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Education in the framework of system theory
La educación con énfasis en teoría de sistemas

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Abstract

Education is being affected by the changes in the field of new technologies of Information and Communication (ICT). The cross-thematic approach (CTA), as a way of organizing curricula, attempts to approach school knowledge from a holistic point of view. We will use the multi-agent system's theory approach in which the cross-thematic approach is the basic process of the system. Under this perspective we focus on factors linking ICT with CTA along with the connection of ICT with teaching methods like: constructivism, discovery learning and problem based learning, which are considered to be the main activities of the basic process. The whole process is implemented by UML (Unified Modelling Language). This work can be extended towards object-oriented software for the educational system depicting its own characteristics.

Key words: system theory, activities, classes, UML, ICT, cross-thematic approach.

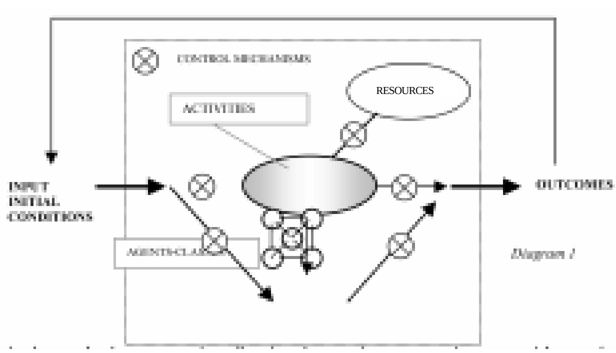
Resumen

Los cambios en las nuevas tecnologías de información y comunicación (ICT) influyen permanentemente en la educación. El énfasis cruz-temático (Cross-thematic approach, CTA), es una manera de organizar los currículos y acercar al conocimiento escolar desde un punto de vista holístico. Se aplica la variante de la teoría del sistema en donde el enfoque cruz-temático es el proceso básico del sistema. Los enlaces de los factores ICT con CTA se integran con la conexión de ICT con los métodos de enseñanza: constructivismo, aprendizaje por descubrimiento y aprendizaje problémico, los cuales se consideran como las actividades principales del proceso básico. El proceso total se lleva a cabo a través del idioma unificado para modelización (Unified Modelling Language UML). Este trabajo puede extenderse hacia el software orientado a objetos para el sistema educativo con descripción de sus propias características.

Palabras clave: teoría de sistemas, actividades, clases, UML, computadores, acercamiento cruz-temático.

INTRODUCTION - SYSTEM'S THEORY

A "system" is a collection of things with certain relationships among them. A system can be described from its inputs, outcomes, agents, activities, resources and control mechanisms. A diagram of a system is depicted below (GIAVRIS, A. & PSYCHARIS, S. (2003)).



The inputs in the system describe the aims and targets we have to achieve. The control mechanisms correspond to the ways we check the operation of the system and describe when and which activity is executed and the agents correspond to the entities with attributes considered useful in a particular domain of the Educational process. The outputs of the Educational System correspond to the expected results of the system. This definition of an agent is taken from descriptions by several authors, who describe agents as conceptual entities that perceive and act (FLORES-MENDEZ, R. (1999), RUSSELL, S.J. and NORVIK, P. (1995)) in a proactive or reactive manner within an environment in which other agents exist and interacting with each other. There are two kinds of activities: actions and interactions. An action is an activity, which the role carries out without interacting with others. After an action, a role moves from its present state to its next state. (GEORGAKOPOULOS, D. & TSALGATIDOU, A. (1998)). An interaction indicates a role's activity that is carried out in sequence with another activity or some other activities in another role (or roles). An interaction involves two or more roles, but is always driven by one of them. An agent and its role(s) are like a class in object-oriented design: it describes behavior, but when the process is enacted there are many instances of it. The study of multi-agent systems (MAS) focuses on systems in which many intelligent agents interact with each other, and their interactions can be either cooperative or selfish.

In a multi-agent system each agent has incomplete capabilities to solve a problem, there is no global system control and data are decentralized

A list of common agent attributes are: BRADSHAW, J.M. (1997) adaptivity, autonomy, collaborative behavior, knowledge-level, communication ability and mobility.

MODELING WITH UML

In many fields of science, a situation or a system is not studied directly but indirectly through a model of the situation or the system. Models are used throughout the lifecycle of a process, supporting the model's definition, re-engineering, implementation and continuous improvement. The UML (Unified Modeling Language) is a modeling language for object-oriented analysis and construction. UML is a famous way not only for describing and modeling software and non-software systems, but also for business modeling. Considering education as a system, we have to include the information system, which is part of an organization from a contemporary point of view. An Information System (IS) is that part of the organization which can be defined as the set of interrelated components that collect (or retrieve), process, store and distribute information to all the agents of the system, in order to support decision making and control of the organization. UML offers insight in modeling with use cases, depicts the different classes and objects of the system and reveals the different components of it. In this paper the following issues will be posed and analyzed:

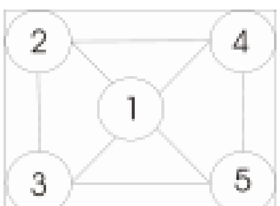
1. What assumptions about education-related agents, underpin the application of system's theory to education, considering Education as a system and actually justifying our consideration?

2. How and why is the cross-disciplinary approach involved in the system previously considered, establishing the cross-thematic approach as one of the main processes of the system?
3. How ICT will make a real impact on CTA in the perspective of the education as a system?
4. How can this approach be implemented to improve and optimize issues which arise when education is considered as a system?
5. How Science teaching is involved in this approach?

THE DIFFERENT CLASSES AND AGENTS IN THE LEARNING ACTIVITIES

Looking at Education as a system with the principles described in the introduction, we are driven to a new way of approaching the school.

The different agents of the Education System, like the central policy making bodies, inspectors, teachers, students, ICT, social partners, parents and generally the local communities, are not isolated but they have to act and react not only globally but also locally, changing their experiences and practices and thus propagating their roles in the education system. In this paper we will reveal the role of each agent in the environment of the cross disciplinary approach, considering it as one of the basic processes of the system, triggering the actions of the different agents considered here, and address the related issues such as: constructivism, discovery learning and problem-based learning. In order to accomplish better outcomes for education these activities and the actors who participate in them should have a strong contact and cooperation in a peer-to-peer review, as it is exposed in UML diagrams. It is important to state here that the traditional mechanistic (Giavris, A. & Psycharis, S. (2003)) approach to Education, does not support the implementation of CTA. On the contrary, in the perspective of CTA approach, classes must be represented in the form of a network with peer-to-peer classes working together (diagram 2).



1 STUDENTS
2 TEACHERS
3 ICT
4 CENTRAL POLICY BODIES
5 LOCAL COMMUNITIES-PARENTS

Diagram 2: The network model.

The CTA, as a process of the system, can be analyzed in many different activities such as: Constructivist activity, Discovery Learning, Problem-based Learning which are not necessarily separated but complement each other. Every class is characterized by its methods with respect to CTA and the ways it interacts with the other classes-agents in a peer-to –peer level, in accordance to System's Theory. Science education standards trend towards the interactive engagement of students to learning activities dealing with authentic problems in contrast to the traditional approach of lecturing which focuses on problem solving. Science teaching should focus on contextual learning. In this environment, and in all the activities we discuss in the article, students are presented with some factual problems and projects. Students have the task to accomplish these learning the concepts they need mainly through the implementation of the projects. In other words, the drift in science teaching is towards to the clinical approach of teaching where students are forced to become researchers rather than passive participants.

ACTIVITY: Constructivist Approach to Learning

This states that our knowledge has been constructed from our own personal experiences and social interaction.

An important consequence of this is that the new form of learning must be based on experiences or, in other words, must be based on experiments to be effective. (Powers, K., Powers T. (1999)).

CLASS TEACHER

Methods: Confront preconceived notions of the students, dispel the wrong ones, and construct the new knowledge. Ask the students to see the implications of a particular aspect of Technology to their lives. Ask students to change the parameters of the model. Ask students to make their own simulation. Students should be shown how the thinking skills are connected with sound decision-making and problem solving. Provide continued explicit instructions and guided practice in how to execute cognitive operations in a variety of contexts. For example the teacher could ask from the students to explain the working of an electric appliance or/and to show their understanding of circuit ideas by successfully finding fault(s) in the connection of the circuit or the way they interpret the functioning of it. Next, teacher will develop his lecture using the principles of current electricity and of circuit continuity or substitution. It is important here to emphasize the crucial role of the experiment as the basic methodological approach of Natural Sciences and the Constructivist Approach to Learning. Another method of the teacher is to help students to create the environment of various experiments (connect the apparatus, measure physical quantities, e.t.c.) and guide them to compare their results with observations of reality.

CLASS STUDENT:

Methods: (motivated by the interaction between Science and Society), assimilate new scientific knowledge and incorporate that in the existing knowledge, do experiments, create models, act as an experimentalist interacting with ICT class, collect data through the simulation and analyze these, use ICT to publish in School Websites. Student has the control of learning, the personal knowledge construction, the self-regulation of learning, the cultivation of autonomy (deCharms, R. (1983)).

CLASS LOCAL COMMUNITIES:

Methods: discuss with Teachers about a local current issue (e.g. hacking the credit cards in a given region), a social problem, (e.g. find a method to simulate population growth at this area.) e.t.c. Announce the results of School work in their Site.

CLASS ICT

Methods: send signals to a central Database asking for background knowledge and information on the topic to be analyzed, creation of Education software to study one particular phenomenon. The software directs learners to use new ways of thinking in their studies.

We should for example create or look for an application, which exhibits the function of an electric motor according to the principles of physics. ICT's friendly interface could allow for the easy switch off and on of the circuit. In such a way students will explore the function of the switch and will look for other kinds of circuits and switches (light electronic diodes, transistors e.t.c.)

We should use a simulation which explores the variation of electric current with time in a circuit with electromotive force, inductance and capacitor. The exponential variation of current could offer a great help in understanding the behavior of this function for the discipline of mathematics in the perspective of the cross thematic approach.

CLASS CENTRAL POLICY BODIES

Methods: inform other schools of the work of the particular school involved in the activity and evaluate the results. Central Policy bodies need to consider how schools position teachers in relation to knowledge about teaching, and how universities and governments might collaborate so as to support schools in positioning teachers as both users and producers of educational knowledge (Edwards, A. (2001)).

OUTCOMES

Engagement with current social issues and experiential learning. Instead of looking at a particular aspect of a phenomenon using the principles of a specific discipline, the creation of a model compounds all the different parameters entering in that, establishing a form of authentic knowledge, which can bring the real word into science lessons. (Borkowski, J. (2002)). During this activity, students can also be involved in data construction. Database construction is an analytical task that calls on a variety of critical, creative and complex thinking skills. Students will have to decide what information should be included and how to organize the information.

ACTIVITY: Discovery Learning

Discovery Learning: Describes the activity in which students are free to make their own discoveries about a certain phenomenon.

CLASS TEACHER

Research, as a dynamic process, in the context of teacher education, illuminates practice and by extension, policy. Research enquiry by teachers helps see their workplaces and the possibilities for action within them in fresh ways. Illumination can occur when teachers simply use research to interpret their learning method. It can also happen when teachers themselves undertake research and, in doing so, use the lenses offered by published research to systematically examine and develop their own practices and the contexts in which they are working.

Methods: Give students structured questions to investigate and develop (in the second phase of the activity), formalize the concepts discovered by the student, emphasize the important key-concepts of their work. In the framework of science teaching teachers could interpret statistically the results of the research and decide on their efficacy of simulations in the classroom, for certain topic oriented sequences of science teaching. In particular teachers could pose questions to be answered using data collected through an experiment, make qualitative and quantitative observations, record these in a database e.t.c.

CLASS STUDENT

Methods: Construct questions, work at their own pace, summarize the important topics. Use different resources to collect data and try to interpret these or try to explore if these data obey the physical law under study.

CLASS CENTRAL POLICY BODIES

Methods: make a module of important topics to discover, evaluate the work of teacher and students and publish them. Creates policy for the incorporation of Research in Teacher Education and Training.

CLASS ICT

Methods: make a model -when necessary- in the computer, compare with an already developed model, publish in the Web, creation of a digital video. Class ICT can send the data to Central Policy Body and these can be recorded in the database. Creation of graphs with the data collected and try to interpret them. Check if the data are in accordance with the statement of the physical law under consideration.

CLASS LOCAL COMMUNITIES

Methods: Suggest issues for discovery related to the interests of the local community.

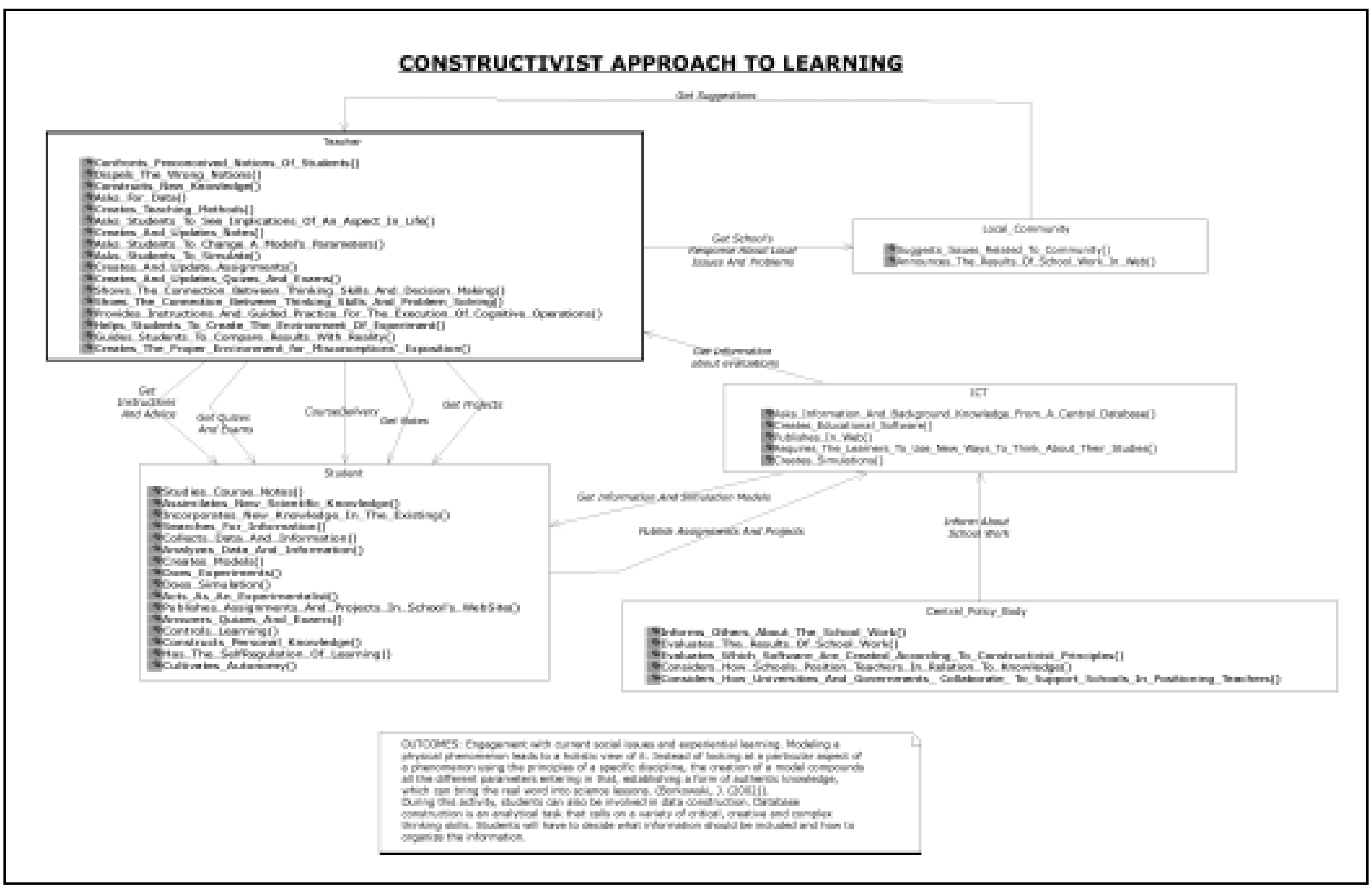
OUTCOMES: Creation of interest and ownership on behalf of the students, competition, evaluation. Teachers must not be considered as technicians making them unable to deal with current complexities of teaching. Instead teaching as a responsive and responsible profession must be based on research.

ACTIVITY: Problem-Based Learning (PBL)

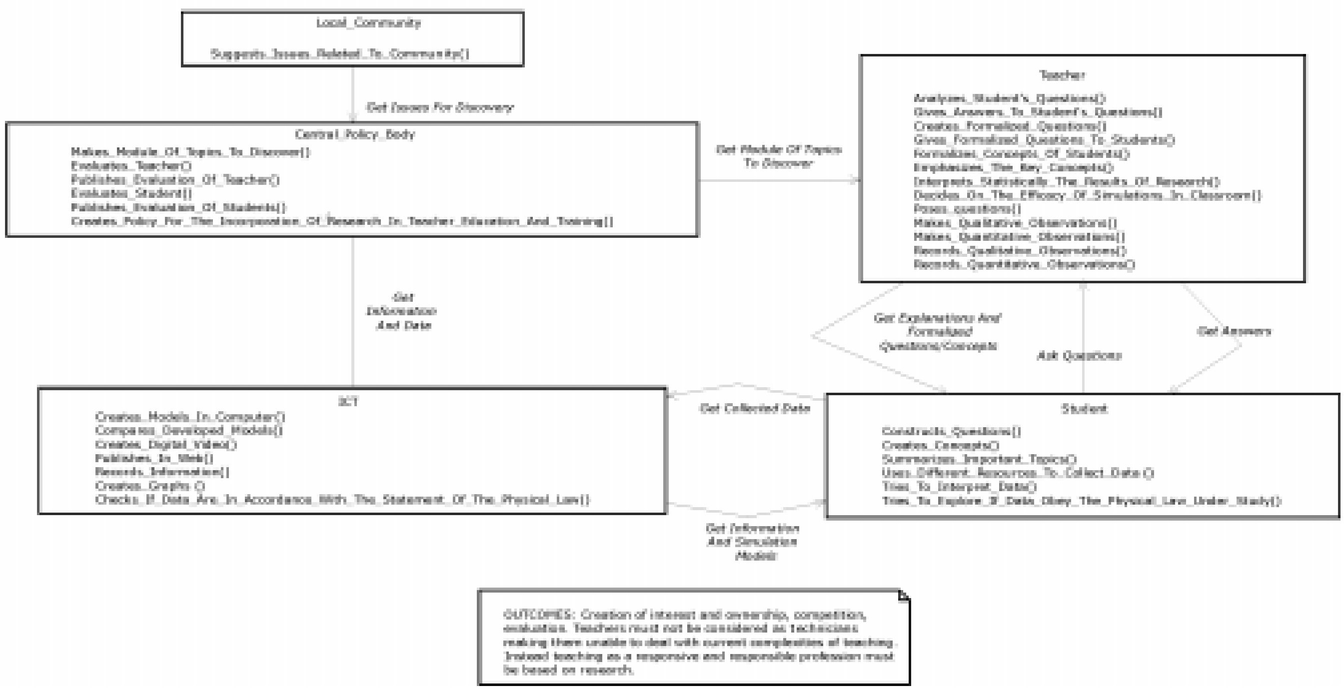
According to this, an ill-defined problem is presented to students. Usually these are unstructured and not well-defined, leading to many different solutions-depending on the initial conditions of the problem, and even the solutions do not satisfy the criteria-conditions of the problems. (POWERS, K.; POWERS T. (1999)). Ill-defined problems are those that require more knowledge than is initially available in order to understand and decide about actions for the solution to be reached. There is a clear distinction between learning via problem-solving learning and problem-based learning. In problem –solving learning, for the courses of Natural Sciences, students are presented with the learning issues in the traditional form of lectures and then they are given specific problems to solve. These problems are usually narrow in concept, and restricted to specific learning outcomes. Under this perspective, there is no opportunity for students to explore different approaches and relate learning with real life situations. On the contrary, within PBL students learn how to tackle real life problems and they develop their own learning techniques creating hypothesis and criteria for a problem like it happens in real life.

Natural Sciences include the disciplines of Physics, Biology, Chemistry and environmental Studies. The core of Natural Sciences is the scientific method of doing experiments and testing hypothesis about certain phenomena.

Natural Sciences can be one of the most appropriate fields to apply PBL, due to the intrinsic nature of it. Students engaged with PBL in Natural Sciences can practice the scientific method of investigation, forming and testing hypotheses and actually interpreting results and data. In addition to that, dealing with Natural Sciences it can improve the quality of our lives. We should mention here numerous problems suitable for the triggering of PBL in science education. Issues related to CTA over a range of different aspects can offer the stimulus for "teaching" students with the method of PBL. The physics of scaling for example can lead to the approximate solutions of physical problems. The connection of scaling with the disciplines of biology and physics can offer great insight into the study of metabolic rate metabolic rate with the mass of the organism, a still long-standing puzzle.



DISCOVERY LEARNING



Problems related to the investigation of the sky at night, the discovery by scientists of the expanding universe and issues from astrophysics could offer the field for the implementation of PBL in the learning process.

The use of x-rays in medical imaging, magnetic resonance e.t.c. is another branch of problems can be offered to students. Problems related to ever day issues from the local press (the role of local communities is essential at this point) can open direction for PBL. For example teachers could take the case of a car accident to investigate whether one of the drivers, or both, are responsible. Students should use the principles of classical mechanics (direction of cars after the collision, stopping distance e.t.c) to find what questions does the inspector in order to find the truth.

CLASS TEACHER:

Methods: Content knowledge, skills and experience needed to solve the problem should be developed in this step. Teachers should assume the role as peer experts and resource facilitators. Teachers have another two roles which change after the interaction with the students. The roles are: cognitive coach, metacognitive coach.

Teachers should also plan for adequate time and a proper environment in which to work. Activities should be planned to permit learners to obtain feedback for their working and to encounter new methods of problem solving.

Teachers should motivate students to gather, organize and evaluate information about a certain phenomenon with loose-fitting solution. The instructor circulates among the different groups, providing assistance, advice guidance but not explicit solutions. The design of circuits, in the realm of computer science or physics, is considered also among the most characteristics examples of problem based learning.

Also the creation and implementation of certain algorithms is a basic property of problem based learning, since most of them have not a predetermined solution..

Teachers ask students for top priority hypothesis or data request to tackle the problem.

Create real world problems (authentic) and experiments.

CLASS STUDENT:

Methods: Create the outcome-solution, self-directed learning, evaluate the information provided, flexible thinking (since the problem possibly changes during the investigation), think the same way as in real life situations.

Learn to approach the real-world problems and create ways to confront problems with no predetermined solution. Explore avenues possibly unanticipated by the instructor and this outcome is highly desirable and must be encouraged by teachers.

Students must get the opportunity to evaluate their understanding and to explore different approaches beyond the factual knowledge offered with the traditional way in the class.

CLASS LOCAL COMMUNITIES

Set the basic competencies and skills students should have so that they will improve their competitiveness in the workplace. Problem based learning and active learning are considered as the most suitable ways for students to develop and improve the personal qualities of discipline, creativity, critical thinking, teamwork and leadership.

CLASS CENTRAL POLICY BODIES:

Methods: By evaluating the results, they proceed to the updating of the curriculum.

Questions raised: what kinds of teachers do we need for particular learners with different needs?'

Using PBL, the whole system needs re-engineering and adjustments Preliminary study must be done in order to create a database of suitable problems which will be evaluated (using appropriate indicators). In addition central policy bodies should guarantee that enough equipments are available, like computers, apparatus for experiments e.t.c.

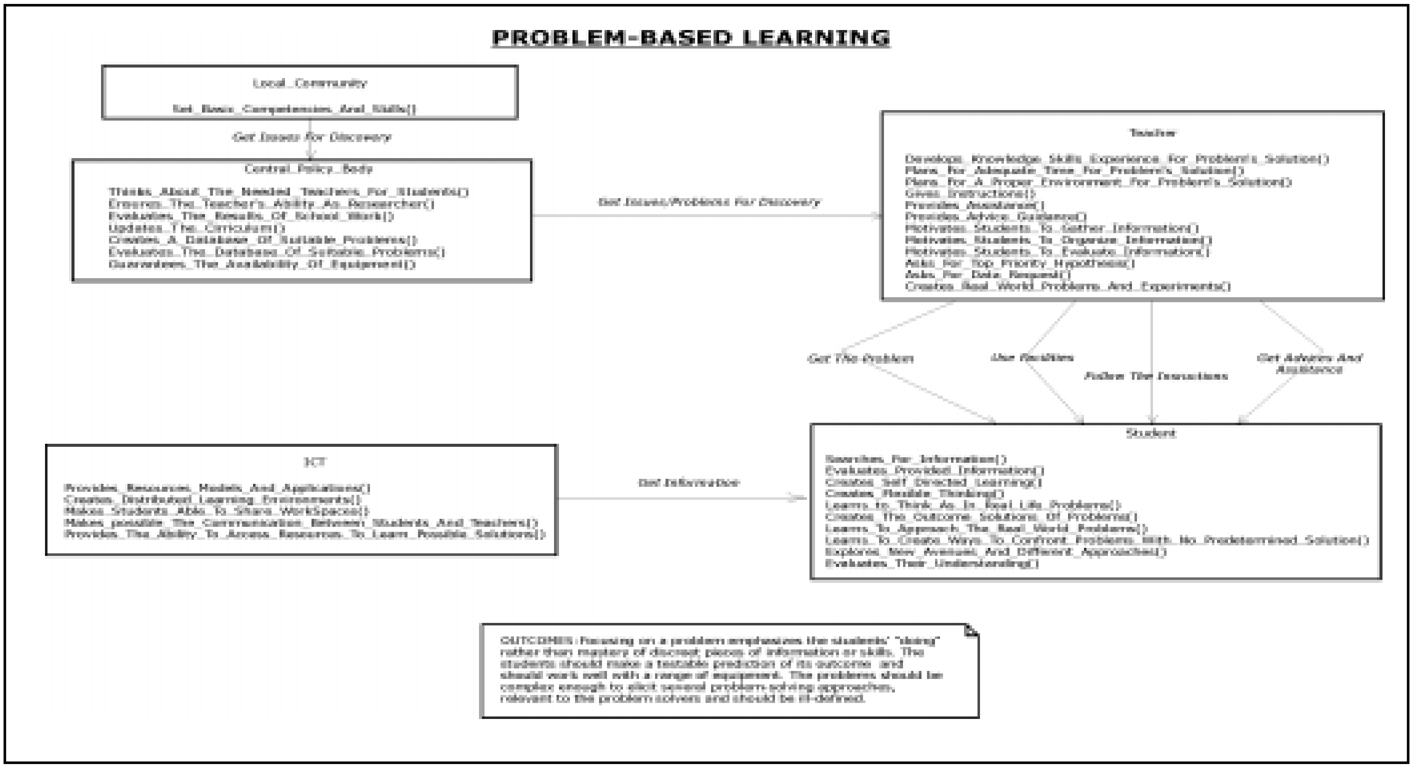
CLASS ICT

Methods: Various information resources, simulations and multimedia/ hypermedia applications could all be used to build essential knowledge and skills.

Using Networked computing facilities create distributed learning environments. Students can share workspaces and communicate with each other and their teachers in various forms. The use of the Information Technology in PBL plays a fundamental role in its success in two components: (a) the organizational aspects of PBL and (b) the use of Web resources to support PBL.

Students have access to resources to learn the possible solutions to the same problem by other people already dealt with the problem under consideration.

OUTCOMES: Focusing on a problem emphasizes the students' "doing" rather than mastery of discreet pieces of information or skills. The students should make a testable prediction of its outcome and should work



well with a range of equipment. The problems should be complex enough to elicit several problem-solving approaches, relevant to the problem solvers and should be ill-defined.

METHODOLOGY

In order to implement the above-mentioned activities in the classroom, special care should be given to the adoption of the attributes and methods of the different agents participating in each activity or-as it usually happens-in the blending of the activities. In particular for science education each activity has its own attributes and methods.

For the constructivist approach referring to lab work, instructions must be divided in different units so they can expose preconceived notions of students. Each lab should begin by briefly stating the aim of the experiment and why we are doing this. Next we should proceed to a short description of the equipments needed and at the next stage we set the questions about the phenomenon to allow the students to make predictions about the outcome of the experiment. These questions about predictions are very crucial and consequently must be answered by the students before they start with the lab work. At this point instead of the physical lab we can use simulation programs or a combination of these. ICT can serve as a learning tool and as a statistical tool. Analysis of data will reveal which simulation program is most suitable for the specific topic oriented learning sequence, which phenomena are interpreted scientifically by students e.t.c. Finally, in every activity we shall use, the construction and implementation of method questions is a necessary procedure in order to relate the exploration of natural phenomenon with the principles of science.

Teachers should guide students to explore in depth the phenomenon from other sources beyond the textbook, guide students to make measurements, plot these and make conclusions. Special attention should be given to the implementation of PBL in Science teaching. Students should then discover the optimal solution of the problem. This is the reason why there is a reluctance to apply problem-based learning into Natural Science disciplines. The main reason for this objection is that some educators feel that before the involvement of students with PBL, a concrete knowledge of scientific issues is required. However, PBL can be successfully implemented if it is organized in a proper way. According to Freedman (FREEDMAN, 1996) traditional methods of teaching physics have led to frequently disappointing results.

CONCLUSIONS

Research–based evidence shows that one of the main goals for education is the development of active students taking with skills demanded form ICT. These issues are not usually met in the classroom. One possible solution is the involvement of students with authentic forms of learning in the framework of the above-mentioned activities. In this article we considered education as a system. With this in mind, we revealed the different agents of the system, their methods and attributes in the framework of well-established learning theories. Using UML, we depicted the basic learning theories as key activities of the educational process. Simulating this work in an object-oriented programming can lead to the discovery of the changes of the attributes of the agents. This is due to the influence of the events caused by the methods of the agents and eventually revealing the stable equilibrium of the System.

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