# Metacognitive Agent's Contribution to the Learner in a Technology Enhanced Learning

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Abstract: Online learning is the field of action of the article. We are, therefore, in full "Technology Enhanced Learning" (TEL).In the absence of the teacher in the TEL and faced with the difficulties encountered, learners have a high probability of being demotivated and can, therefore, give up learning very early.To remedy these drawbacks, the article proposes an intelligent agent that helps the learner to build a reading plan for the course, to choose a learning strategy and readjust it according to his progress towards his objectives. This agent is the metacognitive agent that, by design, is precisely there to encourage the learner to self-evaluate his learning.The article shows the interactions between the proposed agent and the learner through a number of criteria that allow the agent to determine when and how to react.These criteria take into account the progression and speed of learning, the performance of the learner as well as the result of the formative evaluation throughout the learning process.The agent is modeled by distributing the different stages of metacognition and designing the interaction between the learner and the metacognitive agent.

## 1 INTRODUCTION

A number of studies have been conducted to improve the metacognitive competence of programmers (Bernard and Bachu, 2015). Other studies have focused on how learners provide the necessary knowledge (Amine and al., 2017) while other works deal with metacognitive support to accelerate computer-assisted learning (Mohd and Ismail, 2017).

In our work, we start from the observation that the absence of the teacher in online learning requires the learner to cope with the learning process without a guide or guidance. To support, guide learners to succeed in learning, in distance education, and avoid the high dropout rate observed (Clément, 2014), we propose to integrate an agent who encourages the learner to define his goal, to make good planning, and determine the appropriate learning strategy. In case of failure, our agent will trigger a series of incentives before, during and after reading a course. These incentives are done automatically and at predefined times.

The aim of our study is the definition of the interactions between the learner and the metacognitive agent, interactions that go through the integration, in the system, of intelligent agents for the validation of the distribution rules of the metacognitive incentives in a "Technology Enhanced Learning "(TEL).

TEL is an environment that has human users (learners, teachers) and a computer system with which users interact. This interaction is intended to facilitate the training and enrichment of learners. This interaction is intended to facilitate the training and enrichment of learners.Online learning has evolved significantly in recent years. Today, learners have the opportunity to learn lessons through a series of direct interactions with TEL. The problem is that the learner must learn without follow-up and without assistance throughout the learning process.

Our agent can intervene in the learning processes at predefined times, and communicate with other agents to carry out its work. It helps the learner to focus on his goal - a predefined goal - before, during and after reading the lesson.

The main contribution of this work is the modeling of interactions between our metacognitive agent and the learner.

The article is organized as follows: Section II describes the work related to our study. Section III

briefly discusses artificial intelligence and metacognition, and section IV describes the methodological approach. In section V, we present the modeling of our metacognitive agent in interaction with the learner. Finally, in section VI, we present our main conclusions.

## 2 RELATED STUDIES

Learning can take many forms. In face-to-face learning, some works have focused on metacognitive integration initiated by the teacher from time to time. These works show that this kind of metacognitive intervention helps the learner as LilianePortelance does in 2002 (Liliane, 2002).

In classrooms, and in e-learning, some researches have been done to identify tools for improving metacognitive skills in learners. This is the case, for example, of Bernard's team in 2015 (Bernard and Bachu, 2015). Other works discuss the characteristics of a metacognitive support system. The works of MohdRum and others in 2017 (Mohd and Ismail, 2017) go in this direction.

Other studies have focused their research on improving platforms in distance education to help the learner follow his studies. The problem with these platforms is that, in all the works, the focus has been on the integration of agents at the cognitive level of the learner even if we observe the abandonment of the continuation of learning.

Most web-based open source learning management systems, such as GANESHA, MOODLE and BLACKBOARD, are widely used, and successfully, in distance learning. These systems offer a variety of functions to support the learner to understand his or her courses. Despite this, currently such environments offer very little intelligent support for learners.

The software agent technologies are based on:

- **Cognitive agents** (S.Pestyand al., 2003): knowledge and reasoning related to applications,
- **Rational Agents**: justification of decisions and illustration of results according to rules,
- **Intentional agents**: choice of the task according to the means of specific assignment. One example is the BDI agent (Belief-Desire-Intention) (Karl, 2014).

The indirect monitoring of the learner, that is to say the notions of "metacognition" and "intelligent" will be developed in our modeling.

## 3 ARTIFICIAL INTELLIGENCE AND METACOGNITION

### 3.1 Artificial Intelligence

Artificial intelligence is recognized as a computer discipline that aims to model so-called "intelligent" human behaviors such as perception, decision-making, understanding, learning.

The intelligent agent is a physical or virtual entity that operates automatically and autonomously. Indeed, he is able to communicate directly with other agents and to perceive his environment. In addition, he is able to learn from experience and perform activities in a flexible and intelligent way.

An intelligent agent is, quite simply, a simple informationretrieval system in an automatic manner that is to say without the intervention of the user. It is characterized by interactivity, autonomy and intelligence.

### 3.2 Metacognition

Metacognition is about having a mental activity on one's own mental processes, that is to say, what an individual knows about his or her way of knowing. And more precisely

1- to know that we know,
2- to know that one is able to memorize.

Metacognition is thus a factor facilitating learning and contributing to the development of the learner through a better knowledge of oneself and one's possibilities. In a socio-constructive approach, the learner is an actor of his own learning.

In our work, we modeled:

- **the role of the planning phase**: so that the learner is able to organize the way in which he will use the information, that is to say to define his objectives, to ask himself questions before reading a text, etc.;
- **the role of the control phase**: so that the learner can make the decisions that aim to manage the understanding, that is to say, to concentrate his attention, to test himself during the reading, etc. ;
- **the role of the self-regulation phase**: so that the learner is aware of the activities that are strongly related to control, that is to say, reduce the speed of reading to adjust to the difficulty of the text, etc.

## 3.3 The Characteristics of the Intelligent Agent

An intelligent agent is a physical entity like a robot, and a virtual entity like a software. The role of the intelligent agent is to assist you, to help you find the information.

An intelligent agent has characteristics

- **Autonomy**: it can make autonomous decisions;
- **Interactivity**: it can interact with its environment and other agents to accomplish its task;
- **Intelligence**: it knows how to reason and learn from the information it collects..

There are different categories of agents and among these agents we find:

- **the reactive agent:** it uses the stimulus-reaction type capacity;
- **the cognitive agent**: it is based on knowledge;
- **the intentional agent**: it drafts plans and makes them possible;
- **the rational agent:** it is based on logic. Depending on the rules adopted or the methods applied, he justifies it decisions and illustrates the results;
- **the adaptive agent**: it is able to learn according to the constraints of the environment;
- **the communicating agent**: it has the ability to communicate;
- **the metacognitive agent**: it is able to assist the learner when needed, that is to say  to guide the learner to adopt a learning strategy (what ?, when ?, how?). It communicates with other agents (Hamid and al., 2015) (Lotfiand al., 2015). This agent is used here.
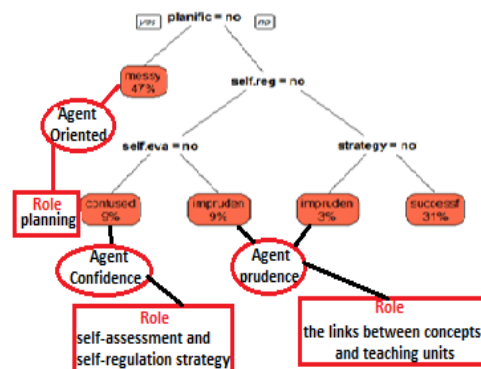
## 4 THE METHODOLOGICAL APPROACH USED



Figure 1: Tree illustrating the operations and the integration of the agents according to the state of the learners (H.Elbasriand al., 2018)

Given the results obtained in the test we conducted at the Faculty of Science and Technology of Settat (Morocco, North Africa) in July 2017 with students in a computer course (H. Elbasri and al, 2018), the following is the method of integrating metacognitive incentives:

- the metacognitive agent focuses, first, on the detection of the state (disoriented, confused, unwise, ...) of the learner as shown in the decision tree (see Figure 1), follows the learner, state by state, and triggers, if necessary, the appropriate incentives according to the rules determined by the decision tree ;
- our study focuses, first, on the management of the dialogue between the agent and the learners. The metacognitive agent acts by sending messages, questions, metacognitive incentives in an implicit manner, the goal being to follow the metacognitive level of the learner;
- the work of our agent is as follows:

if the learner answers the implicitly asked questionnaire, then

- the results are calculated to identify the state of the learner (disoriented, unwise, confused, failure) ;
- the metacognitive agent is used to "encourage" the learner according to his needs, given his condition.

End if

Once the state of the learner has been identified, the metacognitive agent sends explicit incentives to trigger and ask the relevant questions.

If the state of the learner = disoriented, then

- our agent focuses its work on planning (H. Elbasri and al., 2018) : at each shift from one concept to another, at the time of reading, the agent sends out incentives that help the learner to orient him correctly. The agent abstains when the learner, voluntarily and indirectly, has the capacity to plan without help, that is to say when the learner shows autonomy.

End if

If the state of the learner = confused, then

- our agent focuses its work on self-assessment and self-regulation strategy : at each shift from one concept to another, at the time of reading, the agent sends out incentives that help the learner to self-evaluate and self-regulate. The agent abstains when the learner, voluntarily and indirectly, has confidence in himself, that is to say when the learner shows autonomy and confidence.

End if

If the state of the learner = unwise, then

- our agent focuses its work on the connection between the concepts, that is to say on the routing of a course: at each passage from one concept to another, at the moment of reading, the agent sends incentives that help the learner find the links between the concepts. The agent abstains when the learner, voluntarily and indirectly, has the ability to find the links between the concepts when moving from one concept to another.

End if

The aim of the system is to provide the teacher with indicators that classify learners according to their states (motivated, confused, disoriented, etc.) and this, taking into account the difficulties encountered during the training process. The system has 3 agents and 3 databases (see Figure 2).
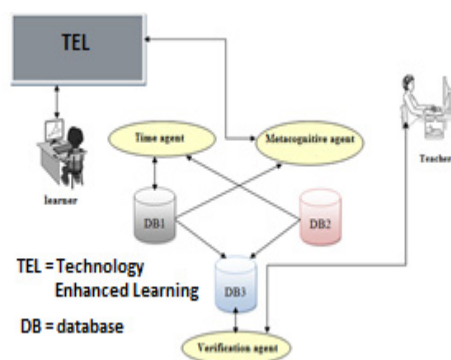


Figure 2: Architecture based on the multi-agent system

The 3 agents developed for automated monitoring are:

- **the Metacognitive Agent** : this agent assists the learner in his learning process. It intervenes at predefined times. It sends message-alerts, metacognitive incentives to help the learner plan his learning, maintain his motivation and self-confidence ;
- **the Time Agent** : this agent records the consultation time of each teaching unit. It also calculates the speed or time elapsed since the execution of the previous task and the progress of the mission ;
- **The Verification Agent**: this agent compares the minimum consultation time and the effective consultation time of the learner and the average mark and the mark obtained by the learner.

The three databases are DB1, DB2 and DB3 and have been designed to record learner traces (see Table 1)..

Table 1: Database contents

| DB1 | 1-The feedback of the learners<br>2-The comments<br>3-The questions<br>4-The answers to the questionnaires |
|---|---|
| DB2 | 1-The answers to predefined questions<br>2-The answers to predefined messages<br>3-The minimum consultation times |
| DB3 | 1- The final results of each learner<br>2-The consultation times<br>3-The objectives<br>4- The strategies adopted<br>5- The references to ambiguities, difficulties<br>6- The links between the concepts |

# 5 MODELING AND DESIGN OF THE METACOGNITIVE AGENT

## 5.1 Design Methods for "multi-agent" Systems

In Table 2, below, are presented some methodologies for designing "multi-agent" systems.

Table 2: Some design methodologies for multi-agent

| Methodology | Description |
|---|---|
| AAII (Australian Artificial Intelligence Institute (Kinnyand al., 2015) | This method defines the specifications of the BDI agents |
| GAIA (Wooldridge and al., 2000) | It uses organizational paradigms. It is relatively limited to describe systems "multi-agent" |
| AUML (Agent Unified Modeling Language) notation (S.Lynch and Rajendran, 2004) | It is designed to fit the ratings "UML" to the writing of the "agent" oriented modeling. |

In this article, we are interested only in the communication between the metacognitive agent and the learner, communication which is done by sending messages whose content is a series of incentives helping the learner to improve his learning and triggering his autonomy. So, to communicate, agentsneed communication protocols to ensure the continuity of relations and exchanges between them. Communication is, therefore, an essential characteristic of our agent because communication is the basis of the social behavior of agents.

To model our agent, we used the "AUML" as a modeling language.

## 5.2 Agent Design

The following diagram allows us to define the functioning of our metacognitive agent and also allows us to define its "capacity", that is to say it specifies what an agent can do and under what conditions it can do the task.
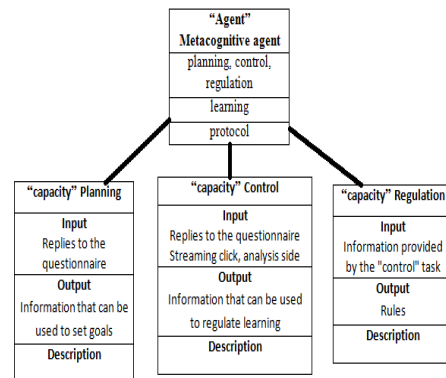


Figure 3: Capacity diagram of the metacognitive agent

Table 3: Capacities of the metacognitive agent

| Capacity | Input | Output | Goals |
|---|---|---|---|
| Planning | Replies to the questionnaire | Information that can be used to set goals | 1- Establish a learning plan and set goals 2- Orienting the action 3- Determine the strategies to reach its objectives |
| Control | Replies to the questionnaire Click streaming Side analysis | Information that can be used to regulate learning | Monitoring learning |
| Regulation | Information provided by the "control" task | Rules | Correct the learning process |

## 5.4 Interactions between Agent and Learner in Proposed Architecture

The diagram in Figure 4 shows, by way of example, the interactions between the agents if the learner is in a state of "disoriented".
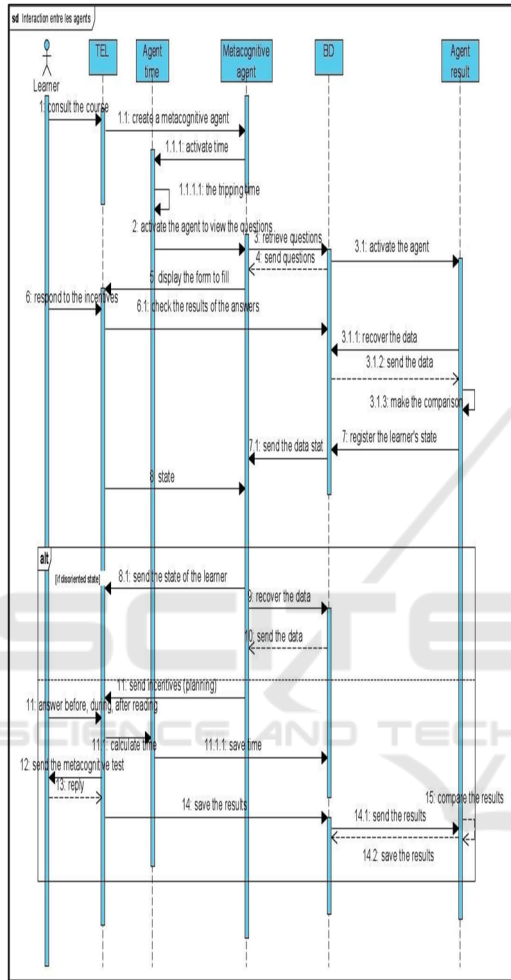


Figure 4: Interactions between learner and agents

## 6 CONCLUSIONS

In this article, we are interested in defining the interaction between the learner and the metacognitive agent in its role and in its interest for the learning system. The proposed agent can help the learner to trigger self-reliance, improve critical thinking and, finally, build one's own active metacognitive level.

Our agent allows the learner to develop metacognitive skills such as:
- to think about your own action,
- to become aware of the routing that led to the obtained results,
- to find, himself, his mistakes and seek appropriate solutions.

The intervention of our agent is done according to predetermined rules and according to the state of the learner.

To make our system dynamic, these rules will be automatically discovered. This will be the subject of future team work.

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