditions of the system.

Make explicit descriptions of the main factors explaining the functioning of the system: objectives, restrictions, and connectivity.

DESIGN (D): conceptual model containing the elements of the solution.

Propose a graphical representation of the interacting elements encompassing the cognitive space of the intended solution. This diagram represents a first order conceptual model of the solution in the human learning system under consideration: our LC is described in terms of three transformation activities (education research, development and communication) and their corresponding domains of action are depicted inside dotted boxes in Fig. 1. At this point there is no attempt to get a complete solution to the problem, only to consider a broad definition of the problematic situation.

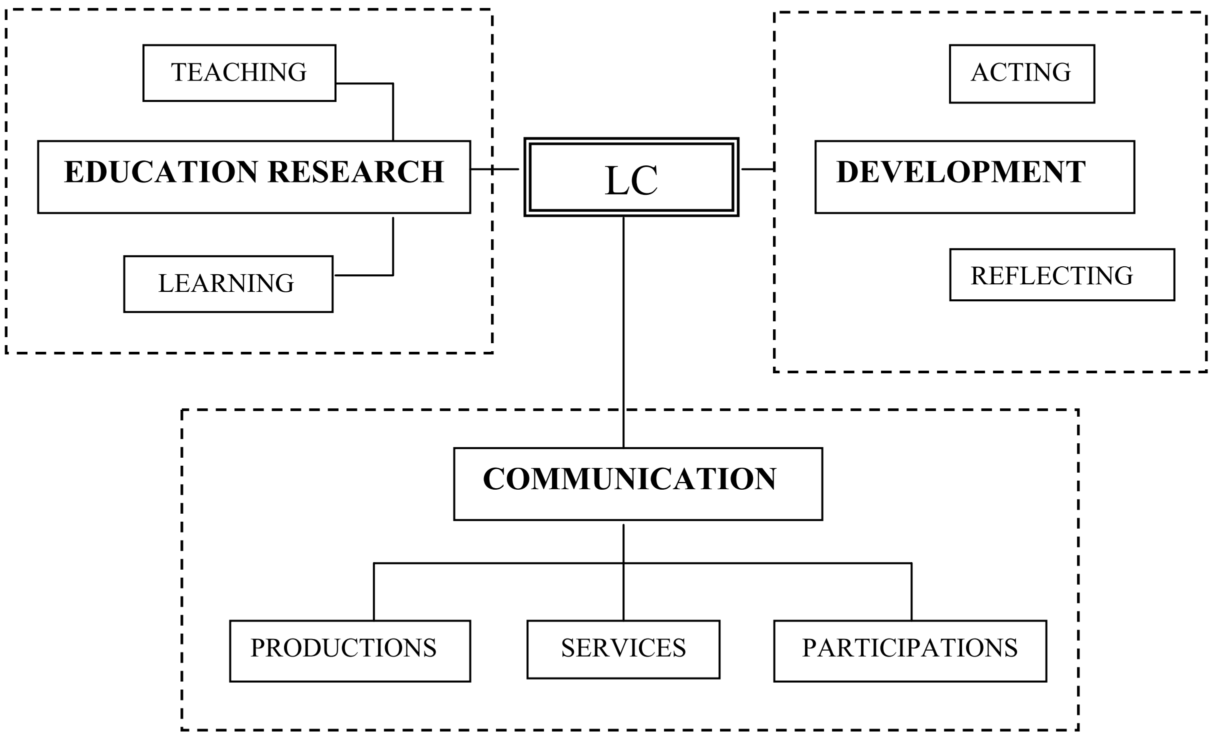

Figure 1. First order conceptual model defining a learning community (LC)

IMPLEMENTATION (I): application of monitoring and control mechanisms.

The monitoring and control of the fulfillment of the transformation activities serve to prove that the first order conceptual model leads to a preliminary solution, which must provide a first description of our LC and indicate where there are opportunities for its improvement. The first aspect is of structural nature and it corresponds to a mechanism monitoring the degree of maturity shown in the transformation activities. The second aspect is of functional nature and it is revealed through a control mechanism determining the performance of the domains of action defining the transformation activities.

The monitoring process is defined in terms of the "21-st- Century Skills" which correspond to digital-age literacy, inventive thinking, effective communication, and high productivity (NCREL, 2000). In the case of our LC, the working conditions of the community can be related to the following moments (Barojas et al., 2001):

M_1: *Induction*: use of traditional technology like chalk and board in the style of conventional classroom settings; however, teaching and learning are critically reviewed by considering the opportunities provided by new technologies.

M_2: *Transition*: familiarity with computational technologies in more modern classroom settings where teaching and learning starts to be more effective.

M_3: *Mastery*: applications of information and communication technologies (ICT) guided by sound and realistic pedagogical principles and procedures enable the creation and improvement of virtual environments serving as empowerment tools for all our LC members.

The control of the activities is made by comparing the performance of the members of the community with respect to four pragmatic pedagogical principles governing science education, taken from Linn and Hsi (2000) and summarized in Table I:

PRINCIPLES	COMPONENTS
P_1 *Making science accessible*	Encourage students to build on their scientific ideas as they develop more powerful and useful pragmatic scientific views.
	Encourage students to personally investigate relevant problems and revisit their science ideas regularly.
	Scaffold science activities so students participate in the inquiry process.
P_2 *Making thinking visible*	Model the scientific process of considering alternative explanations and diagnosing mistakes.
	Scaffold students to explain their ideas.
	Provide multiple, visual representations from varied media.
P_3 *Helping students learn from each other*	Encourage students to listen and learn from each other.
	Design social activities to promote productive and respectful interactions.
	Scaffold groups to design criteria and standards.
	Employ multiple social activity structures.
P_4 *Promote lifelong science learning*	Engage students in reflecting on their own scientific ideas and on their own progress in understanding science.
	Engage students as critics of diverse scientific information.
	Engage students in varied, sustained science project experiences.
	Establish a generalizable inquiry process suitable for diverse science projects.

Table 1. Pragmatic pedagogical principles for scaffolded knowledge integration.

REVIEW (R): *reconsideration of the previous four TADI steps.*

The last step of TADIR examines results and procedures in order to review both our understanding of the conceptual model and the practical implementation of the solution. This step corresponds to metacognition, which according to Schoenfeld (1992) "it is knowledge and control on cognition". In our case metacognition means going back to the statement of the problem through successive reconsiderations of the complete solution process and implies working on higher order conceptual models of our LC. A second order model is obtained by considering each transformation activity as an individual subsystem with meaning and purposes (see Figures 2, 3 and 4, where a dotted box gives the meaning and a double framed box represents actions or products.)

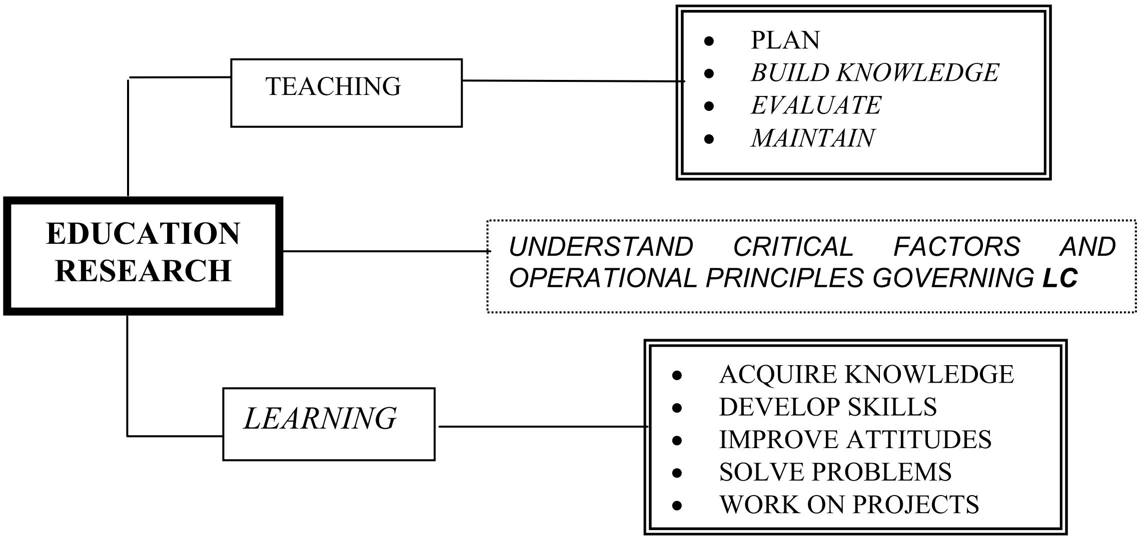

Figure 2. Second order conceptual model for education research

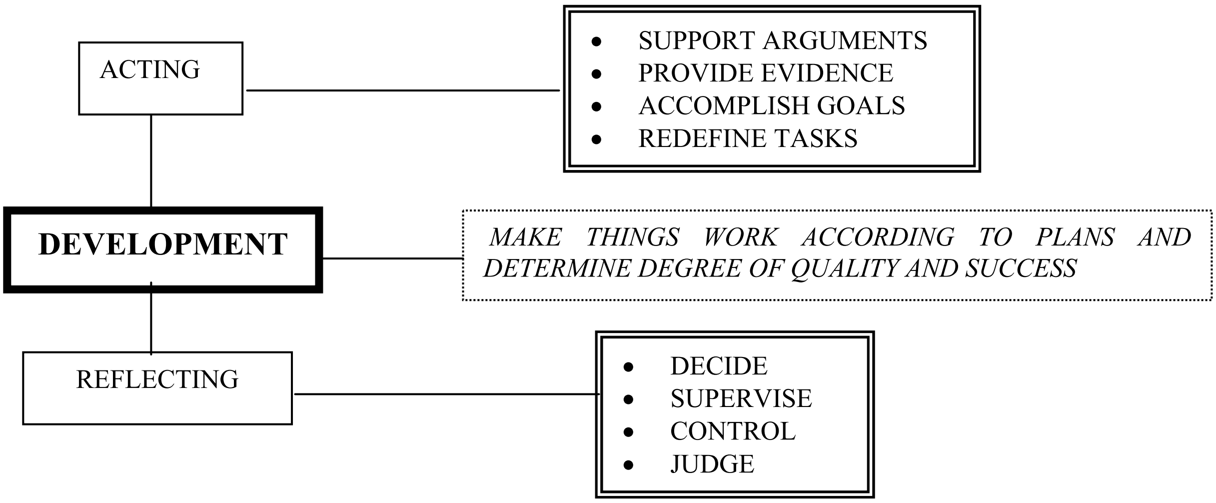

Figure 3. Second order conceptual model for development

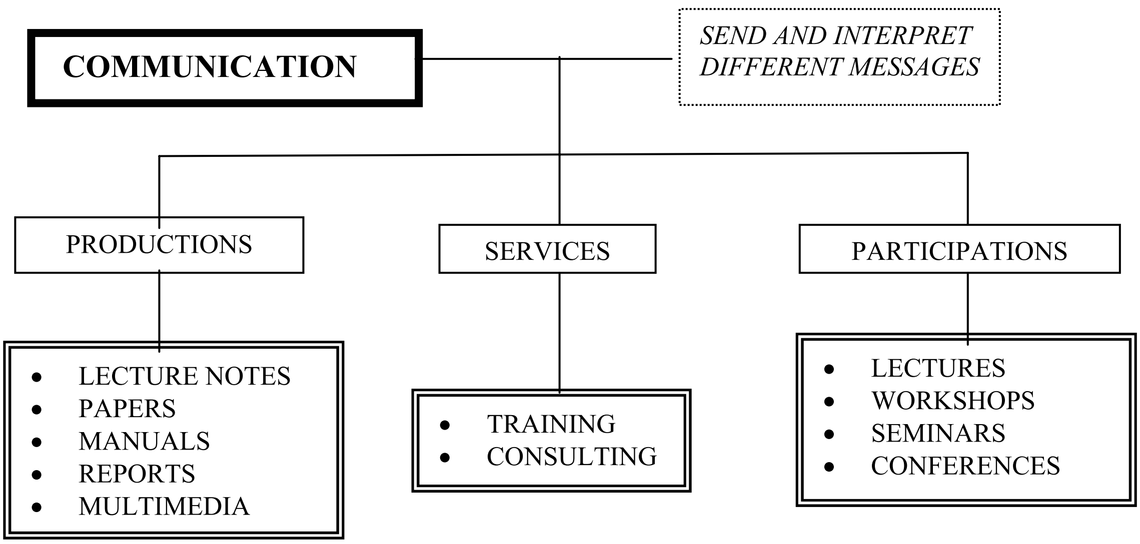

Figure 4. Second order conceptual model for communication

Application of the TADIR Problem Solving Protocol

We are interested in a particular LC in charge of the organization and development of two different teacher training projects referred to the following populations: dentists teaching a laboratory course at college level and high school physics teachers. In both cases the training was related to ICT: how, when and for what purposes resources such as e-mails, electronic forums, web pages or videoconferences would be used (Bates, 1995; Jonassen et al., 1999; Forcier,1999).

Without going into the detailed process of applying the first order conceptual model to the proposed problem (the improvement of the LC of trainers), in what follows we report step by step on the application of the protocol up to a second order.

Review of the Translation Step

The questions answered in the first step of TADIR are summarized below. A full report describing the two training projects will be published elsewhere.

Who belongs to it? The nine members of this LC have different experiences as teacher trainers in science and technology education. Their professional backgrounds correspond to three engineers, four physicists, a designer, and a dentist; three of them are women and six are men.

In what transformation activities are they involved? Although there is no sharp distinction, three members mostly work on education research projects, four members on development, and two members on both. All the members of LC are active in different communication activities and eight of them teach in high school or college.

For what purposes? While members involved in education research pursue postgraduate studies (three at Doctoral level and one at Master´s level), members involved in development work participate on educational projects in their own institutions.

In what subject matters? The activities under consideration, which determine the conceptual space where the solution of the problem is worked out, relate to problem solving, metacognition, teacher training, collaborative work, action learning, leadership in education, applications of ICT in education, design of educational games, and distance education.

With what resources? Available resources include the infrastructure of the working places of the members of our LC, their salaries, and a grant from the National University concerning fellowships and computer equipment.

Review of the Analysis Step

According to the TADIR protocol, this step involves the definition of three elements:

Objectives: O_1 - to find out the critical factors defining the creation, development and consolidation of the two teacher training projects, and O_2 - to establish the operational criteria required for evaluating and improving the solution of the problem.

Restrictions: These are human interaction factors modulating the performance of the members of LC, for instance: appropriate use of infrastructure, experience using ICT for educational purposes, degree of identification with their teacher training project, quality concerning collaborative work, criteria for decision-making…

Connectivity: The instrument of interaction of the members of our LC was an electronic forum (www.alexandria21.net) serving to foster communications, discussions, and collaborative works.

By taking into account these three elements and by comparing the progress made during two years, we detected places where adjustments and changes were imperative for the trainers and of consequence for the trainees. Some of these issues referred to the distribution of contributions and responsibilities in each training project, as well as concerns with group integration and negotiation procedures (Baker, 2002).

Review of the Design Step

The three subsystems composing the second order conceptual model, previously described in Figures 2, 3 and 4, are by themselves complex and dynamic. They are not enough to represent a complete working definition of the solution of the problem; they just contain more information which leads to a better approach to the solution.

In these figures the double framed boxes represent actions or products that have not been described, also there is no indication of the procedures for accomplishing them nor the instruments required for their evaluation. A report that will include these aspects will correspond to a third order conceptual model. Up to now we just intended to show how the application of the problem solving protocol generates a constructive process of thinking and acting to solve problems in human learning systems.

Review of the Implementation Step

The review of this step implies an evaluation of the level of performance of the members of our LC made by applying the mechanisms of monitoring and control previously described. An example of such an application is given in Table 2 where the first column indicates the transformation activities of the first order conceptual model (ACTIVITIES), the second column represents their domains of action (DOMAINS) and the next seven ones correspond to the following aspects: the three moments referring to the use of ICT (M_1 – Induction, M_2 – Transition, and M_3 – Mastery), and the four pragmatic pedagogical principles described in Table 1, indicating the performances of the members of the community (P_1 – Science accessible, P_2 – Thinking visible, P_3 – Collaborative learning, and P_4 – Lifelong learning).

For the evaluation of the performance of our LC we have used the following graded scale for which the corresponding numerical values are given in parentheses: inexistence (0), existence (1), sufficiency (2), appropriateness (3), mastery (4), and effectiveness (5) (Wiggins & McTighe, 1998). These values reflect in average a recent situation of our LC after two years of work, showing places where improvements are required. Here we do not pursue the interpretation of the implications of these indicators.

ACTIVITIES	DOMAINS	M_1	M_2	M_3	P_1	P_2	P_3	P_4
EDUCATION RESEARCH	TEACHING	2	1	0	2	1	1	0
	LEARNING	3	2	0	3	2	1	1
DEVELOPMENT	ACTING	4	2	0	3	2	1	0
	REFLECTING	4	1	0	2	2	1	0
COMMUNICATION	PRODUCTIONS	4	3	1	3	3	2	1
	SERVICES	4	2	1	3	3	3	1
	PARTICIPATIONS	3	3	0	3	3	2	1

Table 2. Sample of an evaluation of the transformation activities

As a result of successive applications of the TADIR protocol we now understand much better the outcomes and performance of the specific LC of trainers involved in solving the problem: *How can we improve a learning community of educators working in teacher training?* The use of the protocol was also helpful in building a functional reservoir for the management of the corresponding organizational knowledge of the human learning system in charge of finding the solution: the LC of trainers. However, we must be aware that the TADIR protocol is just a useful procedure in order to follow the evolution of a system; it is neither a research methodology for generating knowledge nor a rigid recipe for obtaining practical results. The main strengths and limitations in using TADIR derive from these characteristics. We have no intentions of evaluating this protocol neither to compare with similar procedures used in problem solving.

Remarks on the use of the TADIR protocol

In this section we comment on the connections among the TADIR problem solving protocol and two approaches of importance in education: action learning which shows the potential of the protocol, and collaborative work which reveals a promising direction towards possible improvements in TADIR applications.

- Action learning

According to McGill & Beaty (2001), action learning means learning through action and reflection. It is an effective structured process of learning requiring engagement and reflection in order to make things happen or to produce changes. It is also a vehicle for development and change that can occur at the level of the individual, the organization or the society. Action learning is a fruitful methodology that serves to focus willingness and commitment in order to accomplish human specific tasks in the present, based on reflections that take into account both past experiences and future plans for acting.

Successive applications of the action learning methodology serve to detect and correct situations in which different obstacles can hinder or slow down the problem solving process, for instance: conceptual errors, false or unnecessary assumptions, improper reasoning, wrong expectations, results obtained under inappropriate conditions, simplistic interpretations of results, confrontation with unrealistic goals... Action learning can be considered as an intellectual instrument for understanding the process of getting better and better solutions in connection with problem solving in human learning systems. It is in this sense that the TADIR problem solving protocol is a practical implementation of action learning where the cognitive and metacognitive dimensions of the protocol make explicit reference to the dipole of acting to solve a problem and reflecting on the results and procedures.

- Collaborative work

Teasley & Roschelle (1993) define collaboration as a process in which human beings negotiate and share relevant meanings in connection with problem solving tasks. It is a coordinated and synchronic activity resulting from building and sharing a common conceptualization of a problem as well as the procedure to be followed in order to solve it. These authors assume that collaborative work exists in the collective space defining the problem: it corresponds to the definition of a common conceptual structure that supports the activities required to solve the problem by integrating goals, descriptions and ideas about possible solution paths. Collaboration is different from cooperation, where the problem solving task to be accomplished is reduced to a simple division of the work to be done among the members of the group.

Recently, collaborative approaches in education have been successful connecting the educational requirements of the projects under consideration with the advantages of modern technologies. This has been the case with Computer Supported Collaborative Learning (CSCL), introduced by Koschmann (1996). In CSCL the central issue is human communication and collaboration mediated through the computer, which now plays the role of a knowledge-building instrument instead of aiming to replace some capabilities of human tutors. CSCL makes use of the constructivist approach and asserts that contextualized knowledge is built through collaborative learning processes that require the commitment of participants to join efforts in order to solve problems.

As CSCL approach has been critical to make the implementation of educators' plans and decisions more efficient, it presents a promising scenario for TADIR applications. When the members of our LC were involved in any of the transformation activities corresponding to the conceptual model of the proposed solution, they made progress in order to work collaboratively. In pursuing that goal, the TADIR protocol was a useful tool serving to find strengths and limitations of the LC in itself, in the sense that the trainers and the trainees needed to work more in the direction mentioned by Laffey et al. (2002): "CSCL-type systems can facilitate schools becoming learning organizations, not just organizations that support learning."

Taking into account that technology improves the way we do things and changes what we do (Norman, 1993), two relevant consequences can be considered after working on this application of the TADIR protocol in order to develop a technology leadership team:

(1) the convenience to circumscribe the appropriate boundaries of the protocol applications to human learning systems in which effective collaborative conditions are implemented (Johnson & Johnson, 1996), and

(2) the importance of having a framework structure in order to interpret and follow up successive conceptual models for the solution of the problem, like for instance the notion of "Envisionment and Discovery Collaboratories", involving the organization of computerized spaces of action and reflection that support the creation of shared understanding through collaborative design (Arias et al., 2000).

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