An Intelligent Virtual Agent for Collaborative Learning looking to be part of the Team

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Abstract. The Team Role Theory sustains that a balance among the members' preferences towards certain roles improves the team performance. In this paper an Intelligent Virtual Agent originally designed applying an emotion-based architecture to generate particular behaviors, is modeled according to compatible team role characteristics, in order to substitute a student when required, during the execution of a socio-technical task. An exploratory study is also briefly commented.

Keywords: Collaborative Virtual Environment, Computer Supported Collaborative Learning, Intelligent Virtual Agent.

1 Introduction

The reciprocal interplay between learning and working has contributed to the understanding to one another. In this context, the Team Role Theory although originally proposed for working teams, has being found beneficial for the construction of knowledge in Computer Supported Collaborative Learning (CSCL) environments [1].

While the main purpose of CSCL is to scaffold students in learning together effectively; its aim of research comprises not only the techniques but also the social organization to better support collaborative learning [2].

Some learning groups seem to interact naturally, even though, others struggle to maintain a balance of participation, leadership, understanding, and encouragement [3]. According to the Team Role Theory people tend to behave, contribute and interrelate with others at work in certain distinctive ways.

A balanced combination on these preferred ways of interacting with others while working is expected to result in a more successful team than those with an unbalanced composition [4].

On the other hand, Collaborative Virtual Environments (CVE) are a powerful tool for learning that combine virtual worlds in a distributed system, offering a shared space where the students can navigate, and interact with peers, data and objects through visual and auditory channels [5]. In Virtual Environments (VE), materials do not break or wear out; while they allow safe experiences of distant or dangerous locations and processes [6]. Their main uses are likely to be where spatial tasks are involved because they are commonly and predominantly visual; where co-presence is required; and where it is more effective or more enjoyable to carry out a task or activity in virtual than in real, for reasons of cost, safety or interpersonal difficulty [7].

CVE's characteristics make them proper for socio technical tasks (like training in coordinated situation such as rescue operations or enterprise logistic). While this type of tasks is accomplished on line, creating the plan or evaluating results could be carry out by an asynchronous participation, but when it comes to its execution, all the students may need to interact at the same time. In which case a pedagogical agent could take a student's place while at the same time plays the required team role for balance, an agent that will act accordingly to the requirements of the task and to be compatible with the other students' personal characteristics. The agent can either balance the team roles or replace a student.

2   Intelligent Virtual Agent Architecture for Team Roles

PANCHO (Pedagogical AgeNt to support Collaborative Human grOups) is an Intelligent Virtual Agent designed applying an emotion-based Architecture to generate particular behaviors [8], in this case, related to the team roles as defined by Belbin .

The Belbin's team roles [4, 9] is one of the more well known instruments related to personality and team preferences, the earliest and still the most popular categorization. Belbin proposed nine team roles classified in three types: People oriented (P), Cerebral (C), and Action oriented (A), see Table 1. A balanced team should have members of different kind of roles.

In order to identify the role a person will have in a team, Belbin [9] designed a questionnaire for the team member called the SPI: Self-Perception Inventory complemented by the group member, and confirmed by other questionnaire filled out by his/her peers.

Belbin [4] identified that certain roles are compatible or not with the others, and associated this compatibility to a hierarchical situation such as supervisor or peers. Because in a proper collaborative learning situation it is expected to avoid the hierarchical organization [10, 11], only the relation between the team roles in a flat structure are here presented in Table 2.

The team roles are closely related to people personalities. One of the personality models more used as reference is the OCEAN or Big Five Model [12], this model distills the differences between individual personalities into five basic personality factors very briefly explained: *extraversion*, socially compromised; *agreeable*, concerned with cooperation and social harmony; *conscientiousness*, impulses control; *neuroticism*, emotionally reactive; and *openness*, conventional.

Table 1. Belbin's Team Roles

Kind		Role	Description
(A)ction oriented	(SH)	Sharper	Dynamic, challenging. Has drive and courage to overcome obstacles.
	(IM)	Implementer	Disciplines, reliable, conservative. Turns ideas into practical actions.
	(CF)	Completer Finisher	Painstaking, conscientious, anxious. Serarches out errors and omissions, delivers on time.
(P)eople oriented	(CO)	Coordinator	Mature, confident, a good chairperson. Clarifies goals, promotes decision making.
	(TW)	Team Worker	Cooperative, mild, perceptive, diplomatic. Listens, builds, averts friction.
	(RI)	Resource Investigator	Extrovert, enthusiastic. Explores opportunities. Develops contacts.
(C)erebral	(PL)	Plant	Creative, imaginative, unorthodox. Solves difficult problems.
	(ME)	Monitor-Evaluator	Sober, strategic, discerning. Sees all options.
	(SP)	Specialist	Single-minded, self starting. Dedicated. Provides Knowledge and skills in rare supply.

Lindgren [13] reported a rational analysis of those personality factors that influence the most each Belbin's Team Roles. Lindgren gave positive or negative weight to each personality factor for each team role as shown in Table 3.

Table 2. Team Roles relations in a flat structure organization

Role	Relation	
	Compatible with (Preferences)	Incompatible with
Sharper (**SH**)	Resource Investigator (**RI**)	Coordinator (**CO**)
		Team Worker (**TW**)
Implementer (**IM**)	Coordinator (**CO**)	Implementer (**IM**)
	Resource Investigator (**RI**)	Plant (**PL**)
	Monitor-Evaluator (**ME**)	
	Specialist (**SP**)	
	Completer Finisher (**CF**)	
Completer Finisher (**CF**)	Implementer (**IM**)	Resource Investigator (**RI**)
		Monitor- Evaluator (**ME**)
Coordinator (**CO**)	Team Worker (**TW**)	Sharper (**SH**)
	Implementer (**IM**)	
Team Worker (**TW**)	Team Worker (**TW**)	Sharper (**SH**)
	Plant (**PL**)	
Resource Investigator (**RI**)	Team Worker (**TW**)	Completer Finisher (**CF**)
	Implementer (**IM**)	Specialist (**SP**)
Plant (**PL**)	Coordinador (**S**)	Monitor-Evaluator (**ME**)
	Resource Investigator (**RI**)	Plant (**PL**)
	Team Worker (**TW**)	Specialist (**SP**)
		Implementer (**IM**)
Monitor-Evaluator (**ME**)	Coordinador (**S**)	Completer Finisher (**CF**)
	Implementer (**IM**)	Monitor-Evaluator (**ME**)
		Plant (**PL**)
Specialist (**SP**)	Implementer (**IM**)	Plant (**PL**)
	Team Worker (**TW**)	Resource Investigator (**RI**)

Table 3. Lingren's [13] relation between Team Roles and Personality Factor

Team Role	Personality Factor				
	Extraversion (I)	Agreeablenes s (II)	Conscientiousnes s (III)	Neuroticis m (IV)	Opennes s (V)
Sharper (**SH**)	**9**	**-5**	1	-1	0
Implementer (**IM**)	0	0	**7**	0	-3
Completer Finisher (**CF**)	0	1	**8**	-2	1
Plant (**PL**)	0	0	-2	-1	**11**
Monitor-Evaluator (**ME**)	-3	-4	2	2	3
Specialist (**SP**)	1	-2	**8**	0	1
Coordinator (**CO**)	3	3	2	4	2
Resource Investigator (**RI**)	**8**	0	-3	1	2
Completer Finisher (**CF**)	-2	**5**	0	-1	2

Accordingly, the virtual agent *Pancho* defining characteristics *DC(Pancho)* as part of the team will be: its kind of team role *KR(Pancho)*; its team role *TR(Pancho)*; and the personality factors that correspond to them *P(Pancho),* that is: *DC(Pancho)= KR(Pancho)   TR(Pancho)   P(Pancho).*

We will first establish the agent's kind of role that will balance the team, then the specific team role according to the defined kind, and to be compatible with the other team members, and finally the personality factors that match the team role and will determine its socio interaction.

2.1 The Team Roles Balance

A small group is recommended for collaborative learning in order to give all of its members the opportunity to participate. There is not an exact specification about how many members a group should have in order to be called a small, but in groups with more than five members there is a general complain about participation restrictions. [14]. A group integrated by three members was selected to exemplified the approach; according to Bean [15] an optimal group size for the workgroup. To balance the team, the first defining characteristic is the kind of role (KRole) that the agent must play, considering ? Tx, Ty ? Human Group with x ? y:

RealTeam = {KRole(Tx), KRole(Ty)}   **IdealTeam = {A, P, C}**

If KRole(Tx) ? KRole(Ty) ?   KRole(Pancho) ? (IdealTeam – RealTeam).

If KRole(Tx) = KRole(Ty) ?   KRole(Pancho) = p ? KChoice[p] > KChoice[q]
where p ? q, p ? KRole(Tx) and q ? KRole(Tx).

Then by an analysis of incompatibilities the agent team role might assume is, for example, if the agent got a People Oriented team role then:

If (KRole(Pancho) = P) ? (TR(Tx) = SH ? TR(Ty) = SH ?   TR(Pancho) = RI.

If (KRole(Pancho) = P) ? (TR(Tx) ? {CF,SP} ? TR(Ty) ? {CF,SP}) ?   TR(Pancho) ? {CO,TW}

If (KRole(Pancho) = P) ? (TR(Tx) ? {SH,CF,SP}) ? (TR(Ty) ? {SH,CF,SP}) ?   TR(Pancho) ?
{CO,RI,TW}

Once the agent team role is defined then its personal factors can be shaped.

2.2 Shaping the Agent's Personality

People tendency does not necessarily mean they will always act in the same way, although they may have a deep marked tendency. The heuristic adopted for generic purposes was to restrict the values for each of the five factors as presented in Table 3, allowing the tendency to move accordingly to a range of possibilities. Through fuzzy logic linguistic labels, the quantitative of the personality factors are transformed to linguistic variables (as in [16]), see Figure 1. The qualitative linguistic values that each personality factor will take accordingly to the Lingren's weights (Table 3) are presented in Table 4.
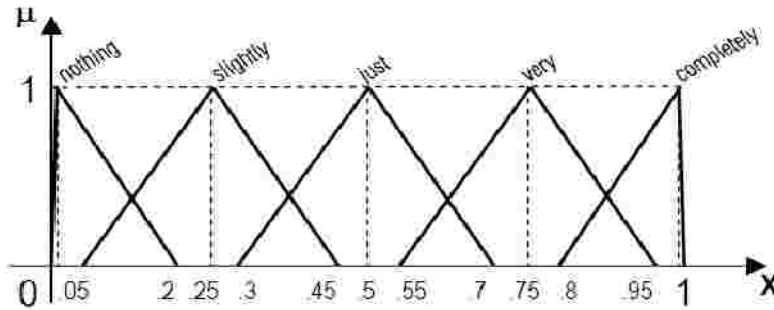

Fig. 1. Semantic Model for the factor degrees

Table 4. Personality factors heuristic in a qualitative domain

Quantitative Domain	Heuristic	Qualitative Domain				
		N	S	J	V	C
[0]	Without influence. All values	ü	ü	ü	ü	ü
[-2, -1]	Minimum influence. Four values according to the influenced pole	ü	ü	ü	ü	
[1, 2]			ü	ü	ü	ü
[-4, -3]	Certain influence. Three values according to the influenced pole	ü	ü	ü		
[3, 4]				ü	ü	ü
[-7, -6, -5]	Significant influence. Two values according to the influenced pole	ü	ü			
[5, 6, 7]					ü	ü
[-11, -10 -9, -8]	High influence. One extreme value	ü				
[8, 9, 10, 11]						ü

The range for the restricted values for the personality factors of each team role for the People oriented, Cerebral, and Action oriented types are shown in Table 5.

The *coordinator* differs from other People oriented roles for his/her emotional stability; he/she is a mature and confident person with high values for all the personality factors. The *resource investigator* is enthusiastic and communicative person (extraversion: completely) that develops contacts. The third People oriented role, the *team worker* is cooperative, mild and diplomatic (agreeableness: very, completely) but he/she averts friction which may provoke edginess (neuroticism: just).

The cerebral type of role is creative, imaginative, and unorthodox (openness: completely) but he/she might be careless with the practical tasks. One main *specialist* characteristic is that he/she is highly dedicated (conscientiousness: completely). As of the *monitor-evaluator*, he/she is strategic and a discerning person, although not very sensible with his/her peers' problems (extraversion and agreeableness: nothing, slightly, just).

Table 5. Personality factors related to People oriented, Cerebral and Action oriented roles

Personality Factors	People oriented roles		
	Coordinator	Resource Investigator	Team Worker
Extraversion	[J, V, C]	**[C]**	[N, S, J, V]
Agreeableness	[J, V, C]	[N, S, J, V, C]	**[V, C]**
Conscientiousness	[S, J, V, C]	[N, S, J]	[N, S, J, V, C]
Neuroticism	[J, V, C]	[S, J, V, C]	[N, S, J, V]
Openness	[J, V, C]	[S, J, V, C]	[S, J, V, C]
	Cerebral roles		
	Plant	Monitor-Evaluator	Specialist
Extraversion	[N, S, J, V, C]	[N, S, J]	[S, J, V, C]
Agreeableness	[N, S, J, V, C]	[N, S, J]	[N, S, J, V]
Conscientiousness	[N, S, J, V]	[S, J, V, C]	**[C]**
Neuroticism	[N, S, J, V]	[S, J, V, C]	[N, S, J, V, C]
Openness	**[C]**	[J, V, C]	[S, J, V, C]
	Action oriented roles		
	Shaper	Implementer	Completer Finisher
Extraversion	**[C]**	[N, S, J, V, C]	[N, S, J, V, C]
Agreeableness	**[N, S]**	[N, S, J, V, C]	[S, J, V, C]
Conscientiousness	[S, J, V, C]	**[V, C]**	**[C]**
Neuroticism	[N, S, J, V]	[N, S, J, V, C]	[N, S, J, V]
Openness	[N, S, J, V, C]	[N, S, J]	[S, J, V, C]

In the group of Action oriented type, the *shaper* is clearly sociable when trying to achieve a goal (extraversion: completely), but his/her cold and critical personality can create antipathy. The *completer finisher* and *implementer* have personality factors similarities, both are responsible and not clearly sociable, but while *implementers* do

not like changes (openness: nothing, slightly, just), the *completer finishers* are conscientious and perfectionist (conscientiousness: completely).

3 ¿Is Pancho my Teammate, a Coordinator or an Implementer?

The agent was implemented in an experimental CVE with ludic characteristics, which goal is to transport a diplomatic by plain, through an enemy zone constantly monitored by other plains and ships with a determined path.

In the CVE, the agent performs the team leader either as a Coordinator or as an Implementer. These roles were selected because they are different kind, the coordinator is People oriented while the Implementer is Action oriented. Belbin [4] described the Coordinator personality as one likely to be a more natural team leader. While the Implementer best team quality is to execute the planned actions, and his/her leadership may lack of spontaneity. Their personality factors were settled as shown in Table 6.

Table 6. Personality factors applied for the Coordinator and Implementer roles

Personality Factors	Coordinator	Implementer
Extraversion	Very	Just
Agreeableness	Very	Just
Conscientiousness	Just	Completely
Neuroticism	Very	Just
Openness	Very	Nothing

As mentioned, the intelligent virtual agent knowledge about the task at hand primarily guides its course of action. And, it is part of an emotional-based architecture, this means it reacts not only accordingly to its personality but also to emotions such as joy, trust, or fear; attitudes towards its pears; and its physical state like being tired or thirsty (see for further details [16]). However, the focus here is its team role characteristics. The actions that the agent takes according to its team role are presented in Table 7.

Table 7. The agent's actions taken accordingly to the team role

Situation	Coordinator action	Implementer action
dangerous type	Takes an immediate action (even if it is not the best one). Sends a message trying to release the team tension	Delays to take a decision until it gets a clear definition of the dangerous situation
risky type	Elaboration of a number of possible actions	Elaboration of an efficient combination of concrete actions
a determined reached percentage of the goal	Sends messages informing the advances to the team's goals	None

With the idea to understand how the human members of the team perceived the Pancho's team role, a first exploratory study, briefly commented in the next section, was conducted.

3.1 Exploratory Study

Four teams with two compatible different roles were formed with Computer Science students. Each team completed the task with Pancho as the third member of the team twice, each one with Pancho in a different role (Coordinator and Implementer).

The Belbin's [9] SPI: Self-Perception Inventory was adapted for three roles: the coordinator, the implementer and the plant. And the participants qualified with it the agent´s profile.

Results are shown in Table 8. The students identified correctly the Pancho's team role as Coordinator only two of the eight times (25% of the times), as Implementer half of the times (four of eight times) and as plant 25% of the time. The Implementer was identified correctly half of the time, twice it received the same qualification as Implementer or Coordinator, and one the same for the three roles.

The results show a tendency to identify the agent as an Implementer regardless to its defined characteristics. The one condition that clearly affected the results is the small size of the sample, but other conditions that may present more accurate results are a larger number of different actions the agent could take, or a greater number of roles that the agent could perform.

Table 8. The participants qualifications for the agent's team role

Student	Coordinator (CO)Team Role			Implementer (IM)Team Role		
	CO	IM	PL	CO	IM	PL
01	9	**11**	10	11	**12**	7
02	9	10	**11**	10	10	7
03	7	**19**	4	12	12	10
04	7	**12**	11	11	**12**	6
05	6	10	**14**	9	**15**	7
06	9	**12**	9	11	**12**	6
07	**18**	8	4	**19**	10	7
08	**18**	7	5	13	13	4

4   Discussion and Ongoing Work

In this paper we presented the rationalization for modeling an intelligent virtual agent, accordingly to a certain team role, with the intention to be compatible with a group of students that take care of a socio-technical task and during its execution. The task is meant to be carried out in a CVE for learning. The agent can take the place of a student in order to complement the group for training purposes or to balance the team.

The implementation of the approach was made in a CVE giving to the agent two types of team role. An initial exploratory study was conducted, although with no posi-

tive or certain results its main outcome is the insights that will help to create a more adequate experimental design.

Currently we are working on the design of an experiment that can answer questions about the improvement in the team performance by using our agent.

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