# SOCIO-CULTURAL MODELLING OF THE STUDENT AS THE MAIN ACTOR OF A VIRTUAL LEARNING ENVIRONMENT

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*Abstract:* - In our paper we are presenting a socio-cultural model of the student as the main actor of a virtual learning environment. The model is part of a larger project - DANTE – *Socio-Cultural Models implemented through multi-agent architecture for e-learning* – that has as main objective the development of a model for the virtual education system, student centred, that facilitates the learning through collaboration as a form of social interaction. The model requires its own universe in which the human agents interact with the artificial ones (software agents). The project presumes the combination of the artificial intelligence (multi agent) system with elements of the socio-cultural theory of learning by collaboration and human actors.

*Key-Words:* - virtual systems, real systems, decision behavior, learning models, agent technology

## 1 Introduction

Current conceptualizations of socio-cultural theory draw heavily on the work of Vygotsky (1986), as well as later theoreticians (see, for example, Wertsch, 1991, 1998). According to Tharp and Gallimore (1988) "This view [the socio-cultural perspective] has profound implications for teaching, schooling, and education. A key feature of this emergent view of human development is that higher order functions develop out of social interaction. Vygotsky argues that a child's development cannot be understood by a study of the individual. We must also examine the external social world in which that individual life has developed...Through participation in activities that require cognitive and communicative functions, children are drawn into the use of these functions in ways that nurture and 'scaffold' them" (pp. 6-7). Kublin et al (1998) succinctly state that "Vygotsky (1934/1986) described learning as being embedded within social events and occurring as a child interacts with people, objects, and events in the environment" (p. 287). Vygotsky's theory of social cognitive development is complementary to Bandura's social learning theory[1].

On the other hand, the same perspective is taken into account in the new IT metaphor "computing as interaction" as well as in the "emergent synthesis" theory used to explain multi-agent systems.

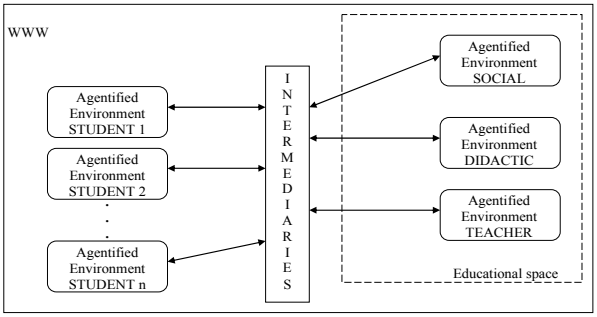
## 2 Learning environment model

The general architecture of the *e-Learning* system proposed (Figure 1) is one with three levels (user, intermediary, supplier-educational space), to each corresponding heterogeneous families of human agents and software (Figure 1).

The *teacher* (human agent) is assisted by two types of software agents: *personal assistant* (classic interface agent) and *didactic assistant* (Figure 2). The personal assistant has the role of secretary; he

[1] Bandura's major premise is that we can learn by observing others. He considers vicarious experience to be the typical way that human beings change. He uses the term *modelling* to describe Campbell's two midrange processes of response acquisition (observation of another's response and modelling), and he claims that modelling can have as much impact as direct experience.

mediates the communication with other human and artificial agents, edits new activities for the student and communicates them to him, supervises the student and the schedule of the activities, which take place in real time. The didactic assistant has the role of assistant from the classic educational system. He assists the teacher in the creation and the distribution of educational resources, the management of the personal database, and on request he transmits messages to the personal assistant for the students or other teacher-agents. The didactic assistant communicates with the agents from the social environment in order to extract group profiles and from the didactic environment in order to access information with documentary character or tools for the construction of didactic activities. The teacher has access to the entire educational universe.




General architecture on 3 levels
(user-students, intermediares-brokers, educational space)

Figure 1. The three-tier architecture of the DANTE system

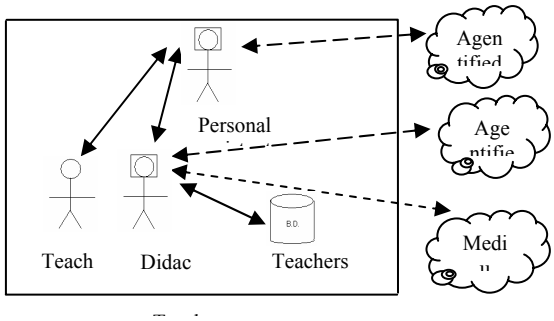



Figure 2. TEACHER Agentified Environment

The *SOCIAL agentified environment* (figure 3) has a social agent and a database with *group models* (profiles of social behavior). The social agent has as main aim the construction of models for the groups of students who socialize in the virtual educational environment. He identifies groups of students who can cooperate in good conditions (respectively they have similar levels of knowledge and comparable personalities).In the teaching model by collaboration each group is considered an active entity and the system must recognize him/her as such. The social agent captures the group models and memorizes them in the database. A modality o construction of the group models might be that in which the TUTOR agent (from the STUDENT agentified environment) supplies the individual model, the individual models are compared, then the similar ones are grouped and constitute the general model of the group with certain number of axis (for example, the degree of trust in proper capacities, common opinions, elements upon which there is unanimous consensus, conflicts, affections, etc.)

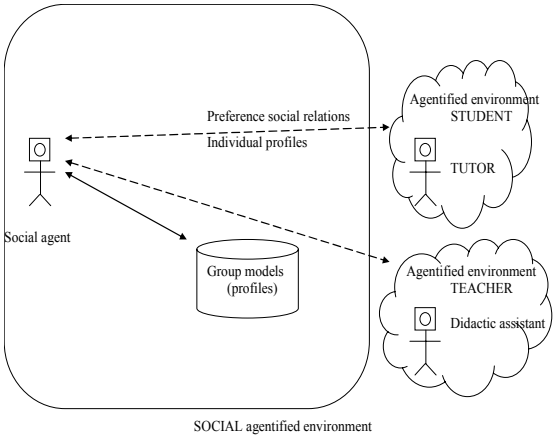



Figure 3. SOCIAL Agentified Environment

The *agentified DIDACTIC environment* (figure 4) assists the cognitive activities of the student and/or of the teachers. Within this environment a Web searching agent evolves together with a semiotic agent who stimulates the interceding agent of the student sending him pictogram-type stimuli, text, numbers. The environment is endowed with a collection of instruments and signs recorded in a knowledge base.

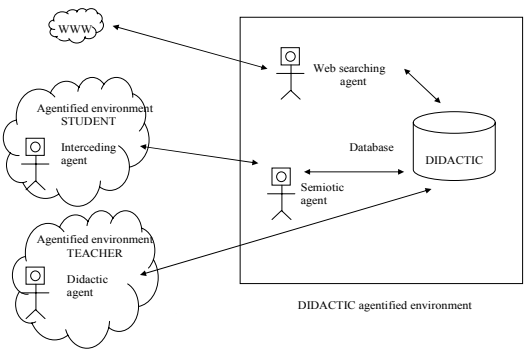



Figure4. DIDACTIC Agentified Environment.

Both artificial and human agents interact. We distinguish different interactions: software agent-software agent, human agent-software agent, human agent-human agent. The system will offer instruments for the synonymous and asynchronous learning. At a first stage, a supervisor agent will be necessary (proper for the chosen e-Learning platform like Message Router Agent of the platform JATLite) at the level of the Web server, which will carry out the connection of different agents, so that subsequently more advanced solutions would be searched/looked for.

## 3 STUDENT model

The student (human agent) evolves in an agentified environment with three types of agents. He/she also has a personal assistant (software interface agent) who monitors all the students' actions and communicates (interacts) with all the other agents, with the agentified environments of other students and the TEACHER agentified environment. The student has at his/her disposal two more agents: *TUTOR* and the *mediating agent*. The TUTOR assistant evaluates the educational objectives of the student and recommends her/him some kind of activities. The decisions are based on the knowledge of the students' cognitive profile (which takes into account the social component). The TUTOR agent interacts with the personal assistant of the student, with the mediating agent and with the social agentified environment. The mediating agent chooses an evolution mechanism of the solution to an exercise or a test proposed by the student, analyses the solution given by the student and produces feedback. The mediating agent can communicate with the personal assistants of other students. As the system is conceived, the accent is put on collaboration activities between students, which consist in knowledge exchange, realization of common projects, in groups, tasks' negotiation, resources' partition, common effort for the understanding of a subject, problem-solving in-group.

The STUDENT model is a mixed one, embedding the behavioral theory with Vygotsky's socio-cultural theory.

In our model we will consider that an action ***i*** is defined by a set of attributes A. An individual has to decide among a set ***I*** of possible actions:

$$\boldsymbol{I} = \{i_k, k=1,2,...,n\} \text{ and } A_k = \{a_{ki}, i=1,2,....m\} \quad (1)$$

For example, when test results are less than the accepted one, the STUDENT can take the decision to fix the problem by requesting further study materials or online self-tests sending and/or asking for support from colleagues. For each action the STUDENT is evaluating a *quality-cost function* where tutor's satisfaction is opposed to real costs of the action (intellectual effort, time consumed). The evaluation of the quality cost-function is influenced also by factors inner to individuals. At individual level we are considering that the evaluation is also influenced by two categories of factors: ***beliefs*** (cognitive) and ***affects*** (emotive).

***Beliefs*** are associations between actions and their attributes. Individual beliefs are cognitive; they depend on the level of education, culture and on the group's beliefs. The strength of the belief is directly determined by the strength of the association between an action and a certain attribute and in general does not depend on the true value of the association. They do not evaluate the *quality-cost function* at all; the belief is strong enough to be recorded in memory and to become automate. For example, in the former situation, some of the students can believe that the effort to acquier more knowledge is vain, too time consuming and too complicated especially in the time intervals between exam sessions. Even if the evaluation of the *quality-cost function* shows that more reading will enhance test results, the belief is stronger and they act consequently.)

***Affects*** are feelings or desires associated with certain stimuli. There are many conceptual models of the affective component of behavior. We will briefly remember some of these models. The *functional theory of attitude* considers that affects help individuals to accomplish a certain actions by application of prior knowledge, value expressions, and adjustments and by ego defence. According to the *Fishbein model* (Fig. 5) the decision to perform a certain action is directly influenced by the link between beliefs and affective responses. If the beliefs are strong and favorable for a certain action, the affective response is positive. This can be formalized as follows:

$$i_k = \sum_i B_i E_i \quad (2)$$

where

$i_k$ is an action, k=1,..,n

$B_i$ is the belief that $i_k$ posses the attribute $a_{ki}$, i=1,..,m

$E_i$ is the evaluation or utility (desirability) of attribute $a_{ki}$, i=1,..,m

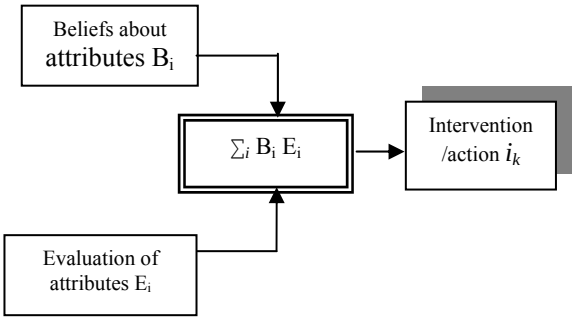



Figure 5. Fishbein model

The STUDENT personal assistant can use a modified Fishbein model where ranks are assigned to the attributes of an action and can be by compare with those of other actions providing the same kind of results.

An important component of the attitude toward an action is ***intention***. Intention is a behavioral component. Behavioral intention describes the attitude not toward an action but toward performing an action. One of the models that take into account behavioral intention is the *theory of reasoned action* that states that behavior is a direct result of intention and that there are involved two factors: *attitude toward an act* and *subjective norm*. The decident attitude toward an act, $\alpha_k$, is the sum of the decident's belief strength in the consequences resulting from performing a certain action (taking a certain decision) weighted by the evaluation of an anticipated outcome (positive benefit or avoidance of a negative consequence):

$$\alpha_k = \sum_i \beta_{ki}\, \varepsilon_{ki} \qquad (3)$$

where

$\alpha_k$ is the attitude toward an action $i_k$, k=1,..,n

$\beta_{ki}$ is the belief that performing $i_k$ will lead to an anticipated outcome *i*, i=1,..,m

$\varepsilon_{ki}$ is the evaluation or utility (desirability) of the outcome *i*, i=1,..,m

The influence of the colleagues from the learning environment can be modeled by introducing the subjective norm. The ***subjective norm*** is the perception of an individual of what other people from the group think she/he should do with respect to a certain behavior, such as reading a specific article or enrolling for a pre-test. For sure our STUDENT is stressed about spending two more hours on reading if it is Saturday as this is a costly operation (being late for a date, etc.). But also the STUDENT knows that this is a special situation and that her boyfriend will appreciate a better mark to the exam ...Normative beliefs and the motivation to comply with the beliefs are the two determinants of the subjective norm. This can be expressed as follows:

$$SN = \sum_j NB_{kj}\, MC_{kj} \qquad (4)$$

where

SN is the ***subjective norm*** - the motivation toward an action $i_k$, k=1,..,n, as determined by the influence of the group

$NB_{kj}$ is the ***normative belief*** that people from the group (j) expect an individual to perform an action $i_k$ will lead to *j*, j=1,..,n

$MC_{kj}$ is the ***motivation to comply*** with the expectation of the group (j) *j*, i=1,..,n

The theory of reasoned action is combining the attitude toward an act and the subjective norm:

$$DB = f[(BI) = f(\alpha_k)w_1 + (SN)w_2] \qquad (5)$$

where

DB is the decisional behavior

BI is the behavioral intention

$\alpha_k$ is the attitude toward performing the action $i_k$

SN is the subjective norm

$w_1$ and $w_2$ are evaluation weights determined empirically

Student cognitive model is based on Vygotsky's theory. This theory of social cognitive development is basically considering that "social interaction plays a fundamental role in the development of cognition" (Kearsley 1994e). An important concept in Vygotsky's theory is that "the potential for cognitive development is limited to a certain time span which he calls the 'zone of proximal development' (Kearsley 1994e). He defines the *zone of proximal development* (ZPD) as having four learning stages. These stages "range between the lower limit of what the student knows and the upper limits of what the student has the potential of accomplishing" ([16]). The stages can be further broken down as follows:

- assistance provided by more capable others (coaches, experts, teachers);

- self assistance;

- internalization automatization (fossilization); and

- de-automatization: recursiveness through prior stages.

Vygotsky's theory also claims "that instruction is most efficient when students engage in activities

within a supportive learning environment and when they receive appropriate guidance that is mediated by tools" (Vygotsky 1978, as cited in [16]). These instructional tools can be defined as "cognitive strategies, a mentor, peers, computers, printed materials, or any instrument that organizes and provides information for the learner." Their role is "to organize dynamic support to help [learners] complete a task near the upper end of their zone of proximal development [ZPD] and then to systematically withdraw this support as the [learner] move to higher levels of confidence." In our model these tools are represented by software agents.

Student population is considered a closed one and individuals are separated into groups, called *classes*. Students from a class communicate one with another and also with students from other classes. We will have intra-class and inter-class communication models and a different student-software agent communication model. A class consists of several teams.

## 4 Conclusion

- The socio-cultural model of the student as the main actor of a virtual learning environment is workable and appropriate to the DANTE[2] requirements.
- The proposed three-tier architecture is inline with modern multi-agent theory and implementation practices.
- The intensely agentified environment offers an adequate infrastructure for the e-learning process.
- As current intermediate results seem to show, the idea of modelling human and artificial agents using similar learning paradigms but avoiding dangerous equivalence is fruitful.

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