

# Collaborative Learning Environments based on “Acting Coach” Agents

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**Abstract:** Effective collaboration does not occur spontaneously. Students participating in collaborative learning environments need to learn about how to collaborate. This can be done by coaching students on which roles they should adopt in a collaborative activity. By giving advice on tasks and behaviours, students become able to adhere to specific roles and learn to collaborate effectively.

This paper identifies the importance of roles in collaborative learning environments. It proposes “Acting Coach” agents as companions/advisors to support learners in adopting suitable roles. It describes a framework where students and “Acting Coach” agents can interact in a collaborative setting. Finally, it shows some of the results of a preliminary study about students and roles.

Keywords: agents, collaborative learning environments, role playing.

## 1. Introduction

Students participating in collaborative learning environments need to be capable of engaging in teamwork and co-operative communication processes. In learning to collaborate effectively, one comes to recognise the importance of “collaboration roles”. Earlier research has examined these collaboration roles and has analysed them from the perspective of patterns of behaviour in-group activities (Brilhart, 1982). Participants in a group typically take on one or more roles. For example, the leader is the one who prepares and initiates the meeting. The observer records and classifies interactions according to behavioural functions. The evaluator prepares and classifies the evaluation. Other roles might include critic, executor, brainstormer, and devil’s advocate.

Collaboration roles can be broken down into tasks (sequences of activities expected of a person acting in a specific role) and behavioural functions (patterns of behaviour consistent with a specific role). Collaborative learning support systems can help learners in many ways, but this research focuses on helping learners to become more effective collaborators by coaching them about specific collaboration roles. “Acting Coach” agents have been created to act as companions, watching people engaging in group interaction, monitoring the roles they seem to be assuming, and suggesting behavioural functions or sequences of activities that might be more appropriate to the role assumed (or assigned). These agents are computer-based personal assistants/advisors that try to encourage learners to collaborate in an efficient and effective way by attending to the roles that their human masters are exhibiting.

Interdependence (Salomon, 1992) and coordination (Malone & Crowston, 1994) are two of the interesting aspects found in the literature about CSCW (Computer-Supported Cooperative Work)

and CSCL (Computer-Supported Collaborative Learning). Based on these concepts, Wasson proposes to use coordination agents to support people participating in telelearning environments (Wasson, 1998). “Acting Coach” agents can be seen as a kind of coordination agent in the sense that they provide advice to the learner in a specific role. They are characterised by monitoring the learner’s actions, and suggesting behavioural functions or sequences of activities consistent with his/her role.

## **2. Team Performance and Roles.**

A team consists of two or more people with different tasks who work together adaptively to achieve specified and share goals. In this context, communication, coordination, team leadership, team orientation, monitoring, feedback and backup behaviour (helping other team members in their tasks) have been recognised as critical ingredients to support team performance (Brannick et al., 1997). Unified theories of teamwork are attitude-based, knowledge-based, or skill-based (Baker and Salas, 1992), but these theories have evolved to consider team characteristics as a function of the environment in which the team operates (Cannon-Bowers et al., 1995). Internal (team processes) and external (team outcomes) performance measures have been developed and evaluated in different kinds of teams.

A role is defined as a pattern of behaviour displayed by and expected of a member of a small group; a composite of behavioural functions performed relatively frequently by a member (Brilhart, 1982). Roles have been analysed as an important factor in team processes and they have direct consequences in team outcomes. In a mature and fully organised team, each member has a definite position or role. Different authors have analysed roles in several contexts; two broad categories are roles in teamwork or work groups and roles in training. In the former category, researchers distinguish between two general kinds of behaviours: task-oriented (individual-oriented) and socio-emotional (team-oriented) behaviour (Guzzo et al., 1995). In the same category, Brihart describes the roles of leader, critic and observer. From the training or learning perspective authors describe additional roles such as: tutor, learner, and troublemaker (Aimeur et al., 1997); task-doer and observer (McCalla, 1990); constructor, checker and repairer (Burton et al., 1997). O’Malley (1987) classifies roles according to the actions: discomposing, critiquing, convincing, reviewing, and referencing.

In general, the selection of roles includes a set of tasks and a pattern of behaviours that an individual team member shows during a meeting. These patterns of behaviour are called behavioural functions. It is important to notice that any participant interaction can be classified as a behavioural function or a group of them. Consequently, it is possible to build a role profile for each participant by monitoring each of his/her interactions.

## **3. Roles = Tasks + Behavioural Functions.**

Using the work of (Brihart, 1982; Guzzo et al., 1995), it is possible to map some behavioural functions and tasks to certain roles. We have extended this to include a richer set of roles and tasks. For illustration, Table 1 provides a sampling of these behavioural functions for a few common roles. This mapping has to take into account frequency of behavioural functions and tasks for each participant during each stage of the meeting. This initial mapping of role patterns should be updated using feedback mechanisms during each meeting.

Role patterns are important for “Acting Coach” agents, which use them as initial categories to compare and classify each learner. In addition, based on these patterns, agents can give advice to the learner when his/her actions seem to be straying from his/her actual role. Feedback received by “Acting Coach” Agents from the learner is important to update these patterns.

Table 1. Roles = Tasks + Behavioural Functions.

<b>ROLES SELECTED</b>	<b>TASKS Chronological order in the meeting.</b>	<b>BEHAVIORAL FUNCTIONS Ordered by frequency in occurrence during the meeting.</b>
Leader	<ul style="list-style-type: none"> <li>•Preparing for meeting (Agenda, purposes of the meeting, specific outcomes of the meeting, etc.).</li> <li>•Initiating discussion (reducing primary tensions, the purpose of the meeting should be described, handouts may be presented, supply suggested structure and procedures, roles should be established, etc.).</li> <li>•Structuring discussion.</li> <li>•Equalising Opportunity to participate.</li> <li>•Promoting teamwork.</li> <li>•Additional tasks according to the current agenda.</li> <li>•Fill out the evaluation forms.</li> </ul>	<ul style="list-style-type: none"> <li>•Initiating and orienting.</li> <li>•Co-ordinating.</li> <li>•Consensus testing.</li> <li>•Suggesting procedure.</li> <li>•Harmonising.</li> <li>•Tension relieving.</li> <li>•Opinion seeking.</li> <li>•Opinion giving.</li> <li>•Information giving.</li> <li>•Information seeking.</li> <li>•Norming.</li> </ul>
Observer	<ul style="list-style-type: none"> <li>•Classify the interactions of each learner according to the behavioural functions.</li> <li>•Additional tasks according to the current agenda.</li> <li>•Fill out the evaluation forms.</li> </ul>	<ul style="list-style-type: none"> <li>•Recording.</li> <li>•Information seeking.</li> <li>•Opinion seeking.</li> <li>•Suggesting procedure.</li> <li>•Evaluating.</li> </ul> <p>And others less frequent.</p>
Evaluator	<ul style="list-style-type: none"> <li>•Sometimes can interrupts as an advisor or coach.</li> <li>•Additional tasks according to the current agenda.</li> <li>•Design and distribute evaluation forms to evaluate each participant and his/her role and the group as a whole.</li> <li>•Classify the evaluation forms.</li> </ul>	<ul style="list-style-type: none"> <li>•Information seeking.</li> <li>•Opinion seeking.</li> <li>•Evaluating.</li> <li>•Suggesting procedure.</li> <li>•Information giving.</li> <li>•Opinion giving.</li> <li>•Norming.</li> </ul> <p>And others less frequent.</p>

It is clear that in a group, an appropriate mix of roles has a positive effect on group performance (Baker and Salas, 1992; Guzzo et al., 1995). Moreover, when each interaction of a team member

is consistent with the role assumed (or assigned), the goals of the group are more likely to be achieved (Brihart, 1982).

How can one help learners to become more effective collaborators? Computer support for collaborative environments based on “Acting Coach” agents provide an interesting approach to help participants in their tasks and catalyse the process of getting used to their role. In order to coach participants about specific collaboration roles, it is necessary to build a framework where components, such as: communication, coordination, team leadership, team orientation, monitoring, feedback and backup behaviour can be handled and controlled.

#### **4. A Framework based on “Acting Coach” Agents.**

In order to provide a complete and useful environment where researchers can test the effects of different team variables applied on several teams, it is necessary to understand the nature of teams and the emerging principles that affect teamwork. Backer and Salas (1992) proposed six general principles for measuring teamwork skills, and Brannick et al. (1997) added twenty additional principles.

In these principles, team performance is not simply represented by what team members do. Observation is critical for measuring and providing feedback regarding team behavioural skills. Measures that assess team knowledge, attitude, and skill competencies must be developed applied and evaluated. Measures and measurement tools must reflect the maturation process of a team, and measures must capture the dynamic nature of teamwork.

The framework proposed in this paper involves a conversational model, a learner model with a role profile per each participant, “Acting Coach” agents, classification of interactions by the observer (using AI tools and sentence openers), role patterns, and a collaborative environment to support rich interaction among participants. In addition, feedback and evaluation mechanisms have been integrated in this system. Figure 1 shows the general architecture of this framework.

##### **4.1. “Acting Coach” Agents.**

“Acting Coach” (AC) agents have been designed to satisfy the need of a personal companion or coach for each individual learner with a specific role in a specific collaborative team. AC agents provide advice to the learner relating to tasks and the recommended behaviour to continue in his/her meeting. Some characteristics of this type of agent are:

- Each learner’s personal AC Agent uses role patterns, learner model information, and meeting information (tasks and behaviours) to determine whether its learner is acting according to a certain role or not. Bayesian networks are being used to build a causal structure to model each role. To get this information, AC agents interact with their learner’s model, the collaborative environment, and the conversation model.
- AC Agents give advice to their learner about the role and possible actions (tasks or behaviour) in order to achieve the goals of the meeting or to solve the problem through a good exercising of roles. In addition, AC Agents get feedback directly from the learner (agent - learner interaction), from actions made by the learner in the collaborative environment, and from the evaluation stored in the conversation model.

- AC Agents encourage learners to adhere to roles by using hints and adjusting some environmental settings according to the learner profile and role information.
- AC Agents build profiles of each learner as he/she plays a particular roles and it updates the profiles during the meeting.
- AC Agents should know about the collaborative environment’s capabilities (CSCW tools, interface tools, resource, and management tools) to be able to customise environment.

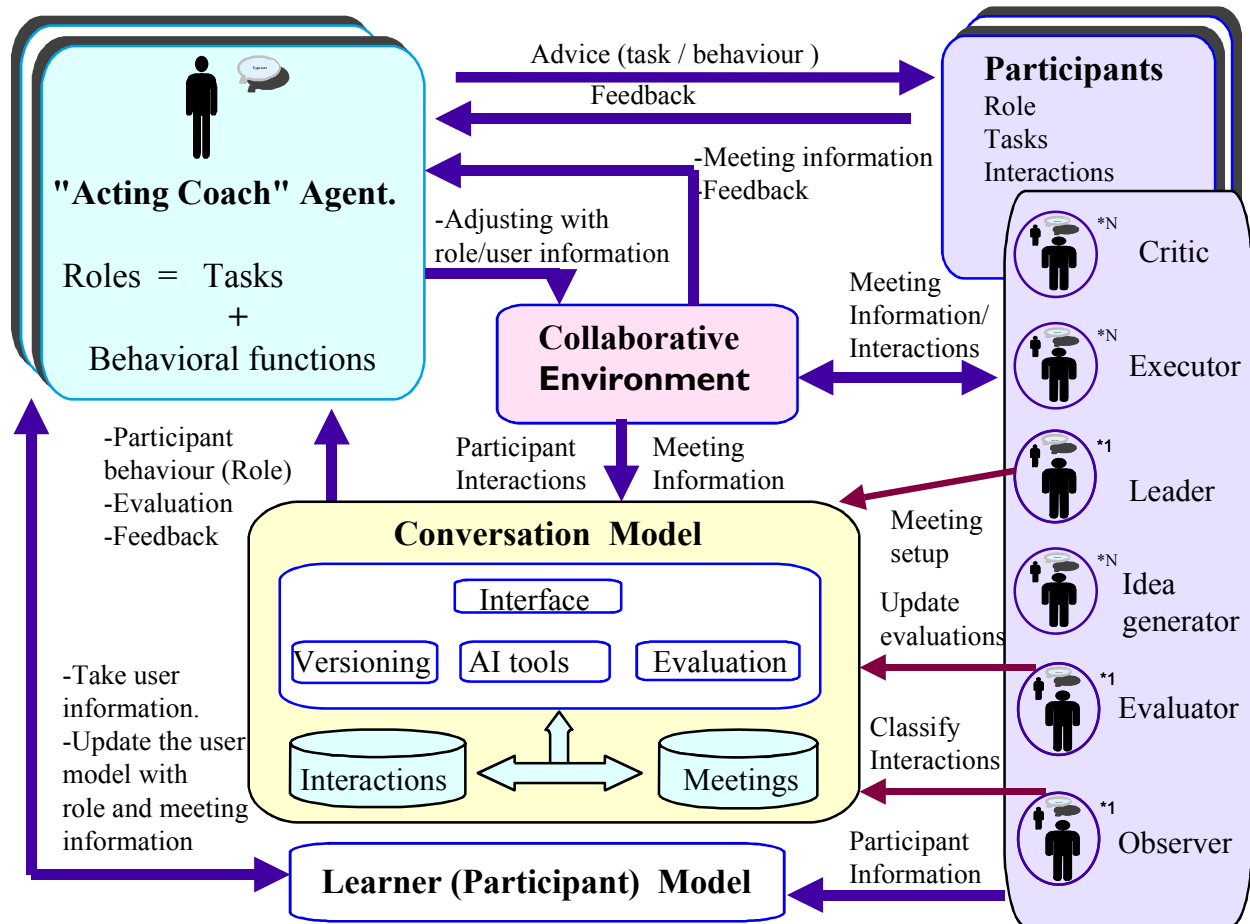


Figure 1. System Architecture.

Communication, reasoning and planning capabilities are needed to make “Acting Coach” agents able to serve as personal agents providing useful advice to the learner. AC agents are goal oriented and their internal architecture is based on the "goals-relationships-resources" agent model (Vassileva, 1998). AC agents use their relationships and resources to reach their goals. In addition, their interaction with the collaborative environment, the conversation model, and the learner model gives them enough information and control over the environment.

This set of requirements given above represents an ideal for AC Agents that current technology can not fully achieve. Compromises must be made. For example, in order to avoid natural

language processing, the observer (human in the observer role) can classify the other learners' interactions. In addition, AC Agents' actions can be restricted only to watch for apparent changes in roles, alerting the learner when he/she seem to be drifting toward a different role.

#### **4.2. The Participant.**

Human participants (learners) involved in role-playing environments have to learn how to deal with a group of tasks and with other learners. Tasks and expected behaviour for each role will change during the meeting or collaborative session. In this framework, participants are provided with information about meetings (goals, tasks, tools, etc.), other participants, team performance and roles. Participants provide feedback in response to the advice given by the AC agent, evaluate the meeting and the AC agent, and provide the information needed to build an initial learner model.

Participants carry out various functions. For example, the leader is the one who prepares and initiates the meeting (agenda, purposes of the meeting, specific outcomes of the meeting, etc.). The observer classifies all interventions according to a list of behavioural functions. The evaluator is the one who prepares, sends, and classifies the evaluation (meeting evaluation, AC Agent evaluation, and role evaluation), which is stored in the conversation model.

#### **4.3. Conversation Model.**

The conversation model has been created to represent information related to the meeting (roles, interactions classified, specific interfaces for the observer and the evaluator, and versioning information). The six components of the conversational model are interface component, meetings component, interactions component, classification AI tools, evaluation component, and versioning component.

The interface component offers facilities to interact with the learner. This component provides a special interface to the observer to classify the interactions and to the evaluator to update the evaluation information. The meeting and interactions components are databases that are maintained and updated using the information generated in the collaborative environment and in the evaluation component. The evaluation component enables updating of the meeting and interactions databases using the information received from the learners, and specially from the evaluator. AI tools could eventually be deployed to offer a list of learners' interactions (pre-classified according to behavioural functions) to the observer. The last component is the versioning component. This component enables the system to maintain control over the information where the observer and the evaluator are working. In addition, it enables the system to reproduce past meetings to be analysed, classified and evaluated.

The conversation model receives information about learners' interactions and settings of the meeting from the collaborative environment, and provides information about participants' behaviour, evaluation of the meeting, evaluation of the role, and agent evaluation to AC Agents.

#### **4.4. Collaborative Environment.**

The collaborative environment is a software application that supports the interaction among people and agents using CSCW tools. Three different types of interaction are supported in this environment: AC agent-participant interaction, participant-participant interaction, and

participant–conversation model interaction. AC agent–participant interaction is based on advice/suggestions given by the agent and feedback/responses of the participant. Participant–participant interaction is intended to be as natural as possible. It depends on the communications tools available. Finally, participant–conversation model interaction is needed in order to classify interactions, and reproduce and evaluate meetings.

Participants can customise the environment directly or AC agents can adjust it based on learner preferences and role information. This is possible because this information is periodically updated and stored in the learner model and in the conversation model.

## **5. Preliminary Study Conducted at the U of S.**

A Preliminary study to determine typical roles in small student groups was conducted at the University of Saskatchewan in the fall of 1998. Subjects for this study were groups of four or five students each working on Software Engineering design problems. Several meeting sessions were recorded and students' interactions were coded and classified.

A preliminary analysis of the data shows that groups with participants who have experience with teamwork have a better team performance (better process and outcomes). Teams benefited from an initial description about roles in teamwork and continuous coaching to reinforce roles through practice. Non-verbal communication (eye contact and gestures) has an important role in these kinds of teams specially when participants are searching for approval or getting consensus on a topic. By analysing the distribution of interactions it is possible to determine centres of power, for example people who are frequently asked before any agreement or new idea. These centres of power can be attributed to one or two participant who act as leaders. When important roles were left unfilled or when too many participants tried to assume the same role, the groups were dysfunctional. Students with a strong background in teamwork were more organised and efficient with the meetings.

Based on these findings, AC agents seem to be an appropriate strategy to support role-playing in collaborative learning environments. An initial selection of roles by the learners makes it possible for AC Agents to monitor learners' roles by analysing tasks and behaviour. In addition, AC Agents can also offer an initial description and continuous coaching on roles during the collaborative session.

## **6. Conclusions and Future work.**

A framework based on “Acting Coach” agents, where researchers can test the effects of different team variables, should integrate knowledge from areas such as: psychology, sociology, education theory, computer support for cooperative work (CSCW), computer support for collaborative learning (CSCL), human computer interaction (HCI) and artificial intelligence (AI). Next steps include using the information gathered from the preliminary study to refine this framework, developing and implementing a system prototype, and employing this system to do controlled studies in "role-playing" collaborative learning environments.

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