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An Architectural Model of Multi-Agent Systems for Student Evaluation in Collaborative Game Software

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Abstract—The teaching of computer programming for beginners has been generally considered as a difficult and challenging task. Several methodologies and research tools have been developed, however, the difficulty of teaching still remains. Our work integrates the state of the art in teaching programming with game software and further provides metrics for the evaluation of student performance in a collaborative activity of playing games. This paper aims to present a multi-agent system architecture to be incorporated to the educational collaborative game software for teaching programming that monitors, evaluates and encourages collaboration by the participants. A literature review has been made on the concepts of Collaborative Learning, Multi-agents systems, collaborative games and techniques to teach programming using these concepts simultaneously.

Keywords—Architecture of multi-agent systems, collaborative evaluation, collaboration assessment, gamifying educational software.

I. Introduction

IN disciplines of the Introduction to Programming from Computer Science courses, we have found a high dropout and failure rate due to some difficulties inherent to new ways of thinking. In seeking for a solution to the problem, studies have been and has been conducted, such as [1], [2], [3], [4], [5], among others.

These studies have pointed out that one of the problems faced with their computer programming students is the lack of familiarity with the languages and forms of writing. Often the teacher, because they already master the subject, fails to grasp the language of the students. When these students come into contact with programming they feel the need to see what the others do. Research in this area point to the practice as a way to alleviate this problem [4]. The practice together with the exchange of experience among peers with similar level of experience, facilitates learning, creating the need in the use of laboratory lessons with group activities.

Researches in Education [6], [7], [8] suggest the need for greater use of tools involving the learner with their reality. Social networks with their inherent and mutual interactions related to the pleasure of participating in activities with other human beings all over the planet [9] are part of day-to-day students competing for your attention school or even generating informal knowledge between colleagues to exchange ideas and solutions.

One research area in education that seeks for the best use of computational tools in the effectiveness of interaction to learn is Computer-Supported Collaborative Learning (CSCL) [10]. This area searches techniques, methodologies and practices to find the best way to provide mechanisms for the realization of collaborative learning.

The collaborative activity happens voluntarily and for this it is necessary motivation. One can imagine the possible effect of using it in a game where the competition encourages the participation of students [11], [2]. One difficulty that arises in collaborative activity integration and games is: ”How the teacher can assess whether student achievement in the activity is taking place for the collaboration, practice or the individual?”.

Evaluating the tasks performed by the group of students is difficult for the teacher who can not be present in every activity with all groups at the same time [12]. There is a lack of activity assessment tools, especially in gaming environments and/or collaboratives [13], [14].

One way of supply this gap is through the use of intelligent agents to monitor and evaluate collaborative activities among students, such as learning diagnostic agents that detect the need to create study group among the apprentices [15] or multi-agent system for monitoring and evaluating collaborative activities, in order to form good group [16] among others. These works do not apply techniques in competitive environments such as games or gamifying software.

This paper aims to combine educational technologies such as Computer-Supported Collaborative Learning, Intelligent Agents and Collaborative Games proposing an architectural model of multi-agent system to be integrated into competitive software, which can be applied to independent groups and groups chosen by the students themselves, which they are renewed every school year.

The architecture presented in this work proposes the use of rule bases in four specific modules: Module Domain, referring to the collaboration characteristics in Educational Games; Teaching module containing the development strategies of collaboration characteristics; Student module with the storage of information generated by learners/students kept and accessed by the Agent Module that contain two intelligent agents (individual and group) who make the evaluation and stimulate collaboration.

This paper presents in Section II related studies that formed the basis for the survey. Section III describes the

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proposed architecture and finally, Section IV presents the final considerations.

II. Related Studies

To develop this work a bibliographical survey was conducted seeking content related to methodologies and tools to improve the Teaching of Programming, works on use of Intelligent Agents in collaborative environments, Digital Educational Games and Metrics for Assessment Collaboration.

A. Teaching of Programming

Studies were and have been performed to detect the difficulties encountered by beginners of programming courses. Some of these studies pointed to practice as the best way to learn to program [4]. Others point to the importance of feedback to students demonstrating its development [3]. Research using the DOJO technique [17] demonstrated that without the stimulus of compensation, this technique does not have the desired effectiveness [18]. The use of pair programming is a collaborative technique used in programming courses that improves performance in programming [19], [20].

The association of learning difficulties in programming with the need of practice and exchange of experience between pairs resulted in different tools [21] who presented a tool that integrates code visualization of others in the development environment (IDE), being exclusively for individual activities, is not prepared for collaborative activities; [5] presents a program development tool that stimulates competition among students following the idea of Computing Marathons; [2] developed a programming teaching tool for children through collaborative game stimulating the participation of colleagues within the individual learning.

The studies presented above clearly identify the need to combine practice to the teaching programming while maintaining their motivation by offering challenges and rewards through notes, scores or feedback that would be better used in competitive environments with collaborative teams.

B. Agents in collaborative learning

An intelligent agent is a software component that has one or a few specific goals and to achieve (it / them) perceives the environment where it lives and analyzing the conditions of this has the autonomy to act and interact with other agents [22], [23], [24].

[15] presents an architecture using intelligent agents in a collaborative environment. This architecture has five (5) types of agents: Diagnostic Agent, Mediator Agent, Collaboration Agent, Social Agent and Semiotic Agent. The interest for this work is in the Collaboration and Social Agents. The role given to the Social Agent is to create a group by looking for individuals who can help students with difficulties and generate a Collaborative Agent for an activity with this group. The Collaborative Agent created for this purpose, will serve as the intermediary between the group, the individual student and the Diagnosis and Semiotic Agents. The focus of this collaboration agent is to detect, point and work with the emotional state of the student.

[25] deployed an agent to promote interaction between learners during text production. The tool analyzes the words and phrases produced during the meetings and sorts them, forming a set of words/phrases relevant to the subject matter. The system displays to the teacher the information quantitatively: the number of interactions and relevant words per apprentice and overall.

A multi-agent system for monitoring and evaluating collaborative activities with the main purpose of selecting good working groups was proposed by [16]. It presents the evaluation mechanism to select the individuals who will make up the groups. As a continuation of that work [26] developed a collaborative Wiki tool where agents collect data from the interactions carried out on the tool and make the score based on user activity in order to form balanced and collaborative groups. The participant must use the system at least once, so data on their profile are stored.

The listed works used multi-agent systems generating or following collective activities but not activities with competitive role.

C. Collaborative Games

The proposal of a development MMORPG type game has the job of [27] , which was inspired by the pedagogical structure of Intelligent Tutoring Systems through the use of agents and MATHEMA Modeling [28]. It shows how the development of the game happens but its main focus is on the authorship, which allows the teacher to build knowledge available in the game. It has the collaboration as the main target, but has a tutoring modeling that can be used for this project to look for focus on collaboration.

According to [12] there are five components that are essential for collaborative learning: **Positive interdependence** - where students are aware that they are a team and so the success or failure of the group is the success or failure of individual ; **Individual accountability** - each group member should be able to contribute their knowledge to the other group members and also learn from the contributions of their partners; **Face-to-face promotive interaction** - produced during the process of learning, in which students share their knowledge, discuss different points of view, help others who are finding it difficult; **Social skills** - students must organize their work and make decisions, showing leadership and conciliation skills; **Group processing (group self-analysis)** - the group must self-analysis to find out if the work is effective, the goals are being met and the work environment is suitable.

To accomplish these components [29] proposes a guide of activities required in an educational game to stimulate collaboration from each of these. This guide will serve as a basis for pedagogical actions undertaken by agents when you need to encourage collaboration and also for the creation of collaborative game.

D. Metrics for Assessment Collaboration

In the work of [26] were presented some ways to monitor the collaborative activities in Wiki environment based on four types of user activity: active use (additions, removals, and shared text changes), passive use (activities of students in that extract information from your group Wiki and do not result in a change in the content of that Wiki), interaction (posted topics, sent messages, the topics sizes), survey responses (student responses for the various surveys or questionnaires posted by the teacher) and evaluation (marks obtained by the student in the system).

In [30] evaluation within a Wiki tool is held in three categories: (a) contribution, (b) coordination and co-decision and (c) other posts; defined for each participant in numbers and percentages with respect to the other; posted by themes or involving co-ordination and co-decision. While in [31] proposed a qualitative method to evaluate the collaboration. In this method text versions undertaken by the teams were compared. Turned all texts produced in a single, observed the different versions of each to quantify what each student has produced. In addition, they noted the comments made during the work on the machine, manually writing down the amount of: answers to questions and comments from other colleagues of different actions.

In this work not only Wiki tools should be used, but also tools like chat , forum and message boards. To support this research it has been found the work developed by [32] which features the use of a set of techniques for analyzing conversations in chat environments, integrating different techniques such as: Surface analysis of texts, posts analysis Networks social and Latent Semantic Analysis (LSA) [33].

The activities of the agents proposed by this research suggest an integration combining competition and collaboration technologies. The integration of these activities may enable the programming environment more continuity stimuli in the work done by students, and the teacher can provide tools to assess the collaboration that occurs in the work done as a team.

III. The Proposed Architecture

The proposed architecture aims to automate the process of evaluation, monitoring and stimulation of the collaboration between learners. For the evaluation are used as the basis, the criteria of [26] for Wiki tools as well as sole discretion of the authors based on their professional experiences. Monitoring the assessment and stimulation process is carried out through the use of intelligent agents. For the stimulation makes use of guidelines related to design and development of collaborative games coming from [29] pointing ways for an educational game to stimulate cooperation.

An Intelligent Tutor System is traditionally divided into four (4) modules: **Domain module**, includes a knowledge base on the subject taught by the tutor; **Pedagogical Module**, which contains the pedagogical strategies used to teach content; **Student module** stores the student development within the tutor, and **User Interaction Module**, which performs communication with the user and processes their activities and answers [34].

In the proposed architecture, shown in Fig. 1, we use the concept of three (3) of these modules: Domain, Teaching and Student, mediated by an Agent module containing two intelligent agents.

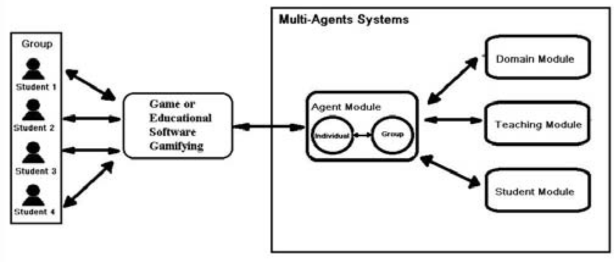

Fig. 1. Architecture of the proposed system

To better understand the operation of the proposed architecture, each module is shown below.

A. Domain Module

In this module are the rules representing what is collaboration and what are effective ways of working in a competitive educational environment. To develop this module theories from [12] were used [29], which have collaboration characteristics in Educational Games.

[12] presents important characteristics for that collaboration occurs. These features mentioned and explained in section II-C, are stimulated and evaluated by individual agents and group. To each of these characteristics is expected a type of behavior, for example, it is expected on the Positive interdependence that the student present his opinion to the group and/or accept the decisions of the group. From these behaviors is determined the collaboration feature. In each behavior the teacher can establish weights of its importance after that will be counted to determine the degree of collaboration of each student, allowing the group to score the agent groups within the current competitive activity.

To determine the characteristics and behaviors presented, the individual agents and group need to extract data of the activities developed by the students during their sessions within the game or gamifying educational software that has this integrated multi-agent system. They use for this, among others, the work of the analysis [26] that assesses five dimensions of collaboration: the active use, passive use, interaction, survey response and the evaluation. In the table I some of these dimensions are described and the actions of the appointed agents.

B. Teaching Module

This module is in the form of rules, techniques and tactics to make collaboration happen. To compose the rules and mindset of those involved in this module guidelines presented are used by [29], [35]. These guidelines have pedagogical techniques to encourage collaboration among members of a team within a competitive environment, mentioned in subsection II-C . For example, the characteristic **Individual accountability** must be a multiplicative factor for each player to increase your score, give the biggest factor for the player with the most difficult

TABLE I
CATEGORIZATION OF BEHAVIORS, CATEGORIES AND METRICS

Characteristic	Behavior	Category	Metrics	Tools
Positive interdependence	Present his/her opinion to the group	Active use	Count the number of valid and meaningful words in conversation.	Chat
		Active use	Count and analyze the number of valid expressions in text produced.	Wiki
		Interaction	Count the number of forum messages posted by to other members forum topics.	Forum
	Accept decisions by the group	Passive use	Count the number of times that agreed with opinion of the group	Activity
Face-to-face promotive interaction	Provide tips and knowledge to other members of the group.	Active Use	Count media quantity/size (file, links, texts) added to the group repository.	Wiki
		Interaction	Count number of messages posted by own topics.	Forum
	Encourage colleagues to continue	Interaction	Use of incentive emoticons in chats or forums	Chat/Forum
Individual accountability	Answering to individual tests.	Active use	Account activity points.	Activity
	Being a leader when prompted	Active use	Count the number of times accepted leadership.	Group activity
		Active use	Number of times you have used the leader to vote for tie.	Activity
		Survey response	Average staff individually received assessment as leader	Opinion survey
Group Processing	Group evaluation of challenges	Survey Response	Add individual's participation in the evaluation.	Evaluation Activity

to realize that this greater effort. Another example of rule to be applied is keeping up the score from other groups in order to promote the stimulation of active competition. This is a reactive group action agent.

One of the techniques suggested by [35] to stimulate the Individual accountability characteristic is attributed surprise challenges to balance the performance of all the group members. These surprises challenges should be assigned to players with lower scores, which are those with learning problems.

C. Student Module

This module is responsible for storing the student's development in the environment of competitive edge software, their collaboration and participation. Their activities and actions within the gamifying environment will be scored and recorded, especially those where collaboration can be seen as chats, forums, materials exchanges, murals, among others.

The information stored by this module, obtained by agents, were based on collaboration valuation techniques adopted by [26] in a Wiki tool, but adapted to other types of tools. Table I gives some examples of metrics that applied by the individual agent to score the collaborative actions of learners. Metrics are parameterized by the teacher while authoring environment, determining the weight of each of the activities and how each action has weight in the total desired trait.

D. Agent Module

The agent module consists of two intelligent agents: *individual agent*, which tracks student activities (their posts, their responses to the activities proposed, in summary, their actions within the software they are using with the multi-agent system) and *group agent*, accompanying the group, registering their collective scores, encouraging the participation of the different elements of the team, among other activities. Each of these agents is responsible for detecting the collaboration in its particular level.

During a session of gamifying software, they are created an individual agent for each player (student / learner) and a group agent for each group. The agents extract the domain module attitudes carried out by participants are collaborative attitudes and store in the Student module. It is up to the group agent to seek in Teaching Module attitudes regarding non-implementation of these and what to do in order to be changed or improved.

As a proposal for the collaborative games presented by [29], [35] each phase end of the collaborative game/gamifying software, each group is asked to evaluate their performance as a group. Incumbent upon the group agent to compare the answers assessment provided individually and analyze the collaborative performance group, applying the next phase techniques to stimulate collaboration if necessary or keep the techniques that have achieved more results in the closed stage.

IV. CONCLUSION

The aim of this study was to present an architecture for multi-agent system, to be inserted into gaming environment or gamifying collaborative educational software, whose main function monitor, assess and foster collaboration among its participants.

The main contribution of this study is to provide the area of Computer-Supported Collaborative Learning a tool that helps in the process of monitoring, evaluation and stimulation of the collaboration in competitive group activities. Another expected contribution is the description and development of intelligent agents to monitor collaborative activities in gaming environments. With these agents is intended to extend the research and its use for other collaborative tools within any collaborative learning environment.

As future work we intend to validate the architecture developing a collaborative game, which can be used in different areas of knowledge but, for validation purposes it will be applied in Computer Programming Teaching.

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