Online Collaborative Problem-based Learning Environment

from theory to practice

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Abstract— **The general hypothesis guiding our work consists in considering that applying the distributed Problem Based Learning (d-PBL) requires computerized environments developed on a strong theoretical basis. Therefore there are two chosen theories: the activity theory and the action theory. Our goal was to study these two theories effects on learning environments design, and to see if they could propose fields for educational exploitation of the d-PBL method.**

Keywords; PBL; Activity Theory; LMS

I. METHOD KEYS

There are four keys to achieve successfully the PBL method:

First, the problems are presented to learners, as they really exist, as ill-structured unsolved problems, stimulating so the generation of many hypotheses about dealing with causes and solutions. These problems stimulations are conceived in a way allowing learners to know by themselves how to get more given information in order to understand and reach the solution, by applying and enhancing abilities to solve a problem.

Second, learners have to assume the responsibility of their own learning, to determine their needs for learning and to find appropriate resources in order to acquire given information (texts, libraries, websites and experts). Moreover, learners must assume the responsibility of controlling and evaluating their own performance and their colleagues'; the PBL is a learning method focusing on the learner.

Third, in order to reach this goal, the teacher's role is to guide or to facilitate the learning process; he's designated by "tutor" of the PBL. The tutor is a guide who stands beside learners and not a wise person standing on the platform in front of his students.

Fourth, chosen problems are the most convenient ones to be confronted by the learner during his life, his career. The required abilities and activities of the learner are those enhanced during real life – this makes the PBL method an authentic learning process.

II. CONSTRUCTION OF AN ANALYSIS CHART

A. *Prior and posterior operation modes*

The main challenge for a conception process based on theory is to make a prior successful study for its value in terms of quality. The problem becomes more serious when there is a formation device, since priorities for designers (technology, computer graphic, ergonomics …) are not always the same for evaluators (education, cognition …). In this sense, it would be important to do a prior evaluation for these devices and platforms, as great efforts of conception were made. Once educational requirements are well identified, the study of a d-PBL system is applicable as a prior study not only a posterior one. In an article about cognition and experience, Nahas[1] says: "*The importance of a prior evaluation doesn't negatively affect the posterior evaluation which will keep all its importance relatively to technological criteria of speed, operating simplicity, permeability etc. While methodological aspects can rather be subject to a prior evaluation, operational aspects will be subject to a posterior evaluation. According to this point of view, we can enhance one or more aspects. The fact remains that the educational quality of formation prevails evidently the methodological aspect.*"

In this perspective, we propose certain analysis' elements elaborated from definition's elements presented in the first part. These elements will be the driving force which will allow judging systems efficiency towards the absolute intended by educational objectives of formation on one hand, and by technical performances on the other hand, and will allow us answering the initial question: is really the d-BL possible?

B. *From the problem to the situation-problem: the 3C3R model*

In PBL method, the problem is the starting point of learning process. A problem is not an exercise or an application of techniques or an immediate and exclusive application of notions recently theoretically demonstrated. It's rather a situation inspired from real life (thus it's contextualized), ill-

structured, relatively complex (defined by many parameters), appealing to previous knowledge (integration, transfer …) and requiring a deep investigation to be solved. In this sense, it's better to use situation-problem rather than problem, since it clearly refers to a concrete context and suggests a more global investigation during the analysis and solving process.

These elements constitute a theoretical framework to formulate a problem-to-solve within a PBL process conception. Now practically, how can one judge objectively a problem quality? Is there any method one can follow to confirm the situation-problem's authenticity, and what are its tools? This operation must be prior for not exposing learners to "fruitless roads".

Woei Hung[2] answered to these needs through proposing the 3C3R model which is a conceptual framework and a tool for conceiving systematically an appropriate problem for the PBL method. This model is divided into 2 classes of components:

- Core Components (3C) which contain the following elements: "Content", "Context", "Connection" and support the content and the concepts learning.
- The 3C3R model helps the designer in going beyond such obstacles:
- How to join between learning's objectives and content?
- How will the degree of "contextualization" be able to affect researching and reasoning in PBL learners?
- How will the information quantity given in the PBL problem be able to affect cognitive processes relative to researching and reasoning in learners?
- How to adapt the problem to learning's objectives on one hand and to the cognitive ability in learners on other hand?

Hung concretely suggests many questions relative to elements whose answers will direct the design of ill-structured problems, to adapt them to learners' profiles and abilities. The model can, according to Hung, adjust them in function of the two model dimensions: Researching and reasoning.

C. The tutor role

Since there are no well determined rules for tutors, it would be useful to consider the following elements for the learning's design, as modified by Neville[3], as being tasks for the PBL tutor in order to facilitate working with tutorial group members:

- Climate setting: to create a healthy environment favorable for the autonomous learning.
- Planning: to organize and structure the tutorial.
- Clarifying needs for learning: to specify learning's objectives and goals.
- Setting goals for learning: to help learners in transforming their educational needs into learning objectives.
- Designing a learning plan: to help the learners through the strategies learning and development plan.
- Engaging in learning activities: to make an orientation in order to be sure that learners are on the right path of their learning.
- Evaluating learning outcomes: to include formative reactions and a summative evaluation.

D. Collaboration or cooperation?

The debate "collaboration" versus "cooperation" is more complex. These two terms are often used as having the same meaning. In a context of problem solving, the "cooperation" means the labor division in all tasks and its attribution to "cooperator" in form of activity where each person or group is responsible of a part of the problem solving.
On the contrary, the "collaboration" involves a mutual engagement for the participants in coordinating their efforts to solve the problem together. The definition of collaboration, as being the "non distribution" of labor, is not enough for clarifying ambiguities[4]. Miyake[5] demonstrated that in a collaborative activity, we sometimes notice a spontaneous labor division; for example the participant, who has more things to say about this topic, takes the role of "task-doer" while others become "observant". The observant can contribute though criticizing the topic and giving it other perspectives.
Thus, the difference between collaboration and cooperation does consist in whether the task is distributed or not; it's rather localized at the level of the distribution nature: in cooperation, the task is divided hierarchically into independent subtasks and the coordination occurs on the moment of partial gathering; in the collaboration, the cognitive process can also hierarchically be divided, but into intertwined layers. In this sense, the collaboration is a synchronous coordination resulting from the permanent effort to do and maintain a shared conception of problem.

E. To evaluate: Who, why and how?

In a PBL process, the tutor is not the only one to evaluate learners. The evaluation constitutes a complex system according to its nature level (it's at the same time summative and formative), to its agents (tutor, learner and group), to its final objective which is to develop a criticizing sense in learners. In this sense, the evaluation goes over the general and specific formation objectives which generally are measured through tests. The PBL method originality and efficiency on this level exist in the fact that they require 3 paths to the evaluation:

- Self-Evaluation
- Peer-Evaluation
- Tutor-Evaluation

III. THE EXPERIENCE

A. First approach: learning protocols

The main objective of researches based on this approach is to redevelop new concepts underlying the creation of integral collaboration environments in order to support the d-PBL respecting the cultural and social factors' role. The frame of the activity theory analysis is used as a reference by this approach because it defines the human being relatively to its activity with objects and actors in his environment.

Relying on activity theory and a PBL method analysis, the supporters of this approach suggest a conceptual framework of a d-PBL virtual environment. This conceptual framework identifies eight components: agent, space, tool, language, document, action, work division and rules.

The architecture mentioned above gave birth to a prototype named CROCODILE. This system uses the client's architecture. Each client provides a personal interface for users to interact with the application. Consequently, learners, distributed geographically or localized in the same places, can participate in collaborative PBL activities, whether synchronous or asynchronous, in the virtual learning environments.

B. Second approach: the models of learning situations specification

Since many years, we are assisting to the emergence of pedagogical modeling languages. The essential of these works focuses on language of IMS Learning Design[6] notation which appears to be compatible with largest set of approaches, and which relies on a theatrical metaphor. In this way the scenario of a learning unit is decomposed into pieces, acts and partitions played by a certain number of actors, each one with a role. The elements of the proposed conceptual model were the object of different actions of researching leading to proposing a UML profile for the modeling of cooperative situations-problems: the CPM profile. This profile is applied according to the following elements:

- An abstract syntax represented by the meta-model CPM which defines the concepts and the relations specializing UML;
- A concrete syntax defining the notation of concepts and their relations and the principles of these concepts' use in UML diagrams;
- A semantic defined on terminological level and notation level.

The architecture mentioned above gave birth to a prototype named SMASH.

C. Third approach: Virtual Documents Repository (VDR)

According to this approach, an on-line PBL application is composed of 3 paths:

- A set of resources containing tools, documents, etc. which can be accessible to learners, tutors and educational responsible persons.
- A set of problems created by teachers for their courses.
- A PBL method helping learners to organize the access to different steps, actions and resources.

To answer the specifications of this model and the needs in question of adaptation, a Virtual Documents Repository (VDR) was adopted as a support for the on-line PBL. SCARCE (Semantic and Adaptative Retrieval and Composition Environment) is a flexible environment of adaptative hypermedia based on virtual document approach and the semantic web evolution. Therefore we are able, through it, to create and maintain the service in which we solve the selection problem, the organization and the filtering on semantic level.

IV. EXPERIENCE RESULTS

The application of educational chart based on these three devices gave the following results :

- The three examples didn't success in bringing the problem's opening to the critical thinking. This factor affects the situation-problem's nature and its objective, and transforms the PBL method to a better version of problem solving method.
- The collaboration's problem exists on theoretical level. Despite the efforts made to take out the difference between "collaboration" and "cooperation", the designer of the three platforms didn't success in translating collaboration in term of tools and learning activities. On one hand, many terms are used in the same sense: collaboration, cooperation, coordination … On the other hand, the cognitive aspect of collaboration was not sufficiently studied in theoretical parts of these approaches.
- The failures on the level of situation-problem and collaboration will affect the process of the PBL tutorial. In addition to groups' animation, the tutor is essentially charged of maintaining the situation-problem, which is the nucleus of PBL, and facilitating the collaboration. Moreover, it's clear that he has lost his role of evaluator.
- Finally, we notice a total absence of evaluation in the three platforms.
- If there is a comparison between these 3 platforms, it's difficult, through this analysis, to recommend one of them. An evaluation leading to such conclusion must be based on a more detailed evaluation chart and an items' equilibration. This task can only be done by relying on case studies.

V. CONCLUSION

Finally, can we answer our initial question: can the PBL be possible? This study offers many elements that we judge as important to propose an objective answer:

1) The activity theory can serve as conceptual framework for the systems design supporting the d-PBL for the following reasons:

a) In this theory, the problem's nature doesn't affect the activity process. For example, the solving of a well-structured problem can be a goal for an activity knowing that such a problem can't release a PBL in any circumstances.

b) The cooperation is an authentic practice in the activity theory, in condition that it respects the other poles of triangles (rules, work division, object, subject ...), but it's essential to achieve successfully the PBL method.

c) The activity theory doesn't integrate the PBL evaluation in learning process (knowing that learning as an activity). However evaluation plays the role of a trainer in PBL.

d) The object (the learning objectives) in activity theory is limited to the problem solving, while the learning's objective in PBL surpasses the problem.

e) Te tutor's role is so limited in the activity theory. He's in charge of organizing and coordinating activities and operations. PBL gives also the tutor the task of evaluation.

f) On the contrary, the activity theory can interfere in specific and important tasks in the process of designing and the d-PBL systems' evaluation, like in system's components identification (subjects, objects, rules ...) and work division…

2) Action theory:

a) According to the software engineers, the human processor's model defines a theoretical work as useful for the quantitative comprehension and evaluation of general man-system interaction mechanisms. The behaviorist perspective of models treating learning as being a task has to be completed with cognitivist and constructivist perspectives .

b) The implementation of task's model in terms of learning's computerized environments focuses on information (research, organization, presentation…). The focus in d-PBL is put rather on learning's absolute objective, not on its steps and modalities.

3) The difficulty in d-PBL exists in tools and technologies, but rather in situations-problems' conception and in educative engineering. The information and communication technologies offer a set of efficient and diversified tools supporting an ill-structured problem's steps. The d-PBL successful result depends on content, tutor, and instructional design more than in computerized system and technology.

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