Cooperation between Humans and a Pedagogical Assistant in a Learning Environment

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Abstract.

We present a Pedagogical Assistant (PA), which is an advisor in an interactive learning environment. The PA must cooperate, in the one hand, with a group of learners, and, in the other hand, with a teacher that have to manage sessions between the PA and the learners. The PA must face two types of cooperation. We study them as embedded in two spaces of cooperation : a local-cooperation space and a global-cooperation one. In the former, a group of learners cooperates with the PA. In the later, the teacher cooperates with several local-cooperation spaces through the PA. These two types of cooperation occur at different levels and in different workplaces. Two interdependent systems constitute the PA to allow cooperation between a teacher and the learners. The first system help learners to realize a project, and thus acts as a learning cooperative system. The second system works with the teacher to configure a local-cooperation space and analyze the cooperation within the local-cooperation space. In this paper, we present the model of the learning environment based on different cooperation spaces, the model of the learning cooperative system and the implementation of these models in a real-world application.

Topics : Models of Cooperation, Learning Cooperative System, Applications

Field : Human-Computer Interaction

1. INTRODUCTION

A part of the research in the Computer Science Department of the "Université du Maine" (France) focuses on the design of learning environments that are tailored to people taking into account their own knowledge and culture about technology. These implemented environments are baed on the microworld approach [Papert 80] and use Fischertechnik© micro-robots (see Figure 1). The micro-robots are built from various bricks (e.g., motor bricks, captors and assembling bricks) from learners' instructions under the control of a computer.

(j'ai supprime l'image pour eviter les problemes de transfert de fichier par mail)

Figure 1 : Example of micro-robot

The micro-robotic's activities aim at helping learners to discover technology by handling, building, designing and driving micro-robots through a project based on a pedagogical approach. The role of the teacher is to set up and manage the activities of several learners groups (each group is composed of 2-3 persons).

A first learning environment for pupils and adults used LOGO as software to drive micro-robot [Vivet et al. 91b]. For adults, we focused the experiments with low qualified persons in two projects : QUADRATURE [Vivet et al. 91a] and PLUME [Vivet et al. 93]. The goal of the QUADRATURE project was to train low qualified adults how to adapt the change of their production equipment. The PLUME project addressed problems in a small company. The training goals of the PLUME project focused on the acquisition of basic competence in reading (studies of text), writing (vocabulary, grammar), counting and problem solving. The technical content of the training was oriented towards Computer Integrated Manufacturing (CIM). An additional part of the training goals was in the development of communication skills.

Beyond the effectiveness of the approach, we observed in QUADRATURE and PLUME projects that our environments implied an overload of the trainers (we say over-appeal [Leroux 92b]) because they had different roles to play :

- to transmit information, knowledge and exercises with the help of reading sheets ;
- to teach programming concepts to help the students to program the movements of their micro-robots ;
- to help learners to activate micro-robots and to debug command programs ;
- to manage activities between the different groups of learners and manage their pedagogical interventions during them.

We chose to decrease the teacher's over-appeal, and improving his/her task, by increasing the autonomy of the learners groups and by having a better interaction between the computer and the human actors [Vivet 90]. This leads to a new learning environment model that relies on the cooperation between learners groups, a teacher and computer based interactive learning systems.

This cooperative model, called ROBOTEACH [Leroux 95a], is fully developed and evaluated n an application designed to train people in technology. The implementation is in a micro-robotic context. ROBOTEACH acts as a Pedagogical Assistant (PA). Its objective is to support teachers by improving their interactions with learners.

Hereafter, wefocus on the presentation of the learning environment model. In Section 2, we discuss briefly the terms cooperation and collaboration between a user and a computer.In Section 3, we present the learning environment model with its different cooperation spaces, the levels of cooperation of the spaces and a typology of the cooperation. We conclude the section by a comparison of the functionalities of our model with those of other learning environment models. In Section 4, we describe the cooperation modelling at the PA level during the realization of a project by the learners. After, we present an example of implementation of this model in the ROBOTEACH application.

2. RELATED WORKS ON COOPERATION

The terms of cooperation and collaboration are often used one for the other. Indeed, there is no consensus on them (e.g., see [Schmidt 91; Ferber 94; Baker 92]). However, the presentation of our model of learning environment requires a clear distinction.

We synthetize our viewpoint on cooperation and collaboration in the Table 2 according to three criteria : the global goal, the task and the responsibility of each agent with respect to the global goal. We consider that : (1) cooperation concerns the solving of a problem that is common to several agents with a task sharing; and (2) collaboration is the joint solving of a problem by several agents.

	Global goal	Task(s)	Responsibility of each agent with respect to the global goal
Cooperation	joint	different(s)	shared
Collaboration	joint	joint(s)	joint

Table 2 : Synthetic viewpoint on cooperation and collaboration

The main difference between cooperation and collaboration is at the level of the tasks that each agent must accomplish in the collective process to solve a problem. A collaboration concerns a task that is common at all the agents. A cooperation concerns a division of the task in sub-tasks that are treated individually by the agents, each agent becoming a specialist. All the agents have the same global goal, even with different local goals.

Moreover, we consider cooperation according to two viewpoints. Cooperation may be considered as (1) the agents' attitude to work together; and (2) the *a posteriori* interpretation of an observer that interprets agents' behavior according to social criteria such as the interdependency of action or the number of communication acts that occurred [Ferber 94].

Ferber (1994) defines two types of cooperation, namely the intentional cooperation and the reactive cooperation. The intentional cooperation corresponds to a situation in which the agents have the intention to cooperate (after the identification of a common goal). This supposes that agents are cognitive agents. The reactive cooperation concerns agents that do not possess explicit intention, but participate at a collective behaviour that corresponds to one of the two following criteria : (1) the coming of a new agent in a group differentially increases the performance of the group and (2) the action of the agents permits a conflict to be avoided.

We think that the terms of intentional and emerging cooperation in multi-agent systems may be used for cooperation between human and machine. The notion of “intentionality” is linked to the notion of planning : cognitive agents plan their actions to cooperate in an intentional way. The cooperation among reactive agents emerges from their interactions, and only is visible from the viewpoint of an external observer.

3. PRESENTATION OF THE LEARNING ENVIRONMENT MODEL

A cooperation among several agents implies some mechanisms to insure their coherence at the level of the group. Our approach focuses on an organization of the environment that provides constraints and predictions of how agents must behave in a structure of distributed authorities (dissemination of the authority : teacher --> pedagogical assistants --> learners groups). Such a structure permits the teacher to avoid over-appeal, the pedagogical assistants taking in charge part of the authorities. This corresponds to a transfer of responsibility at the level of the activity management.

3.1. The proposed model

The model of the learning environment (see Figure 3) is based on the articulation of two cooperation spaces : (a) a space of global cooperation, and (b) several spaces of local cooperation. In the former space, a teacher and local-cooperation spaces interact. In a local-cooperation space, a group of learners (2-3 persons) and a PA cooperate, possibly interacting around device(s).

The devices are not obligatory in our model ; the space of local cooperation may be limited to a PA and a learners group. Nevertheless, the role of devices may be important in specific pedagogical situations. For example in the micro-robotic environment, we use a Physical Objects Based Microworld (POBM) composed of various micro-robots, handbooks and a workshop of various bricks to build devices. The learners design, build, and handle micro-robots from the POBM. The interactions between the learners, the PA and a POBM is essential in pedagogical approach for the micro-robotic's activities.

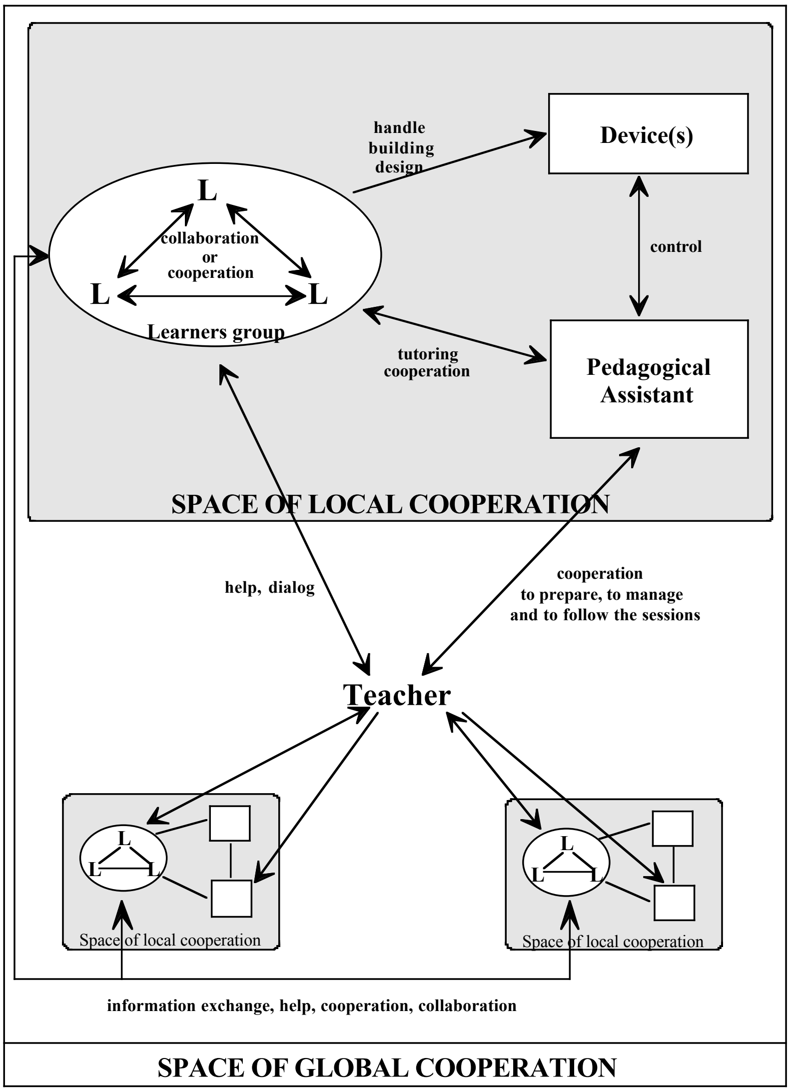

Figure 3 : Model of the learning environment

The space for cooperation is a central notion of the model. It is a place where exist cooperations and/or collaborations (intentional and/or emerging) at different levels, in different workplaces, and with agents that are heterogeneous by their nature and roles (teacher, assistant and learner).

We have implemented and evaluated this model in micro-robotic's activities [Leroux 95a]. In this implementation, ROBOTEACH is the PA and the micro-robots are the devices.

3.2. A space of local cooperation

In a space of local cooperation, learners collaborate or cooperate on the activities that are proposed by the PA. With the elements of the device unit, they must design, build and handle devices. The role of the PA is to manage the organization of the overall activity (the tutoring role) and optimize the collaboration process among learners by cooperating with them during their activities.

3.3. The space of global cooperation

The global-cooperation space contains all the local-cooperation spaces and the teacher. The learners groups may communicate straight with others, provide help to others, cooperate, collaborate, and compete in concurrent projects.

The teacher is the central agent that authorizes and eventually coordinates or regulates the exchanges between the groups. S/he has a global view of the activities of each local-cooperation space, and may support some learners locally. The teacher also may take appointments with learners for an evaluation purpose. The teacher then cooperates with the PA in each local-cooperation space to determine and plan the activities of the learners groups.

3.4. Other viewpoints on cooperation spaces

This section presents the different levels and types of cooperation between the agents that intervene in the learning environment.

3.4.1. Different levels of cooperation

There are several levels of cooperation:

* Cooperation inside a group of learners. The learners in a group collaborate for realizing their activities because they have the same responsibility in the achievement of the common activity. The collaboration may evolve towards a cooperation if the learners become specialized.

* Cooperation between a learners group and a PA. A learners group cooperates with a PA to have guidelines during the activities for achieving their project, especially when they need a support.

* Cooperation between learners groups. Such a cooperation occurs when several groups have the same project to realize (competition model) or have to produce several different parts of a complex project (integration model). They may exchange information or support a group with a particular problem already solved in other groups.

* Teacher-learners groups cooperation. This cooperation permits to coordinate the groups that are responsible of parts of a global project only. A cooperation between the teacher and a particular group occurs if the group has a problem for which the PA cannot provide advice and support.

* Teacher-PA cooperation. Such a cooperation presents three phases, before, during and after sessions with learners. Before a session, the teacher sets parameters to configure the local-cooperation spaces. During a session, the teacher may change the initial configuration of a local-cooperation space to facilitate or complicate the task of the concerned group. After the session, the teacher analyzes events and interactions occurred during the session to evaluate the work realized by each group. A cooperation between the teacher and several pedagogical assistants occurs for a project in which each group has a part to realize.

3.4.2. Typology of cooperation

One has an intentional cooperation, even the cooperation between the teacher and pedagogical assistants, except for the cooperation between a learners group and their PA where the cooperation emerges from interaction between the agents. In the latter case, the PA is composed of software agents that have not the capacity for planning their actions with those of the group. We define interaction in that case as an emerging cooperation.

3.5. Other learning environment models

The Figure 4 gives the model of the learning environment that is proposed in [Sandberg et al. 93]. Note that we have added a module on the learning objective. This model presents a synthesis of results coming from several researchers in Intelligent Tutoring Systems (ITS).

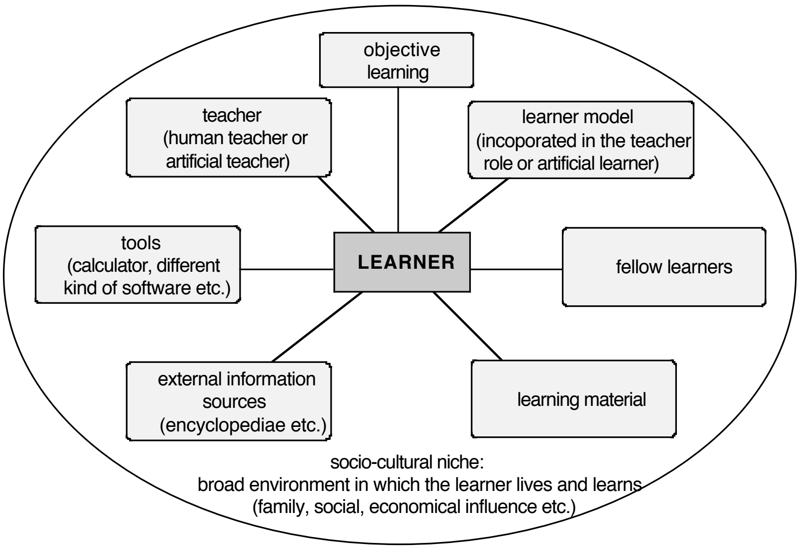

Figure 4 : Learning-environment model of Sandberg et al. [Sandberg et al. 93]

Our model of global-cooperation space includes all the components of this model. Our local-cooperation model is closed to the model proposed by Paquette (see Figure 5) [Paquette 91]. In this model, the target system meets knowledge and objects of the learning. The system accesses them through a communication system that proposes different modes of access to the knowledge. The target system is progressively designed and developed by the various agents.

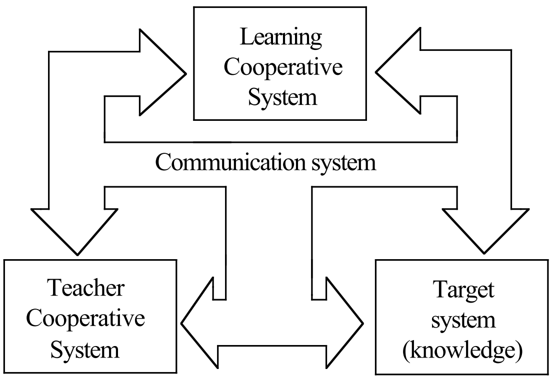

Figure 5 : The learning model by Paquette [Paquette 91]

The learning cooperative system is composed of several learners that work jointly. The teaching cooperative system is composed of several teachers that cooperate in the building of the target system and help learners during their work. Comparatively to this system, our teaching system is composed of a unique teacher.

4. COOPERATION MODEL FOR THE PEDAGOGICAL ASSISTANT

There are three situations of cooperation in our learning environment for: (a) a project at the level of a local-cooperation space; (b) the configuration of a local-cooperation space; and (c) the realization of a project that is common to all the groups. Cooperation with the different human actors in these three cooperative situations is insured by the two components of the PA. The first one works during the realization of a project by the learners and acts as a learning cooperative system. Jointly with the teacher, the second component intervenes in the configuration of a local-cooperation space[1] and acts as a meta-cooperative system [Leroux 95b]. We present in this section the model of the learning cooperative system and an example of implementation in the ROBOTEACH application.

Research in human-machine cooperation now focuses on a joint problem solving process by the human and the machine [Fischer 90; Woods et al. 90]. Such "joint cognitive systems" aim at accomplishing tasks that neither the human nor the machine may do alone. Thus, cooperation is to progress by helping the other [Karsenty and Brézillon 95] and thus join the realm of Decision Support Systems [Brézillon and Pomerol 96]. We follow this approach to design the two parts of the PA with an asymmetry between the roles of the human and computer agent : the former always has the final decision in the problem solving.

4.1. The learning cooperative system model

The learning cooperative system is composed of two heterogeneous agents (see Figure 6) :

- An interface module that supports the activity (e.g., programmation environment), and
- Software agents that are specialized to realize specific tasks (e.g., a program generator).

[1] C'est pas tout. Il y a aussi l'analyse d'une session dont tu parles avant.

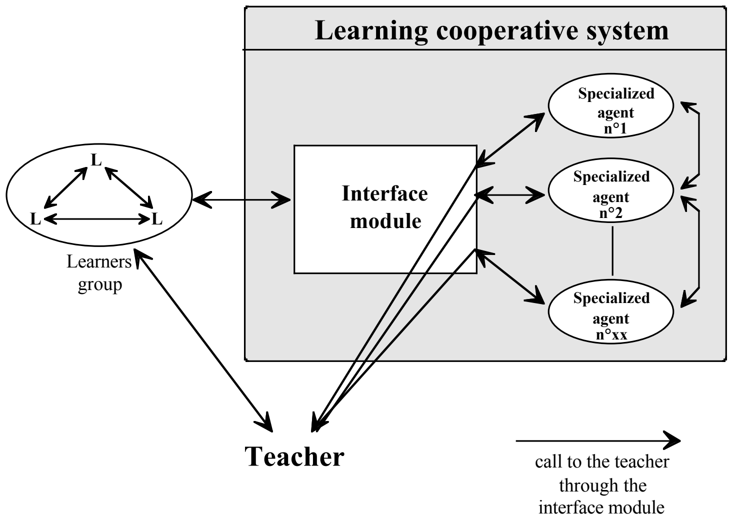

Figure 6 : The cooperation model in the learning cooperative system

A learners group and the software agents cooperate to solve a problem through the interface module. The interface module presents a part of the knowledge that is shared by agents. Software agents are activated by either the learner through the interface module or events occurring in the interface module. A communication between two agents may be private.

In this cooperation model, the teacher intervenes on the request of software agents or learners group. A software agent call the teacher when it cannot help the learners group. Acts between agents are not planed because they occur in fonction of the events : the cooperation emerges from the interactions.

4.2. Example of implementation

Two support units for micro-robotic's activities have been implemented from the learning cooperative system model in the ROBOTEACH application [Leroux 95a] : (a) an environment of description, and (b) an environment of programming and driving of micro-robots. We present the former in this section.

One of the difficulties of the learners in micro-robotic's activities is in programming the device movements. We have developed a description environment to facilitate the creation (design and writing) of programs. This environment generates automatically programs of a micro-robot from a description of the micro-robot built by the learners. The learners may drive their built micro-robots from the generated programs in a specific driving environment.

The goal of the description environment is to acquire a rational description of the device from interaction with the learners. It has knowledge about program creation but it does not know the micro-robot. The goal of the learners is to activate the micro-robots they have built. They have difficulties to write driving programs but know the composition of the device. So the learners and the description environment cooperate to achieve their own goal.

The architecture of the description environment (see Figure 7) is composed of an interface module and two specialized agents : (a) one for the program generation and (b) another to help learners during the description process.

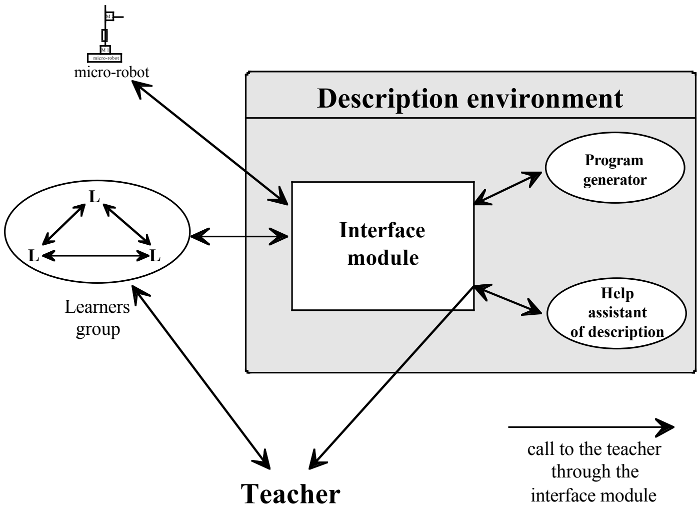

Figure 7 : The architecture of the description environment

The learners describe and check their description through interface module by direct manipulation of graphical objects. The help agent intervenes when the learners ask it or when an error occurs. The software agent gives help from the learners' description and its own knowledge about micro-robots and technology. The program generator interacts with the learners group as soon as a description of a part of the micro-robot is accomplished.

5. CONCLUSION

In this paper, we present a new paradigm for modelling situations of computer-based learning. Our model of learning environments is based on the articulation of two cooperation spaces, namely a space of global cooperation and space of local cooperation. In these spaces, the agents (PA, teacher, learners groups) must obey to rules that depend on the situation. For example, the PA may support the teacher in the configuration of the local-cooperation space or play the role of tutor in the management of the activities of learners.

In this situation of computer-based learning, there are two types of cooperation, namely an intentional cooperation among cognitive agents and a cooperation that emerges from the interaction between a learning cooperative system and a learners group. The emerging cooperation is possible through an interface module that supports the cooperative activities.

We have concretized our ideas by the implementation of a PA called ROBOTEACH that is detailed in [Leroux 95a]. This system integrates most of the models and functions that have been discussed in this paper. The PA has two sides. Firstly, it is a learning cooperative system in the domain. Secondly, it is a meta-cooperative system to support the configuration of local-cooperation space and the event analysis in this space.

Designing and developing such a meta-cooperative system is an ambitious project that has been just initiated [Leroux 95a, 95b]. Our work is described in the emerging stream of the "Intelligent Assistant Systems" (e.g., see [Boy 91; Brézillon and Cases 95]. Our first results are:

- the design and development of an author/trainer environment in the ROBOTEACH application ; and
- the first elements of an architecture to implement the meta-cooperative system.

We have already an idea of the functions that may be offered by such meta-cooperative systems. However, this supposes a cooperation with researchers in various domains including ITS, artificial intelligence, CSCW, groupware, cognitive ergonomy, interface design, etc.

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