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Learners' Assessment in a Collaborative Learning System

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Abstract: SACA is a collaborative learning system based on agent model in which learners collaborate to learn the concepts' knowledge of the matter to be taught and to resolve the assessment exercises. In this article, we are interested in the way to assess the acquisition of knowledge by learners. The assessment process is based on the use of a set of assessment parameters that can be defined according to learning context (University, secondary school, etc.) and learner's knowledge levels (beginner, intermediate and advanced). The defined parameters are updated by the teacher who creates the pedagogical content (concepts and exercises). They concern the models of exercises, the examination time, the presentation's sequences of exercises, etc. In SACA, different categories of learners (students, workers, etc.) can collaborate for resolving individual or collaborative exercises. We present the results of the first experiment done at Guelma University.

Key words: Artificial agent, assessment parameter, collaborative learning, exercises model, assessment

INTRODUCTION

The presence of an affective assessment mechanism in a learning system is essential since the assessment of learners is a crucial part of the instructional design process and therefore of an educational system. Through the assessment, the learner is able to identify what he/she has already learned and which are his/her strengths and weaknesses, to observe his/her personal learning process and to decide how to further direct his/her learning process (Gouli *et al*., 2001).

Most of current learning systems integrate an assessment module (as external or internal entity) to evaluate learners' knowledge. Generally, this module supports a few types of exercises (questions with multiple choices in most cases). In the web, we have found some conceived systems used for the assessment of learner's knowledge (Corso *et al*., 2000; George, 2001; Govaere, 2000; Gouli *et al*., 2001; Jean, 2000; Labidi *et al*., 2000). We have observed several anomalies in such systems. Among them:

- Firstly, they only support one type of exercises (sometimes the proposed type doesn't correspond to the nature of the presented knowledge).
- Secondly, in these systems, the number and the type of exercises for each unit of assessment (concept, chapter or all the matter) is fixed for all the users of the system. Furthermore, the assessment period is the same for all the learners.

These points make the conceived assessment systems limited in evolution and adaptation to different target populations, because the same matter can be learnt by learners, from several fields (university, secondary school, professional, etc.) and with different knowledge level (beginner, intermediate and advanced).

To solve these problems, we propose a new method for assessing learners. It is based on the management of a set of parameters for each type of target learners (object of the assessment). The values of these parameters can be initialized according to the learners' knowledge level, the learning context and the current laws concerning assessment process (for example: the passing mark to the following level and the examination time). So, this assessment is parametric and adaptive. The goal of this assessment is to test the acquisition of the matter's concepts by a learner and to know his/her cognitive level in order to update his/her model. This method is adopted by an agent-based collaborative learning system called SACA (which is the French acronym of Système d'Apprentissage Collaboratif à base d'Agent).

The system is composed of a set of artificial agents that support the learners' activities: learning, assessment and collaboration between them. The assessment process is ensured by an artificial agent called the assessment agent.

In this study, we introduce the principles of the assessment method, the list of the used parameters, the type of the used exercises, their use in a collaborative context and the assessment scenario, etc. Furthermore, we

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present the results of an experiment done at Guelma University and some system's interfaces relating to the assessment process.

ARCHITECTURE OF SACA

SACA's main goal: Collaborative learning is a learning strategy where s everal learners interact with each other in order to achieve their common goals. Its impact on learner's level is ensured; it is obvious that it is necessary to be interested in learning group environments instead of individual learning environments (Okamoto and Inaba, 1997). Computer-Supported Collaborative Learning (CSCL) systems are those that support collaboration between learners. SACA belongs to this category of systems.

The main goal of SACA is to take into account the aptitudes and the needs of the learner during collaboration in order to provide him/her an effective collaboration (Lafifi and Bensebaa, 2006). This latter aims at improving the knowledge level and the capacities of learner (Lafifi and Bensebaa, 2006).

Structure of the matter to be taught in SACA: The matter to be taught is made up of a set of concepts regrouped into pedagogical objectives. These ones correspond to a mental structure, an abstraction and sometimes represented by conceptual networks. The teacher (instructor) can create pedagogical objectives, associate to them a difficulty level and establish prerequisite relations between them (Lafifi, 2002). Each PO (X) can have a set of prerequisite pedagogical objectives that must be acquired by learner in order to learn the concepts of X (Bensebaa and Lafifi, 2000).

In SACA, pedagogical objectives are represented by artificial agents called Domain Agents. These agents hold a set of information such as the knowledge represented by the pedagogical objective and the domain agents associated to their prerequisite pedagogical objectives.

Agent model in SACA: An agent is a computational entity that executes in behalf of other entities (users, programs, etc.) in an autonomous way; makes actions in a pro-active and/or a reactive way and presents some capabilities to learn, cooperate and move (Olguin *et al*., 2000).

Recently, various CSCL systems based on agent model have been developed. In these systems, agents with their own goals and functions are embedded and perform their own tasks through collaboration among them by communication to achieve a goal as the system requires (Okamoto and Inaba, 1997). We distinguish different kinds of projects working on multi-agent based learning environments, some of them work on generic platform of agents but usually the focus is given to a specific agent type. Interesting results have been achieved by pedagogical agents regarding the student motivation and companion agents acting sometimes as mediator of the learning process. Finally, tutor agents are usually related to student modelling and didactic decision taking (Webber *et al*., 2001).

Among CSCL systems based on agent model, we can mention GRACILE (Ayala and Yano, 1996), SHIECC (Labidi *et al*., 2000), SPLACH (George, 2001), Alice/WhiteRabbit (Blanchard and Frasson, 2002), SIGFAD (Mbala, 2003), I-Help (Vassileva *et al*., 2002), etc. In SACA, an agent is constituted of a set of modules and knowledge bases. Therefore, an agent possesses:

- Communication module: It allows the agent to communicate with other artificial agents in the system,
- Control module: Based on a description of the agent's behaviours toward the messages that can be received from the other agents. It manages a knowledge base called behaviours knowledge base,
- Reasoning module: It uses the agent's knowledge and a set of reasoning rules allowing it to accomplish its role in the system. It manages a knowledge base called reasoning knowledge base,
- An optional module called interpretation module: associated to agents having an interaction with human actors (learner, teacher and tutor) because its main function is the interpretation of the human agents' actions (Lafifi, 2000).

Multi-agents architecture: SACA is constituted of a set of artificial agents. Some of them are associated with system's human actors. Each learner has the following agents:

- An Assistant Agent of Learner (AL): It proposes to the learner an interface which makes the learning task easier for him/her. It detains learner's student-model, his/her historic of learning and other information in its reasoning knowledge base.
- Pedagogical Agent (PA): Its role is to present the pedagogical objectives to the learner according to his/her final profile and his/her current knowledge state. They are expressed by pedagogical objectives.
- Collaboration Agent (CA) (Mediator): This agent takes into account the collaboration process between learners as well as the associated problems (interrupted collaboration, double collaboration, etc.).

- Assessment Agent (AA) (Evaluator): Its role is to measure the learner's knowledge level by proposing to him/her a set of exercises from various models and difficulties. It is solicited to verify the acquisition, by the learner, of the pedagogical objectives' knowledge of the matter to be taught.

The teacher must initialize the assessment parameters and organize the matter to be taught as well as its structure in pedagogical objectives (set of concepts). To carry out these tasks, he/she has two agents:

- An Assistant agent of the Teacher (AT): It proposes to the teacher an interface in order to assist him/her in the creation of the concepts and the exercises of the matter to be taught.
- A Mediator agent of the Teacher (MT): It facilitates the communication between the teacher and the learners or between teachers themselves (Lafifi and Bensebaa, 2004).

In SACA, learners are organized in groups where they are helped and followed-up by human tutors. Each human tutor has an artificial agent called Agent of the Tutor which assists him/her in the realization of assigned tasks: giving councils to learners and following-up their learning processes (Lafifi and Bensebaa, 2006).

PRINCIPALS OF LEARNERS' ASSESSMENT IN SACA

Assessment tool: The assessment is an essential process in an educational system. It allows the representation of the cognitive state of learner (Govaere, 2000). Moreover, at the end of the assessment process, the system can have information about the acquired knowledge, the current knowledge to acquire and the not acquired knowledge (Jean, 2000).

Every e-learning system that aims to achieve a teaching/learning process of quality should necessarily have some way to assess the reached level of success (Cuadrado *et al*., 2005). An exercise or a question is a tool that can be used to measure learner's knowledge level, as well as his/her acquisition degree of concepts' knowledge. In SACA, the exercises or questions belong to the following categories:

- Closed questions (questions like: True/false, Question with Multiple Choices (QMC),. ..),
- Half-open questions (questions with only one word to introduce, open questions but directed...),

Each type of exercises can test different kinds of knowledge. Among these kinds we can quote: «definitions», «correspondence between elements», «dependence degree», «methods and rules», etc. (Benadi, 2004).

Individual and collaborative assessment: To define learners' level clearly and ensuring a best assessment, several kinds of exercises (different forms of exercises) can be used:

Individual exercises without collaboration: This type of exercise is assigned to each learner. Collaboration during assessment is not authorized.

Individual exercises with collaboration (TWISA): The learner has individually assigned exercises. He/she can ask other learners for collaboration to solve an individual exercise later. So, learners can collaborate to obtain the answer. But, the final answer of the exercise must be elaborated and sent by the concerned learner (the mark is attributed to this learner). We call this new assessment strategy: Twisa.

The principle of Twisa is that the learners collaborate between themselves to solve the exercises (or problems) of each one of them in turn (Fig. 1). This principle is inspired from the word Twisa used by Algerian farmers during tilling or harvest. They use all available means of each one of them (tractors, reaping-machines …) to help a farmer among them in turn. Learners can collaborate by using different tools: chat, email... For this kind of exercises, the teacher must create, at least, two exercises that have the same aim but with different data (equivalent exercises) (Lafifi and Bensebaa, 2006). When the first exercise is presented to the learner, he/she can collaborate with his/her group's members to obtain the answer. After that, a second exercise is presented to this learner who must resolve the exercise without collaboration.

Collaborative exercises: This type of exercises is assigned to all group's members (it can be a project for example). The obtained mark is given to all group's learners.

Assessment method of learners in SACA: We have proposed a new assessment method that allows ensuring a parametric assessment by using some assessments parameters related to assessment exercises (their models, numbers and presentation's sequences, etc.). Other categories of parameters can be used to adapt the system to the change of the learner's knowledge level (taking into

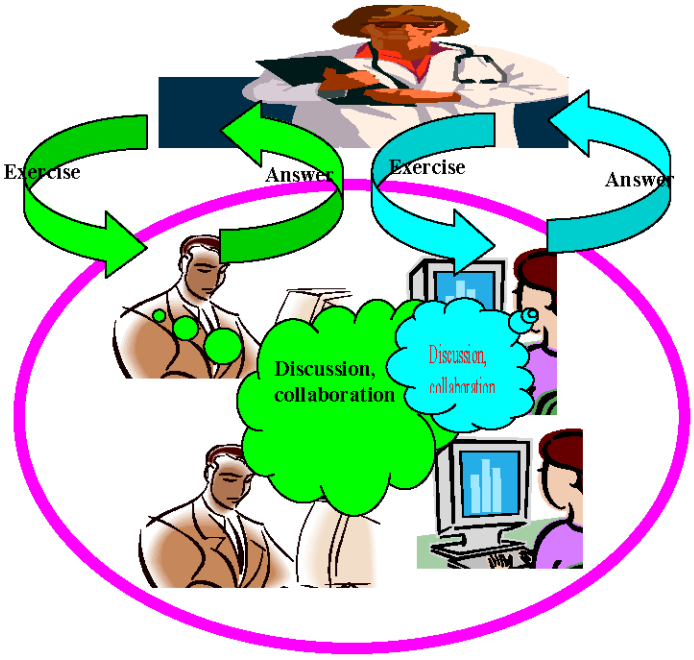

Fig. 1: Principles of Twisa strategy

account the learner's level in any action to propose: assessment, learning or collaboration). Thus, it is an adaptive assessment in which, in contrast to the static nature of tests with fixed questions, the assessment process is dynamic (Gouli *et al*., 2001).

The assessment agent, responsible of learners' assessment in SACA, uses a set of assessment parameters that will be re-initialized when the teacher introduces a new matter. The assessment parameters used in the current version of SACA are:

- Parameter 1: Models of Exercises to be presented: indicate the list of exercise models to be presented to the learner. For example, in Algorithmic matter, its value can be QMC and True or False for students of professional field and Algorithm mistakes detection and Simulating an algorithm for students of computer science department. In the case of students of secondary school, the value of this parameter can be Correspondence list and True or False.
- Parameter 2: Number of exercises to be presented by PO: It can be fixed for all the pedagogical objectives or variable from one PO to another.
- Parameter 3: Number of exercises to be presented for each model of exercises: This number can be fixed for all the models or variable from a model to another.
- Parameter 4: Method of presenting the exercise models: Indicates the manner to present the sequence of exercises. It can be random or according to a specific order (a precise list of models).
- Parameter 5: Coefficient of a PO: Every PO has a coefficient which represents its importance in the matter to be taught.
- Parameter 6: Passing mark for each PO: Minimal mark to obtain for the acquisition of each pedagogical objective.
- Parameter 7: Authorized time for each type of exercise (resolution time): Each exercise is associated with a resolution time. It depends on the exercise's difficulty (easy, average and difficult).
- Parameter 8: Taking into account the not consummated time: This parameter allows to take into account the not consummated time of the previous resolved exercises. The non-consumed times can be accumulated and used as additional time for the resolution of the future exercises.
- Parameter 9: Method of presenting the exercise solution: For each resolved exercise, the solution can be imperatively given to the learner, left to his/her choice (to his/her request) or masked. The teacher must choose the method of the solution presentation according to each target population (category of learners).

Fig. 2: Some assessment parameters.

- Parameter 10: Authorized number of exercises without answers for each PO: The learner is free to give or not the solution of an exercise. But the number of exercises without answers should not exceed a number beyond of which the PO is declared not acquired independently of the final mark of the learner (obtained for this PO).
- Parameter 11: Cognitive profile of the learner: It indicates the final learner's knowledge level (weak, average, good and excellent). This level is used to adapt the content of the matter to be presented to each learner (Fig. 2).

Assessment scenario in SACA: At the end of visit of the last concept of the current pedagogical objective, the Pedagogical Agent (PA) sends an assessment request of this PO to the Assessment Agent (AA). This latter presents some exercises according to the assessment parameters' values to check the acquisition or not of the pedagogical objective's knowledge.

After receiving from AA the final assessment's result, the PA applies a succession of pedagogical rules to decide the forthcoming action to undertake. If the assessment's result indicates that the PO is acquired then the PA proposes to the learner the next PO to learn else it proposes either the relearning, or the reassessment of the not acquired PO. In both cases, learner's student-model is updated (the result is sent to the assistant agent of the learner) (Fig. 3).

Another option is offered to the learner, which is the self-assessment. In this case, learner must choose a pedagogical objective (self-assessment object) among those constituting the matter to be taught.

It is possible that the test can be interrupted for technical reasons (for example: problem with the Web or the telephone line); the system saves learner's answers and restores the assessment process -for the next access- from the point where it had stopped.

- Request for self assessment (concerning a PO).
- Presentation of exercises.
- Answers of exercises.
- Request for the learner's assessment (concerning a PO).
- Assessment's result of a pedagogical objective.
- Cognitive profile of learner.
- Result of self assessment + cognitive profile.
- Collaboration (Twisa or collaborative resolution).

TOOLS AND MECHANISMS USED FOR FACILITATING LEARNERS' ASSESSMENT IN SACA

Collaboration tools: In the case of Twisa or collaborative resolution of exercises, learners collaborate by using synchronous or asynchronous tools. These tools are: forums, electronic mailing, chat and semi-structured interface (Fig. 4). In each tool, the learner can save the steps of the collaboration process (list of the sent and the received messages) (Lafifi and Bensebaa, 2006).

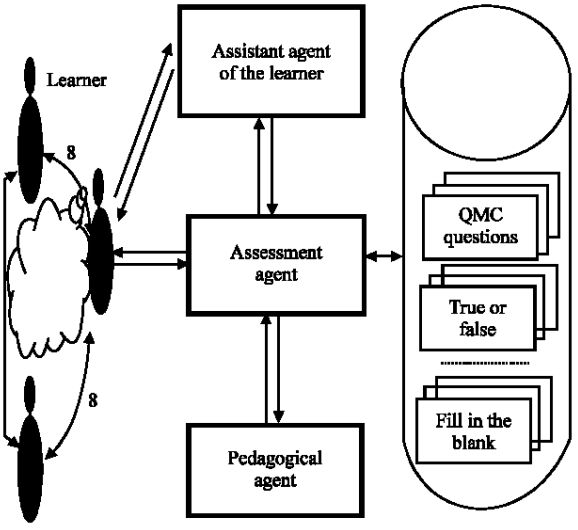

Fig. 3: Assessment cycle in SACA

Bill-posting of the assessment report: Learner's assessment report is established at the end of the assessment process. It resumes the number of the presented exercises with correct response, with false response and without responses. Also, the obtained mark (Fig. 5).

Historic of assessment: Through this function, learner (teacher/tutor) can see information on himself/herself (on learner). This information is presented as follows:

- List of acquired pedagogical objectives,
- List of non acquired pedagogical objectives,
- List of current pedagogical objectives.

The learner can see also a historic of assessment relative to exercises that are presented to him/her as well as his/her proposed answers and exercises without responses (Fig. 6).

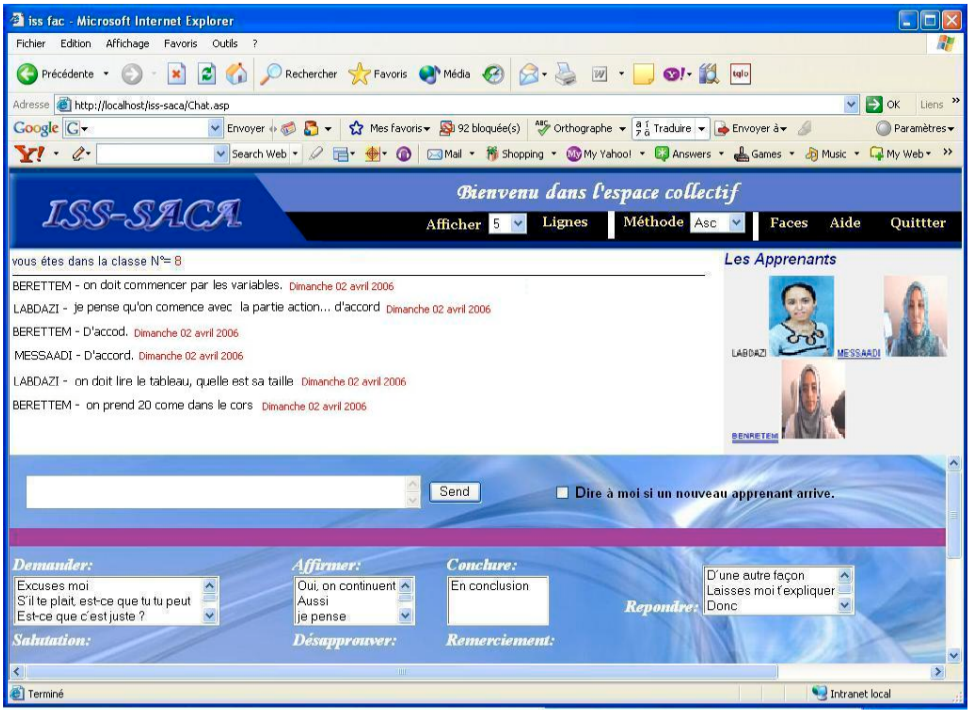

Fig. 4: Collaboration tool used in the case of Twisa (semi-structured interface)

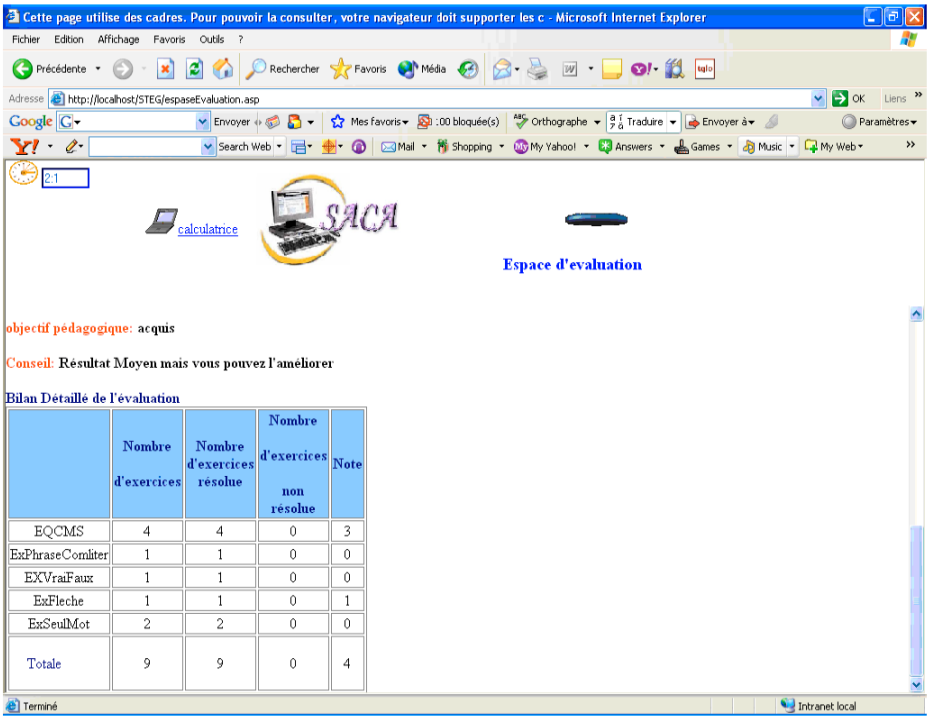

Fig. 5: Final assessment's result

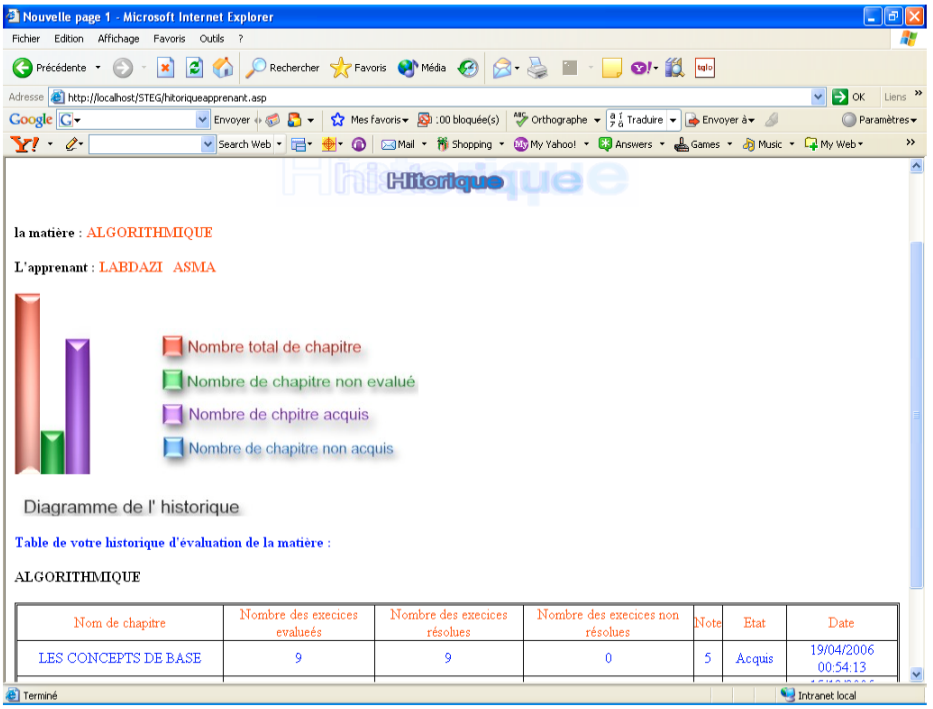

Fig. 6: Historic of assessment

MATERIALS AND METHODS

Methodology: An experiment has been done at Guelma University (Algeria). The learners were from computer science department, level: 1st year students (60 students). These learners learned a matter called Algorithmic 1 which is composed of a set of pedagogical objectives that contain about 50 concepts. The teacher created, for each one of the concepts, a set of exercises from different types and models. These exercises belong to the following models: Question with Multiple Choices, True or False, Correspondence list, Fill in the blank, Simulating an algorithm, Algorithm mistakes detection, Classification and Open answer with only one word.

The participants are divided into two groups (at random). The first group (control group) follows a system prototype with only individual assessment while the second (experimental group) follows a system prototype with all available assessment modes (twisa and collaborative resolution). All the learners are organized in groups followed up by eight human tutors of computer science department. Learners access to the system using the intranet of the university.

At the end of the experiment (after two months), a questionnaire is submitted to the learners of both groups.

Our hypothesis is that Twisa increases the cognitive level of learners. In other words, the collaboration between learners, for resolving exercises, increases their cognitive levels.

RESULTS AND DISCUSSION

To verify our hypothesis, we have compared the means of control group and experimental group. To know if the difference is significant between the two means we have used paired samples t-test (student t-test). After using R software (http://www.r-project.org/) which is a free software environment for statistical computing and graphics, we have obtained the following results with 95% as significant level ($\alpha = 0.05$):

From the table of t-test, $t_{0.975}=\pm 2.04$, so $t_{score}<t_{0.975}$ (-2.74 <-2.04) the difference was very significant, so the hypothesis is proved and we can affirm that Twisa can increase the cognitive level of learners in collaborative learning system (Table 1).

Table 1: T-test statistics

N	Mean of control group	Mean of experimental group	t_{score}	Degree of freedom	P-value
30	9.8	11.03	-2.74	29	0.0102

Concerning the experimental group, 90% of students have used Twisa. 59.26 of them proposed a correct answer of the first and the second exercise, 18.51% of them proposed a correct answer for the first exercise only, 7.41% of them proposed the correct answer for the second exercise only (which constituted a surprise for us because the learners gave the correct answer when they assessed individually and gave the false answer when they assessed collaboratively) while 14.81% of them proposed wrong answers for both exercises. These results show that the learners gave correct answer when they collaborated (77.77%). So, collaboration can ameliorate cognitive level of learners.

As a general observation, QMC is the exercises model where 80% of learners' responses were correct and open response with only one word is the exercise model where only 22% of responses were correct.

CONCLUSION

In order to know the learner's knowledge level at any moment during learning process, an assessment process is necessary. This process consists of presenting to the learner a set of exercises/questions from different models with various difficulties.

Our objective was to propose an assessment method that can be adopted by an agent-based collaborative learning system (SACA). This method is based on two principles. Firstly, it proposes the use of a set of parameters that can be initialized by the teacher according to learners' levels and learning context (so, SACA is an open system that can support many categories of learners). Secondly, this method uses some exercises that can be resolved individually or by collaboration. We have used a new assessment strategy TWISA intermediate between individual and collaborative assessment. Through Twisa learners can collaborate to obtain the correct answer for a question but the final answer must be elaborated by the concerned learner (individually).

Our first experiment (at Guelma University in Algeria) has shown good results concerning satisfaction and added value to the knowledge levels of learners. For each sample of learners, teacher can change assessment parameters by holding some characteristics of learners such as their basic levels of knowledge, final levels to reach, etc. Furthermore, our system is able to extract the cognitive level of each learner (good, weak, etc.), at any moment, by using the assessment results of learners and the values of assessment parameters.

During this first experiment, we have mentioned some problems (or remarks) quoted by students like:

- Some models of exercises are poorly presented (like classification model).
- Some system's interfaces are more overloaded (those concerning collaboration in the case of Twisa or collaborative resolution of exercises).
- No possibilities for saving answers or questions.
- Some learners refused to collaborate during Twisa.

These remarks are significant and are taken into account for another version of the system which will be used in a second experiment with a population sample larger than the first.

For future work, we plan to develop the collaborative resolution of exercises (problems) by attributing different roles to students (moderator, supervisor, etc.).

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