A LOOK AT THE LEARNING PROCESS IN REMOTE LABORATORY

Tele-experimentation situations at ICAM

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Abstract: The aim of this paper is to present several steps of the methodology that have been defined to analyse a learning situation of tele-experimentation at ICAM (High School of Mechanical Engineering). According to the pre-defined objectives, we establish a framework based upon Activity Theory that will lead us to the definition of indicators i.e. granular key-elements and thus to the effective elaboration of questionnaires and observation grids.

Key words: Remote laboratory; Tele-experimentation; Activity Theory; Learning process.

1. INTRODUCTION

In this paper, we present a pedagogical analysis of the learning process of students, using an experimentation platform of a remote laboratory carried out at ICAM[1] Institute in Lille. The experimentation platform is the main contribution of ICAM in the European Project of Divilab (DIstributed VIrtual LABoratory)[2].

The Divilab project aims at proposing a generic concept of remote laboratory allowing learners to realise their practical work (in Experimental Sciences) at distance by means of multimedia tools and accessible via Internet or intranet. Thus, the Divilab environment is concerned with virtual laboratory works e.g. interactive manipulation of virtual objects with a 3D interface as well as a distance real time laboratory.

At ICAM, the remote experimentation is applied to the domain of Automatic control dedicated to postgraduate students i.e. engineers in initial formation whereby hundred of them are involved.

The main objectives aimed by the Institute are:

- to offer an experimental and distributed environment which is flexible and freely accessible by learners i.e. without time and space constraints. Indeed, the main objective is to offer self-training to students in such a way that they can consider different points of views about their experiment, and getting involved in reflective activities through inductive approach to learning.
- to enable the learner to develop scientific knowledge and know-how in the domain of the automatic control called "digital control of continuous dynamic system", and to enforce cognitive appropriation. The purpose is mainly to develop the learner's autonomy, to motivate him to become more active in his learning process and to encourage the collective work (richer exchanges) within the experimental activities.
- to initiate innovative educational approaches based on the use of technologies so as to enhance the quality of scientific teaching without raising costs .
- to encourage the mutualisation and the sharing of experimental equipment, often very expensive, between partner establishments.

This paper has been co-authored by the two following authors, Patricia CAPPELAERE as PhD student in Educational Sciences whose role consists in setting up the pedagogical analysis of the environment as part of Divilab with Dr Allal SAADANE, from ICAM, as responsible for the research

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program of the tele-experimentation platform and for the global evaluation of the whole system.

The paper is composed of four parts. The first part gives us a general view of the ICAM tele-experimentation platform and of the learning activities within the remote laboratory. The second one presents a basic analysis of the mediated environment which allows us to apprehend the way it is articulated. The third one proposes the Activity Theory as an analysis instrument with which some triads would be defined. Finally, the last one presents the core of our analysis studying the triads related to the learning context with the intention to elaborate questionnaires and observation grids.

2. DESCRIPTION OF THE ICAM TELE-EXPERIMENTATION PLATFORM

The aim of the ICAM tele-experimentation platform is to develop learning activities through the implementation of computers in the experimentations.

2.1 General presentation of the technological device

The conception of the platform gives the learner the possibility to realise experimentations at a distance and on a real device, apparatus situated in the Institute laboratory controlled from a graphic interface on the learner's computer via Internet. This one is linked with an internal computer having appropriate software and hardware at its disposal and keeping the control functionalities. The computer controlling the real apparatus e.g. the experimental benches is distinct from the one which lodges the server. In other words, this remote laboratory offers remote access to real laboratory equipment and instruments.

2.2 General presentation of the learning activities

The platform offers three tele-experimentation activities whose topics are: Initiation to the identification methods of linear systems, Polynomial control of linear system and Control of the MIMO systems i.e. multiple inputs/multiple outputs systems.

Five lab sessions (each one for a duration of four hours) cover the whole three tele-experimentation activities with the participation of twelve to fourteen students. These ones are invited to work in small groups of two or eventually three people if need be (binomial or trinomial groups). Every lab

session is composed of six groups of two or three students. The entire class is shared into two groups having freely register for remote or local lab sessions from the beginning to the end of the teaching.

Computer application as online simulation for each activity is proposed to the learner so as to test and adjust the control parameters of the studied process before starting the experimentation on the real and remote system. The online simulation, used as part of design methodology, also helps the learner to predict the behaviour of the process and its limits.

The assessment of the practical works by every group of students relies on returned intermediate reports made online recapitulating the theoretical parts, the experimental protocol justified, and presenting the discussed results and argumentative conclusions. The report must also specify the gap or the differences between the obtained results with simulation software, and those obtained through the physical system. A lab session exam is organised by the tutor in the local laboratory to give final assessment.

In its actual version, the communication tools between the learning community for the tele-experimentation are not integrated into the platform. Indeed, the eventual interactions between learners and the tutor online basically rely on the electronic mail (asynchronous mode) and on the telephone (synchronous mode).

For each activity, learners have at their disposal online:

- the description of the experimental process
- the description of the objectives to achieve for the practical work
- a presentation of the structure and the objectives of the control system that they wish to put into work
- an online course support
- an interface allowing to achieve by choice, either an online simulation, or an experiment on the distant experimental process.

The remote environment is the translation of in-situ laboratory experiments to distance learning[1]. Some publications about the architecture of ICAM platform and more details about ongoing works and other aspects of this kind of distributed environment will be done later on.

3. BASIC ANALYSIS OF THE ENVIRONMENT FOR IDENTIFICATION

First of all, we have based our analysis on the nature and the type of e-learning education for which the laboratory focuses on. We have thus selected three characteristics which identify the tele-experimentation platform and its own context. We think that these ones play an important

role in behavioural aspects of learners as well as in the pedagogical position of the tutor with regard to the learning activities.

The first characteristic leads us to distinguish two types of remote command and control which mainly determine a tele-experimentation situation : the tele-operation and the tele-piloting[2]. Tele-piloting consists in driving, directing a remote system e.g. a car or a robot. More generally, tele-operation consists in making the remote system functioning. The tele-experimentation in the ICAM environment is related to the principles of tele-operation since it includes an internal computer connected to the physical system and operating a remote command without the move of this one.

The mediation i.e. the way the platform is mediated states an horizontal type of mediation. Indeed, the learner's computer is located on the same level as knowledge that is to be acquired. The computer typically plays the role of a tutor or a companion, helping the learner to attain focused objectives. The computer which is the main artefact in this environment intervenes all along the learning process and is entirely integrated into the core of the environment.

The third characteristic takes into account the place where the experimental activities are realised. For all students concerned, the tele-experimentation is divided into two levels: local training courses in the Institute (with the presence of the tutor) and remote training courses (with a tutor online in the respect of the pre-defined hours of the lab sessions). The appropriation of knowledge is shared with home (remote lab sessions) and the Institute (local lab sessions). The online environment is then usable in both local and remote mode where the learner can choose his best moment to work.

4. THEORETICAL FRAMEWORK AND ANALYSIS STRATEGY

In our analysis, we emphasize on the learning process, especially the interaction between learners and the mediated environment. Our analysis object is to define how the learner realises his activities within the mediated environment, and to determine the whole processes and the learning strategies deployed to learn and to reach goals. Thus, our study aims at passing judgement on the act of learning, the process, and not on the result of this act, the product.

Activity Theory constitutes the theoretical framework of our analysis since it helps us to understand the learner's actions, mainly his purposes, the aim he deploys in exploring, for example, an hypertext or an hypermedia. Activity Theory takes into account the context in the understanding of an

activity. Engeström[3] (1987) proposes us the expanded model of an activity involving a set of nodes open to interact between them (see the figure bellow). This model not only considers the action mediated by artefacts (tools) but also a community context with the addition of rules and divisions of labour. For our part, it gives us the possibility to make correspondences between our specific triads and the real activities of the learner.

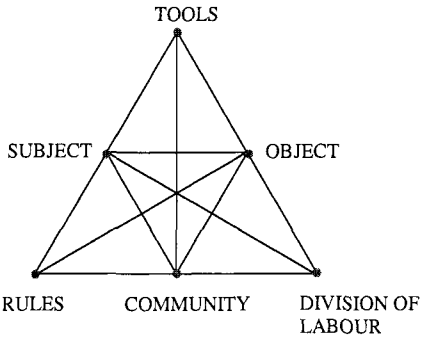

Figure 1. Expanded model of Activity

This model can be summarised as describing human activity as an object transformation process including :

- A *subject* : every human beings involved in the activity
- An *object :* the objectives that motivate the activity
- *Tools* : the mediated environment, material and human resources
- *Rules* which express implicit or explicit norms, habits, etc
- *A Community* : the environment in which the activity takes place
- A *division of labour* : the assigned roles as well as the schedule

According to this theoretical framework, we can define the nodes in relation with the tele-experimentation. The nodes and their characteristics are based on the learning scenario and on the orientation that we wish to lead for our analysis. Thus, the subject is the learner, since our look is centred on the learning process. The object is regarded according to each lab sessions for each has different objectives for the realisation of the activities. The tools concerned are the material and symbolic ones : Internet, simulation software, online contextual documentation according to steps in the scenario, communication tools like electronic mail and telephone. For its part, the community refers to all the learners sharing the same object, i.e. the group of two or three students according to the experimental context, and the tutor online. The division of labour, in our analysis, implies the horizontal repartition of actions within the group and between different groups. Finally, the rules concern the norms and the implicit and explicit practices which

support and regularize the actions and the interactions within the system. This pole is separately analysed as a pole intervening, in some ways, in each triads that we have defined.

5. ANALYSIS METHODOLOGY

Our analysis methodology is articulated around the following structure of work:

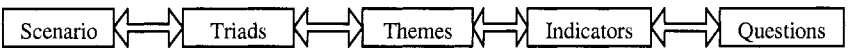

Figure 2. Structure of work

Regarding the pre-defined scenario, we have considered the most representative triads of the learning situation in order to study different approaches of our analysis. Each triad is related to a theme so as to characterize the choice and the nature of our indicators, key elements orienting and conceptualising our questions and our interrogations. The final structure of this work results in the elaboration of questionnaires submitted to the students and our observation grids.

5.1 Our selected triads

Each triad concerns three particular nodes, but is kept implicitly linked to the whole other nodes of the activity.

5.1.1 Triad tools/subject/object

This triad is translated by the following question: how does the learner use the tools to realise his object? The relation between the three nodes is referred to the theme as follows: the learner's adaptation to his environment.

The concept of adaptation gets us to analyse the conditions of the realisation of the learner's activity within the environment and to analyse the visible learner's behaviour.

We determine three indicators:

- the obstacles and the facilities of tools use : this indicator allows us to know whether the tools facilitate or constrain the learner to realise his activity, and to precisely define the degree of learner's mastering concerning the use of tools during his learning process. Is there familiarity or dismissal?

- the relevance of tools use : this indicator is analysed according to the relation between the expected uses and the real ones so as to define the tools' appropriateness with the pedagogical objectives.
- the realisation of tasks : this indicator induces us to know whether the learner realises the different tasks of the experimental activity by following the expected directives and protocol.

5.1.2 Triad subject/tools/community

The study of the triad brings us to the question: how does the learner move closer to the community and which tools does he use for that? The theme is based on the individual and interpersonal interactions between the learners.

We retain as indicators the analysis of the interactions between:

- subject/subject "in" : interactions between the subjects belonging to the same binomial group.
- subject/subject "out" : interactions between subjects belonging to different binomial groups.

These indicators rely on a quantitative approach regarding the subject's exchanges with the tools used.

5.1.3 Triad subject/community/object

The question is to know : how does the subject use the community to realise his object ? We have retained the notion of interdependence between the subject and the learning community as theme.

Corresponding to this, the indicators are:

- the learner's integration into the community.
- every kind of help and remediation processes when realising the experimental activity.
- the realisation of the tasks, more precisely the way the subject follows his activity through, within the community.

Theses indicators allow us to analyse the learner's behaviour and aptitudes for decision making, for auto-evaluation and for hetero-evaluation processes. In other words, we wish to know his personal and social implication in the environment with the view to determine his position (active or passive) in the realisation of the activity.

5.1.4 Triad community/tools/object

This triad is related to the following question: how does the learning community use the tools to reach the object? Here, the theme is defined as : the analysis of the interactions between the agents, i.e. learners and tutor[4].

Different types of interactions within the community can be interpreted according to the use of tools, to the related objectives, and to the implication of the agents.

Our indicator considers the relations between the number of people involved in the activity: the role of these people, tools and objectives. We thus focus on the following interactions:

- Binomial group/binomial group : interactions between binomial groups of students.
- Tutor/ binomial group : interactions between the tutor and a particular binomial group of students.
- Tutor/binomial group/binomial group : interactions between the tutor and several binomial groups of students, for example.

This indicator takes into account the frequency and the quality of the types of interactions, in order to know whether the interactions express an information or help request, a proposition in or out of the context of the learning process according to the use of tools, and in the synchronous or asynchronous communication mode.

This indicator handles a quantitative and qualitative approach of the interactions.

5.1.5 Triad community/subject/division of labour

Here, we ask the following question : how does the learner manage his activity with the community and how is the division of labour established? The theme retains the key concepts of collaboration and cooperation[5].

We put our attention on the learner's position and strategies about the management of his work taking the group structure into account. This analysis allows us to distinguish cooperative and collaborative approaches in the learning process[6], i.e. the learner's specific role and actions in the community[7].

The corresponding indicators are:

- the confrontation/juxtaposition of points of view : cognitive and socio-cognitive conflicts
- the management of the activity of every member of the community : the establishment of motives and the distribution of these ones.
- the transformation of representations or points of view .

6. CONCLUSION

We have opted for a mixed analysis methodology so as to turn the collection of quantitative and qualitative results to good account. The instruments for questioning rely on a survey with questionnaires and observations.

The observations in-situ of the lab sessions enable us to comprehend the way the learners behave in mediated environment and to appreciate their behaviours. The indicators corresponding to our selected triads of the learning situation will support the questionnaires and our observation grids for which related items are defined.

Three questionnaires (with the collaboration of ICAM) will be submitted to students covering the three general steps of the teaching that is to say before, during and after the lab sessions, with the view to appreciate the evolution of learners' considerations about the e-learning situations that the Institute proposes.

At the present time and since the lab sessions are going to start soon, we have submitted a pre-questionnaire to the students, which states three important points. First, their expectations and their commitment in the experimentation platform, for instance their consideration about e-learning situations carried out in a remote or local mode, the resources they feel necessary to realise their experiment in good conditions. Secondly, their experience in e-learning situations. Finally, their experience and knowledge about the use of computer sciences such as Internet, electronic mail, web surfing, forum, etc.

The collect of the pre-questionnaire will be done later on.

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