Didactics in Online Learning Technical Courses: A Case Study Based on Activity Theory

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Abstract— **Online Learning of technical courses is a major challenge of e-learning. Researches in this field are multiple and cut across many other disciplinary ranging from teaching technical courses to IT. These researches adopt different teaching approaches and materialize through disparate software for the contents and choices for interaction.**

This work is based on some central concepts in the Russian psychology, including the Theory of Activity (Activity Theory: AT). According to this theory, collaborative learning is based on a set of interactions between the subject, the goal (learning) and instruments available, which interactions are also involved learning community, rules and division of work that emanates. In this work we focus on the relationships between the activities of these "communities" of learners and learning that can happen there. The practical implications of this approach for the design and the choice of tools and resources are then presented and discussed in the context of a technical course, in occurrence "Technologie des Colonnes".

Keywords— **Activity Theory, Collaborative Tools, Distance learning, Supervised Learning, Interaction Analysis.**

I. INTRODUCTION

Over the Internet, e-Learning has speeded up the knowledge transfer without restrictions on time and space in recent years. What we know is less important than our capacity to continue to learn more until e-learning appeared. While e-learning technology has matured considerably since its inception, there are still many problems that practitioners find when come to implementing e-learning in their curriculum.

This century requires a flexible learning environment which is able to adapt according to teaching and learning objectives, students' profiles and preferences for information and communication technologies and services. Advances in technology offer new opportunities in enhancing teaching and learning.

Researches in organizational modeling and design of educational content on one hand and the Activity Theory system (Engestrom) [1][2] on the other hand allow us to propose models that arouse commitment and create new motivation forms of learners, tutors and teachers in the learning communities so as to integrate multiple activities. The driving ideas of this work are inspired by work in Robert Lewis [3].

Specifically, the objectives of this work are:
- The definition of variables and methods to evaluate the contents of an online teaching experience of the pilot class using AT.
- Capitalize the experience and make a return to use of an e-learning device for improving content and educational approach in the context of technical course.
- Generalizing the approach used as support the design and the content of scriptwriting in the case of technical courses.

In order to have an overview of all these aspects, this paper is organized as follows. In Section 2 we introduce the main concepts on Activity Theory and its relationship with e-learning. Next, Section 3 presents the features of the e-Learning approach, and the story board of the course used in this experience. Then, Section 4 treats the analysis of interaction and collaboration tools. Its details different points of view of Activity Theory model to evaluate collaboration activity of our course. Finally, the main concluding remarks are given in Section 5.

II. ACTIVITY THEORY AND E-LEARNING

"Activity Theory is a philosophical and cross -disciplinary framework for studying different forms of human practices as developmental processes, with both individual and social levels interlinked at the same time."(Kuutti, Nardi, and Kaptelinin) [4][5][6]

This theory is found in fairly answered manner (Engeström and Kuutti) [1][7] in the Anglo - Saxon literature, as a basic reference in the field of work study or cooperative learning supported by technology. His origins date back to 20-30 years by the Russian psychologist Vygotsky [8] and Leontiev [9] in especially. The synthesis

of the main concepts of this theory, presented below, is based on Lewis [10] and Bardam [11] papers and on the website of the Center for Activity Theory and Developmental Work Research (University of Helsinki, Finland), whose director is Yrjö Engeström itself. Vygotsky formulated the new theoretical concept of "artifact-mediated and object-oriented action" [8]. Human activity is not a direct response to the environment; the relationship between the human and the environment objects is mediated by cultural means (mediator artifact) built by man to become able to control and transform its environment.

A. Profile mediation relationship of the individual to the environment

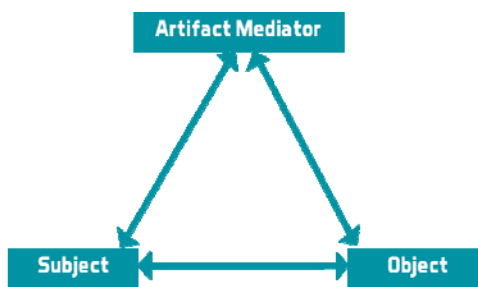According to Vygotsky [7], human activity has a tripartite structure (figure 1).

Fig. 1 Profile mediation relationship of the individual to the environment. Engeström [12].

This mediator artifact can be a hardware tool (hammer) or a psychological tool (for example: the language tool artificially built by man, which allows him to make contact with other individuals in the environment).

B. The levels of human activity

Leontiev continued Vygotsky's research and refines the Activity Theory [9]. He distinguished individual activity of collective activity (in which several individuals share the same object). The key to the collective activity resides in the division of work. He proposed to consider the activity as a system and to take it as the unit of analysis for the social science. This human activity is divided into three hierarchical levels (table 1):

- The activity itself is directed towards an object (a transformation of the environment understood in the broadest sense). Example (from Kuutti [4] quoted by Lewis [10] and by Hashim [13]): An activity can be to build a house (object = build a house).
- This object is achieved through the actions of individuals. These actions aim to achieve goals. Carry bricks by truck and fix the roofing are actions that aim to achieve the object of the activity.
- These actions in turn are produced by means of routine operations, which depend on the conditions in which the action takes place. Nail and change speeds when driving are operations that accomplish actions.

TABLE I
LEVELS OF HUMAN ACTIVITY. LEONTIEV [9]

Activity Level	Subject to	Leading by
Activity	Object / Objective	Community
Object	Goal	Group or subgroup
Operation	Condition of realization	Individual (routine) Machine

Leontiev himself never completed the original activity diagram of Vygotsky.

C. The system of human activity

The following diagram (figure 2) is due to Engeström [1], and is considered as the current diagram of a system structure of human activity.
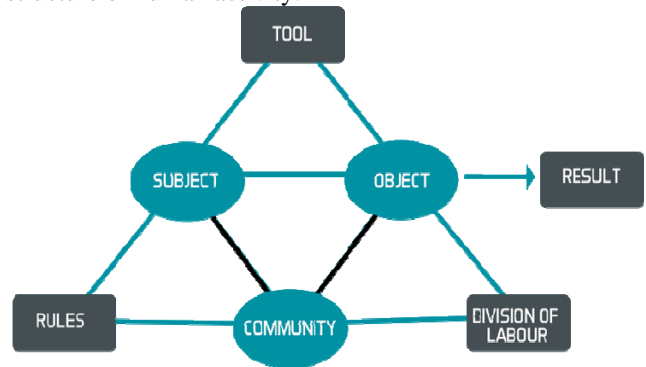

Fig. 2 *The system of human activity. Scanlon [14]*

The activity theory proposes to consider the activity as an observation unit for the social science, so especially for the observation of learning device.

Through its community concepts, division of labor, instruments mediators ... this theory is particularly appropriate for the analysis of collaborative distance learning situations.

III. THE SCENARIO OF OUR COURSE

A. Objective

The objective of this course is to enable students to understand and to master the operation of a column where a unit operation consisting of a mass and / or heat transfer is carried out. For this, students must have a perfect knowledge of all modes of contact and their implementation as well as all the elements that constitute a column.

Knowing the unit operation, the product to be treated and the feed to be treated, the student must be able to identify the type and characteristics of the column to use.

B. Division into modules

Each unit begins with a brief description of the objectives and tasks to be performed by the students. The content is made available to students in the form of a power point document and a certain number of resources in the form of PDF, word and URL.

The division into themes is detailed in table 2.

TABLE II
DIVISION INTO MODULES

Theme	Units	Theory and explanation	Interactive part	Evaluation
Introduction	Introduction Objectifs (1 week in face-to-face)	- Ppt support - Video : Fonctionnement d'une colonne		Glossary
Les colonnes à plateaux	Constitution (2 weeks online)	- Pdf support	Flash Animation : la constitution	Quiz 1
	Hydrodynamique (1 week online)	- Pdf support		Quiz 2
	Dimensionnement (1 week online)	- Ppt support		Homework 1
Les colonnes à garnissage	Les garnissages (1 week online)	- Ppt support		Quiz 3
	Construction des colonnes garnies (1 week online)	- Pdf support	Flash Animation : simulation de la construction d'une colonnes garnies	Quiz 4
Les colonnes dans les procédés industriels	Procédés et colonnes (1 week online)	- Ppt support - Video : Procédé industriel		Homework 2
Conclusion	Révision Récapitulation (1 week in face-to-face)	- Ppt support		Written exam
Practical work	Colonne à distillation (1 week in face-to-face)	- Manual of practical work		
	Colonnes à absorption (1 week in face-to-face)	- Manual of practical work		Report 2

C. Pedagogical scenarios

In this section we specify weeks, content, mode, etc ... of our scenario (table 3).

TABLE III
PEDAGOGICAL SCENARIOS

week	Mode	Contents	Learning activity	Learning model
1	Face-to-face & Online	- Introduction à la technologie des colonnes - Objectifs du cours	- Production of a glossary on terminology of "Opérations unitaires" (groups of 10)	- Collaborative Learning
2	Online	- Constitution d'une colonne à plateaux (virole, tubulures)	- Read - Forum	- Individual Learning - Collaborative Learning
3	Online	- Constitution d'une colonne à plateaux (plateaux)	- Quiz 1	- Object approach
4	Online	- Hydrodynamique des plateaux	- Quiz 2	- Object approach
5	Online	- Dimensionnement d'éléments de colonnes	- Homework 1 : Exercices sur le calcul des colonnes	- Problem approach
6	Online	- Les garnissages des colonnes (description, caractéristiques physiques)	- Quiz 3	- Object approach
7	Online	- Construction des colonnes garnies	- Quiz 4	- Object approach
8	Online	- Procédés industriels	- Homework 2 : Conception d'un procédé industriel incluant des colonnes (groups of 5)	- Collaborative Learning
9	Face-to-face	- Revision, recapitulation	- Written exam	- Individual Learning
10	Face-to-face	- Practical work : Distillation	- Manipulation, report (groups of 5)	- Collaborative Learning
11	Face-to-face	- Practical work : Absorption	- Manipulation, report (groups of 5)	- Collaborative Learning

D. Evaluation

For the evaluation, we summarized the process in the table 4:

TABLE IV
EVALUATION

Activity	Evaluation	Total (points)
Glossary	- Collaborative contribution	10
Forum	- Participation : 5 points - Individual contribution : 5 points	10
Quiz 1	- Maximum of 2 attempts	10
Quiz 2	- Maximum of 2 attempts	10
Homework 1	- Individual exercises	10
Quiz 3	- Maximum of 2 attempts	10
Quiz 4	- Maximum of 2 attempts	10
Homework 2	- Individual contribution : 5 points - Collaborative contribution: 5 poins - Report : 5 points - Presentation : 5point	20
Written exam	- Individual test	20
Practical work 1	- Manipulation : 5 points - Report : 5 points	10
Practical work 2	- Manipulation : 5 points - Report : 5 points	10

IV. COLLABORATION ANALYSIS BASED ON ACTIVITY THEORY MODEL

The study we present is based on analysis of the messages sent to the discussion forums, exchange messages in various chat rooms, access to different resources and rules of coordination used during the experience of the pilot class (course: "Technologie des Colonnes").

The Activity Theory highlights the characteristics features of efficacious working communities, and it is interesting to examine how they can be transposed to distribute learning communities. To analyze our experience, we have resorted to cutting triad presented by Lewis [10]. In this analysis we tried to consider a set of parameters that are linked to one of the triad dimensions and have an existence in the time and the space from the experiment.

It is probably futile to try to analyze all the relationships that influence learning activities, because of the multitude of interdependent parameters. But this complexity might be reduced by examining one by one nodes triads.

First we will present the experiment figure and then we'll analyze and interpret some results of this experiment.

A. The pilot class figure

A total of 40 second-year students (Technical University Degree, Process Engineering, option: Chemical Industries) and 1 tutor participated over a period of 11 weeks. Three forums and 145 messages posted. There have been 68 participations in the 4 chats for about 2,000 words per session. Connections to the course were 348 in number.

B. Analysis according to the triad: Community-Object-Subject

This triad represents the reconciliation of individual objectives in order to achieve common actions. Can a common object be defined? An activity emerges and is established with a number of intentions. In a community, this requires the establishment of a common language and the commitment of individual members to contributing to an explicit common object. In other words, the actions cannot be predefined. The interpretation and the negotiation should be allowed. As well as taking both individual and collective possession of the work object.
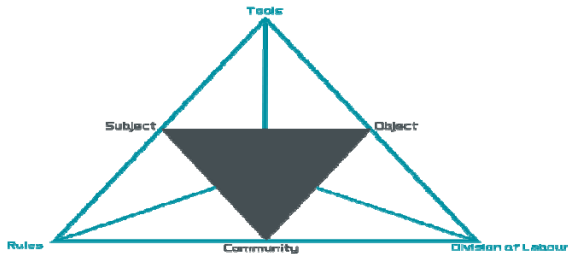
Fig. 3 *Triad Community-Object-Subject*

In the context of theme 1 of the course, each student must participate in the forum by posting messages concerning "Technologie des Colonnes". This is a separates groups forum. Once a concept or definition is raised by a learner in the forum, the group coordinator must insert it in the glossary. The glossary will accept only unique entries. Each group must insert 10 entries in the glossary. The coordinator must notify each member of the group of the work evolution, to push them to seek more definitions. This insertion is performed only if the concept has not been inserted by another coordinator of another group. So, we considered the following analytical variables (figure 4).
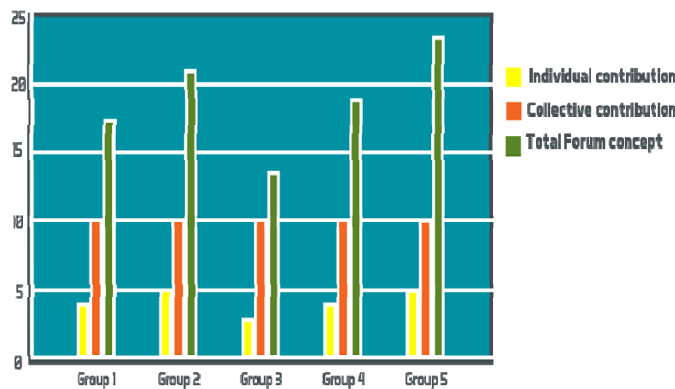

Fig. 4 Analysis by the triad: Community-Object-Subject

If we distinguish these three variables as shown in the figure 4, we noticed that the role of the tutor in this kind of situation is very modest. It appears, moreover, that the interventions of tutors are located mostly in the "structuring" category, although included in it as many interventions by the learners. Moreover, we note that it is the learners who ask the most questions and the number of responses to the questions is the same for almost all groups. This data also indicates that learners assume their role as

actors in transmitting knowledge that will be available to other group members.

C. Analysis by the triad: Community-Object-Tools

The triad Community-Object-Tools (figure 5) is about how the tools (for example: hypermedia documents) can be designed and used in ways that promote the achievement of an object by the community as defined in the previous triad. Are the tools appropriate considering the objectives?
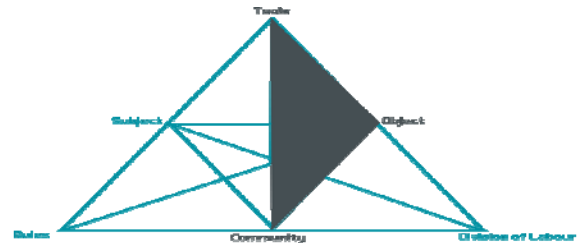

Fig. 5 *Triad Community-Object-Tools*

This analysis was done on the basis of a survey carried out at the end of the course. This survey consists on asking each learner which resources helped him in the achievement of each activity.
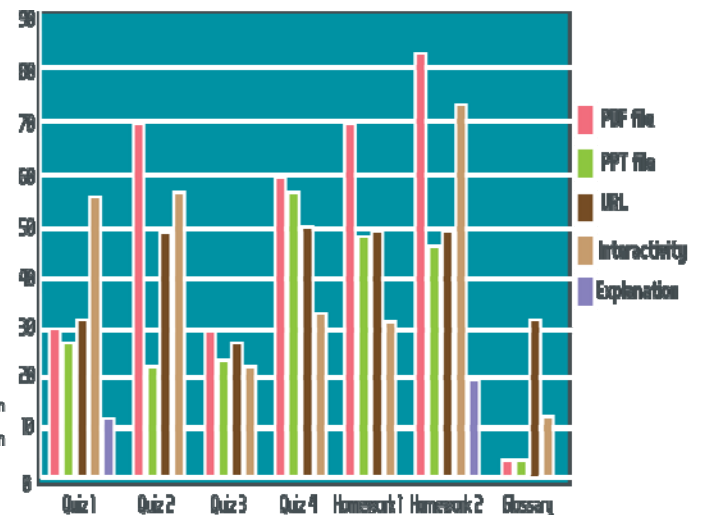

Fig. 6 *Analysis by the triad: Community-Object-Tools*

According to this analysis (figure 6), we note that the documents in detailed course materials contribute significantly to the achievement of individual activities such as quizzes and homework. PowerPoint presentations have a stable factor for all individual activities but, on the other side, links web resources contribute as much to the collaborative activities of the groups.

D. Analysis by the triad: Community-Subject-Tools

This triad concerns common tools. It includes communication tools, which are essential in a dispersed community. Other personal tools are required. Its nature varies according to the distribution of work established by the community.
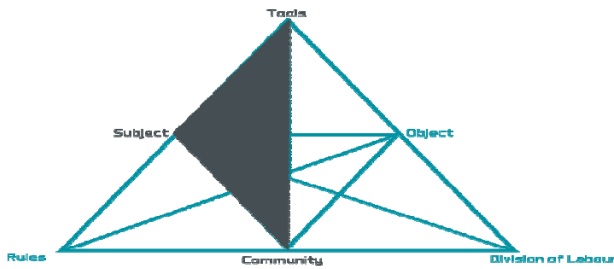
Fig. 7 *Triad Community-Subject-Tools*

Going back to intentional learning communities, it is clear that the tutors play a key role, not only in providing access to communication channels, but also by controlling their effective use and involving problems in order to support communities still fragile. This triad is an extension of the previous regarding the "groupware", i.e. software for group communication, shared workspaces, group document editing, etc ... But it concerns the subject rather than the object.
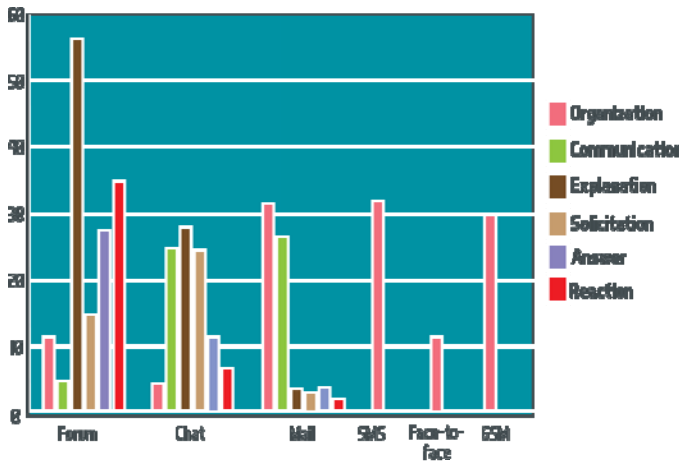

Fig. 8 *Analysis by the triad: Community-Subject-Tools*

According to this analysis, the forums are in the lead for the participation in the collaborative challenges in learning environments. Discussion forums are not only social meeting places. They fill, moreover, an important function as spaces where tutors and learners interact in a learning objective. Meeting spaces in the learning process, as "physical" classes, they are places where teachers and learners expose ideas, formulate questions and respond, react and communicate. For this reason, a dimension which analyzes these processes a didactic point of view is required.

In chats, because of their synchronism, learners communicate, solicit, demand clarification, but organize themselves and react little.

During this experiment, we received several phone calls and SMS. All these communications were initiated by a class representative who asks questions about the organization of activities. Almost the same questions were asked during the two face-to-face sessions (week 1 & week 9).

The e-mail was used only for the purpose of communication and organization. It is perceived as a substituent of GSM and SMS communications.

V. CONCLUSIONS

The We have presented an approach that is based on the Activity Theory, through analysis of monitoring a pilot class on a technical course "Technologie des colonnes" hosted on an e-learning device.

The study that we presented is based on the analysis of messages in discussion forums, exchange messages in different chats, access to different resources and rules of coordination used in forums and chats during the experiment of our pilot class.

The Activity Theory highlights the characteristics features of efficacious working communities, and it is interesting to examine how they can be transposed to distribute learning communities. To analyze our experience, we have resorted to cutting triad [10].

In this analysis, we detailed the following three triads:
- Community-Subject-Object
- Community-Object-Tools
- Community-Subject-Tools

So, we tried to consider a set of parameters that are linked to one of the triad dimensions and have an existence in the time and the space of our experience.

Through this analysis, we found that collaborative learning approach offers a good path in the design and the teaching of online technical courses. The question is, where and when collaborative activities must be inserted into the device.

We noted that chats in the beginning of each course topic is very important and defines an explanatory point and a consciousness of tasks by the learner, and that a forum throughout the activity of a theme enriches the development and production phases of the learner.

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