Towards A Multi-Agent Based Model of Argumentation and Dialogue for E-Learning

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Abstract**—** Argumentation and dialogue play an important role in promoting successful E-learning activities. Usually, students need to interact with a learning facilitator at some point, in order to ask for clarification, obtain guidance and explanations. A successful E-learning model is expected to provide the E-Tutor with an insight of what learners need and learners with the knowledge, experiences and insights which they need to achieve their learning objectives. The adaptive role of an E-Tutor is essential to learning because E-resources, such as online databases and/or World Wide Web resources are not often able to satisfactorily address a particular group or individual's learning requirement. Therefore, an E-Tutor has to avail the learner timely access to what it needs and it can understand. Furthermore, argumentation and dialogue have an important role to play in shaping learners' conceptual change and developing learners' reasoning skills. In this paper we make a first step towards developing a multi-agent based model of argumentation and dialogue for E-learning. We discuss the notion of a successful E-learning system and the need for communication, argumentation and dialogue in E-Learning. We also discuss some of the aspects of knowledge representation for an E-learning system. We finally present a formal model of argumentation and dialogue.

Keywords**—** E-learning, Multi-Agent System, Knowledge Representation, Dialogue, Argumentation.

I. Introduction

THE current economic and technological trends increases the need for more people to acquire new skills and learn new knowledge in a timely and effective manner. The advances made in Computers, Information and Communication Technologies (CICT) are offering the needed tools and methods to means to meet such demands in teaching and learning [24]. They offer new opportunities for collaboration, communication and learning. Collaboration can take place at a distance, by the use of asynchronous and synchronous computer systems. Synchronous collaboration has to be fast [13]. Consequently, learners have less time to produce careful explanations, to evaluate information thoroughly, to ask elaborated questions and so on. In general, asynchronous collaboration is much slower, learners have more time to develop extended explanation, to elaborate and explain ideas and to reflect on proposals and to reach shared understanding. Communication, through the use of dialogue rules and history, enhances deliberation, helps to keep track of lines of arguments and structuring interaction [34, 35, 36]. A history of the dialogue can be used to reason about earlier stated information. Contradictions, gaps or conflicts may be revealed through based and time-delayed discussion.

The efficient and effective communication of knowledge, experiences and insights between entities, such as tutor, student and/or student groups, is a prerequisite for successful education. A successful E-learning model includes providing the E-Tutor with an insight of what learners need. It has also to provide learners with the knowledge, experiences and insights which they need to achieve their learning objectives. Therefore, an E-Tutor has to avail the learner access to what it needs and it can understand.

However, an E-Tutor is more than a static of source of information. Usually, learners need to interact with a learning facilitator at some point, in order to ask for clarification, obtain guidance and explanations. An E-Tutor can play a role as a mediator for the learners as they interact with the various elements of the learning environment, such as other learners and E-Tutors [11]. The adaptive role of an E-Tutor is essential to learning because E-resources, such as online databases and/or World Wide Web resources are not often able to satisfactorily address a particular group or individual's learning requirement.

This can be achieved using dialogue which plays an important role in promoting learning [12, 27]. It could guide the learners to become more independent when they reflect on their own problem-solving. Hence, dialogue helps the E-tutor to pass on its comments, explanation and answers to the learner's queries and enables the learners to express their needs. Furthermore, many theories of learning have suggested that dialogue has an important role to play in shaping conceptual change and developing reasoning skills [26].

In this paper, we propose a multi-agent system that assists in the process of E-learning. In section 2, we discuss some of requirements of an E-Learning system. In section 3 we discuss the notion of communication in E-Learning. In section 4, we discuss the knowledge representation issue. In section 5, we present a model argumentation and dialogue.

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II. AN E-LARNING SYSTEM

E-Learning involves the use of a number of CICT-based tools [1, 7, 41] that can be applied in various educational contexts. It does not presume any educational model and/or philosophy. If we can ensure that technological tools are properly used when implementing an education model, then the usefulness of E-learning will be more dependent on innovations in learning models rather than technology. CICT-based tools can be used in an assistive role to complement/enhance face to face to face education or in an essential role in distance education. It is recognized that E-Learning changes the role of the teacher, particularly in online environments.

CICT-based tools can help in making accessible the right piece of information/knowledge at the right time to the entity that needs it. In other words, it is a question of information/knowledge management in an organization that has information, knowledge, techniques, tutors and students as its major assets and agents. These tools may also play an important role in enabling tutors and learners to create, acquire, make use of and disseminate information/knowledge. In this context, E-learning must be regarded as an incorporated part of the overall course design and there is a need for an argumentation and dialogue model between the involved entities.

The development of teams (e.g., learning community) is essential to high-quality E-Learning [9, 28]. A learning team is intentional. It has a culture created and recreated through communication. Team means that the members involved know about each other and have expectations regarding each other. Building an effective team for E-Learning is not easy or automatic [9]. In this context, ideas about learners becoming co-creators of knowledge have been developed [31, 32, 33]. In their constructivist, intentional-learning model they adopt the practice of knowledge building which is characterized by the use of by discourse and dialogue.

An E-Learning system must allow the E-Tutor to play both the role of content deliverer and a facilitator. Facilitating online conversation(s) is crucial to creating an engaged conversation [6]. A key issue to the success of an E-learning system is that the E-Tutor, in the role of facilitator, is present for learners online. In such cases, it can model critical enquiry and engage the learners in higher order cognitive, social, and emotional learning [29, 10].

Some of the requirements of an efficient E-Learning system are:

(1) Information integration: The core idea of an E-Learning system is to attend to a student's needs using a knowledge/information repository that consists of facts, theories, explanations. Such pieces of information/knowledge are expressed in different formats, text, images and sounds, which need to be properly integrated and tagged.

(2) Timely responses: the E-Tutor should enable learners to have access any time to the required knowledge. Responses to questions posited by learners must be relevant, appropriate with respect to the competence level of the learner, and timely. This necessitates a formal model of dialogue and argumentation.

(3) Flexibility: It may be helpful to allow learners some control over the learning process regarding style, content, strategy and so on.

(4) Learner's modeling and monitoring: A model of the learner could help the system in addressing individual needs and in performing appropriate monitoring procedures.

III. COMMUNICATION IN E-LEARNING

Communication is an essential issue. It involves [4] an ability to fully understand the content of what is being negotiated from the perspective of the discipline that has proposed it. The competencies, which determine how well learning tasks are performed and decisions are made, are a function of the knowledge being employed, including understanding, expertise, experiences and skills.

E-Learning is the activity of communicating insights, assessments, experiences or skills. It can be employed to transfer/exchange various types of Knowledge/information such as: (1) simple facts; (2) proof/recipe specifying the steps to accomplish a task (know-how) or reach a conclusion; (3) the cause effect relationships that concern a phenomenon and other types of knowledge. In addition to relevant information, there may be a need to exchange contextual information and other constraints associated with the application of the piece of knowledge being exchanged. However, it is important to emphasize that what is important in E-learning is the extent to which the learner acquires potentially useful knowledge and utilizes this knowledge in its own operations.

To be able to organize the knowledge of an E-Learning system, there is a need:

(K1) To identify, model and explicitly represent the E-Tutor knowledge. This entails modeling its processes, together with its control mechanism, and its decision-making.

(K2) For the ability to handle the computational aspects of multi-agent systems such as task allocation, interaction, coordination, process and organization representation, collective learning, consistency management, protocol, adaptation and evolution of knowledge.

(K3) For the ability to assess the performance parameters of the system in real time.

Some of the major problems that face E-learning activities and/or are associated with immediate knowledge transfer between the E-Tutor and learner are:

(D1) Students' ability to clarify a message or to find a weakness in an argument is rather limited.

(D2) Cooperation is necessary between the E-Tutor and the learners.

(D3) Constraints and contextual factors: There is a need for shared knowledge and shared understanding of the context and constraints of the learning environment.

(D4) Time pressure: overloading the E-Tutor or the students with more than they can handle could have the adverse effect of confusing the process.

III.1 Dialogue in E-Learning

An E-Learning system has to allow some flexibility to the learner. For instance, A learner can either allow the lecture to run uninterrupted from the beginning to the end, or, she/he can interrupt recalling a particular topic, slide, relation between concepts/topics. She/he should be able to repeat a previous slide or video clip. She/he should also be able to initiate a dialogue asking for more evidence, arguments, in favor or against, and proofs. She/he should be able to make comments, exchange ideas and so on.

Furthermore, In collaborative learning situations, learner should be active, i.e., search for information, engage in discussion, ask questions, discuss replies, make proposals, challenge proposals and reply to challenges and other proposals. Collaboration with the E-tutor and with other learners provokes activity, makes learning more realistic and more stimulating. Learners can propose various answers and solutions and evaluate them on different criteria [23]. Such activities require a model of argumentation and dialogue.

There are many different uses of dialogue in E-Learning. For example, in [8] ”Daphne”, a computational agent conducts an advice giving dialogue with the user to provide healthy nutrition education. Two kinds of asymmetric dialogues are introduced in [27] to support learning. One is the computer being a ”facilitating tutor” and the student the ”explainer”: the tutor raises some questions, students answer the questions, and the tutor solves the contradictions of the student’s commitments and helps the students to reach the correct answer rather than directly tell them. The second dialogue type is similar to the first, but includes further didactic features. [3] investigated the computer mediated dialogue in legal educational context, which is explanation based, both participants adopting symmetric roles [2]. In [24, 25] a study of simulation-based learning identified two types of dialogue, an inquiry dialogue with asymmetric roles and a more collaborative game generating cognitive conflict and reflection.

However, there is no agreement regarding the types of dialogue which are effective in educational contexts. Several types of dialogues can be used [37, 38]. The distinction between the types of dialogue is based on collective goals, individual goals and reasons for starting the dialogue. Each type of dialogue can be formulated as a set of rules. These constitute a model, representing the ideal way by which cooperative agents participate in the type of dialogue in question. It is important to note that in the course of communication, there often occurs a shift from one type of dialogue to another. Dialogue embedding takes place when the embedded dialogue is functionally related to the first one. We now give a brief presentation of some dialogue systems that are essential for accomplishing a concrete task.

1. Information seeking: When a user make a query, the system makes an attempt to extract enough information from the user as is needed to search for the required information.
2. Inquiry: The basic goal of *inquiry* is information growth so that an agreement could be reached about a conclusive answer of some question. The goal is reached by a incremental process of argumentation that employs established facts in order to prove conclusions beyond a reasonable doubt. In short, the aim is to acquire *more reliable knowledge* to the satisfaction of all involved. Inquiry is a cooperative type of dialogue and correct logic proofs are essential.
3. Negotiation dialogue: The task of negotiation dialogues is that the dialogue participants come to an agreement on an issue. Negotiation dialogues differ from many other user/system interactions because in a negotiation both parties will have their own goals and constraints.
4. Persuasion Dialogue: The goal of *persuasion dialogue* is for one participant to persuade the other participant(s) of its point of view and the method employed is to prove the adopted thesis. The initial reason for starting a persuasion dialogue is a conflict of opinion between two or more agents and the collective goal is to resolve the issue. Argument here is based on the concessions of the other participant. Proofs can be of two kinds: (1) to infer a proposition from the other participant’s concessions; and (2) by introducing new premises probably supported by evidence. Clearly, a process of learning (e.g., knowledge update/belief revision) takes place here.
5. Problem-Solving dialogue: In a problem-solving dialogue, both participants collaborate with the common goal of achieving a complex task. A problem-solving dialogue may involve all the other types of dialogue, i.e., information seeking, inquiry, negotiation and/or persuasion sub-dialogues.

III.2 Argumentation and Negotiation in E-Learning

Learning can be considered as an ongoing argumentative process [23]. It is the process of determining and generating acceptable arguments and lines of reasoning underlying assumptions and bodies of knowledge. Learning can be regarded as an activity that encourages knowledge creation through mechanisms such as belief revision, conceptual change, self-explanations and reflection [23].

We believe that there is a relation between knowledge construction and argumentation in (collaborative) learning situations. Collaborative argumentation allows learners to articulate and negotiate alternative perspectives regarding a particular task. In learning contexts, learners may need to assess the information they receive critically, considering the problem or question under discussion. Various perspectives can be discussed and/or elaborated upon by the use of critical argument [34]. Learners can verify information when they do not fully understand information which they have received.

When learners disagree regarding previously stated information by their E-Tutor or another learner, they can use challenges. Challenging information means that the learner poses questions which are aimed at triggering justifications.

IV. Knowledge Representation for E-Learning

Information, Knowledge and expertise are essential ingredients in an E-learning system in order to competently exchange the appropriate knowledge/information, handle learning tasks, provide innovative approaches to solve problems and evaluate the consequences of decisions and actions. Hence, there is a need to investigate how knowledge can be acquired/generated and how it can be represented so that different applications can make optimal use of it according to what is needed. There is a need to capture appropriate experts' knowledge/wisdom in many forms such as text, sounds and images in order to be presented to the student in various media formats such as PowerPoint slides, images and narratives.

Knowledge/information should also be accessible and understandable to various levels and types of students users who need different types of knowledge/information to perform their learning tasks. The emphasis should be on a Knowledge Representation (KR) that is open to:

(C1) assessment to ensure that there is an adequate understanding of the knowledge/information in the application and for inspection/verification processes. Continuous monitoring and evaluation may help to decide whether there is a need for revision, update and learning new knowledge/information.

(C2) modification to allow an update of the knowledge/information as needed to meet the requirements of the applications and the needs of students and learning objectives.

It has been said in [22] that:

"We need additional research to expand the use of artificial intelligence and knowledge based systems in Knowledge Management (KM). We need to know what forms of knowledge representation appears to work best for particular types of knowledge/information ".

These objectives can only be realized with knowledge, if it is appropriately represented and intelligently manipulated. This requires a broad view of the different roles that a KR could play, bearing in mind that its central role is capturing the complexity of the real world. We believe, following [5], that a KR can offer:

(KR1) A description, of the world, which enables a reasoner to determine the consequences by reasoning about it.

(KR2) A set of ontological commitments which could form a basis for defining the appropriate ontologies.

(KR3) A (possibly incomplete) theory of intelligent reasoning, expressed as:

- (i) the representation of fundamental conception of intelligent reasoning
- (ii) the set of inferences the representation sanctions.
- (iii) the set of inferences it recommends.

(KR4) A means of communication.

(KR5) A method for efficient computation.

Furthermore, representation and reasoning are entangled. The recognition that a (particular) representation embeds a (possibly incomplete) theory of intelligent reasoning encourages diversity because what the reasoning theory, embedded in one representation, may have ignored or overlooked, would be emphasized in the reasoning theory of another representation. Hence, diversity could be a step towards completeness if an integrative approach to KR is employed. By combining representations within a unified reasoning theory, good use of both the similarities and differences could be beneficially exploited.

We may distinguish, along another dimension, between a static (possibly timeless) representation of knowledge, which is particularly useful for knowledge re-use and a dynamic representation of knowledge needed for knowledge creation. The degree of adaptability of an E-Learning system is dependent upon its capability of sensing complex patterns of change in the reasoning environment(s) and using that information for adapting the appropriate knowledge to guide decision-making processes and actions.

The dynamic view is based upon the ongoing re-interpretation of data, information and assumptions while pro-actively deciding how the decision-making process should be adjusted to deal with future possibilities. It also allows for diversity of interpretations of the same information across different contexts and at different times. Allowing for diversity in representing the same situation is one of the keys to success in properly managing and making an optimal use of the knowledge available. The diversity of representations allows for a deeper and a better understanding of the different patterns and characteristics of a situation, and naturally supports cooperative work.

Effective cooperation is essential in learning situation which:

(1) allows the transfer (e.g. exchange between a E-Tutor and a student), and combination ((e.g. exchange between student groups) different expertise.

(2) facilitates the application of multiple perspectives on a given problem.

Cooperative work is distributed in time, space and logic (control). The pattern of interaction and cooperation changes dynamically with the requirements and constraints of the situation.

V. A Model of Argumentation and Dialogue

The primary purpose of an E-learning system should be to make knowledge/information accessible and reusable by its different components whether human or software agents [22, 26]. The core of a E-learning system is an argumentation and dialogue model [21] that allows dialogue participants to communicate effectively; convey information, generate appropriate questions that express their learning needs, annotate responses (e.g., in the form of arguments) and judge their suitability and quality [16, 17, 7, 15]. The participating agents are expected to recognize their limitations, determine when they should seek help. For instance, a learner may decide to interrupt the flow of a lecture if she/he faces difficulty comprehending a concept. She/he may want to challenge a particular claim or statement in a lecture.

Agents are computational entities that have the ability to acquire and manipulate (modify, derive), through reasoning, knowledge [39, 40, 30, 20]. In this regard, the E-Tutor is a agent that may participate with a learner. We may have several E-tutors, each one is specialized in a particular topic or has a well well-defined role. These E-Tutors may collaborate among each other to provide an appropriate answer to a question posited by a learner. The E-Tutors may form groups of agents that can handle some particular types of queries or can deal with specific types of learners. We shall assume that agents are cooperative, abide by the rationality rules, such as rules of relevance, and they fulfill their commitments and obligations in a way that truthfully reflects their beliefs, intentions and/or desires and satisfies the learning objectives.

V.1 Reasoning with Incomplete Information

Since no agent has complete knowledge/information, it seems natural to employ a partial information state-based framework to model collaborative dialogue and argument between agents [14, 15, 18]. The basic idea that underlies the use of the notion of Partial Information State (PIS) is that it is useful to view dialogues in terms of the relevant information that the participants have at each stage in the dialogue.

The basic language, L_{NML3}, is that of a non-standard propositional logic. It consists of

(1) a set of propositional letters (e.g., $p_0, p_1, \ldots, p_k, \ldots$).
(2) the connectives "~" (negation), "&" (conjunction), "V" (disjunction) and "→" (implication)
(3) a modal operator, "M" (epistemic possibility).

Well-Formed Formulae (WFF) of L_{NML3} are given as follows:

(a) propositional letters are WFF
(b) if A and B are WFF then so are ~A, A&B, AVB, A → B and MA.

Nonmonotonic reasoning is represented via the *epistemic possibility operator* “M”. Informally, MA states that A is not established as false. Using M, we may define the operators “U” (*undefined*), “D” (*defined*) and ¬ (*classical negation*) where UA is true if the truth value of A is undefined and DA is true if the truth value of A is not undefined.

NML3 formalizes some aspects of revisable reasoning and it is both sound and complete [18, 19] .

V.2 Modeling Dialogue

We adopt the notion of a *dialogue game* in which two agents (an E-Tutor and a learner) interact with each other by making make moves in order to pass on *relevant* information with respect to their *goals*. The goal of the learner would be to acquire more reliable knowledge/information. She/he may ask many types of questions such as a question that could lead to the clarification of a concept, a technique or some evidence to support a particular claim. The role of the E-Tutors would be to address the learners’ questions. There are situations when the E-Tutors may need to ask questions in order to understand the intention of the learner.

It is important to note here that there are two types of interactions: (1) Learner with an E-Tutor and (2) an E-Tutor with another specialized E-Tutor or an agent that has some other role to play. The agents’ PIS change as a result of the interpretation of dialogue moves with other agents. These changes trigger the production of a succeeding move. The interpretation involves some *understanding* (ability to make sense or use of) the presented information. It does involve an *integration* of the offered information with the PIS of the receiver.

When agents interact among each others or with a learner, they do so in a context. We take a context to encompass all the relevant information that bears on the interpretation of the utterance on hand and on the information that is relevant to producing the goal(s). An agent can only interpret an utterance with respect to the knowledge/information it has available or it could access. Therefore, failure to complete the interpretation process/proof will point to those propositions which induce failure. Thus, part of a context is entirely local to the agent and dependent on what the agent could access and properly interpret. In this regard, a model of the user provides important relevant information to the communicating agent that could influence its answer given to a learner’s question. In other words, two learners who ask the same question may not receive the same answer.

The idea of a dialogue between a learner and an E-Tutor could be as follows: a learner may make a move to satisfy a particular learning goal which the E-Tutor can help with. It could be as simple as repeating a previous slide or video clip or as complex as some elaboration/clarification on the relationship(s) between two concepts. The effect of this move, after being interpreted by the E-Tutor, is that the E-Tutor’s information state may/will undergo some change. This move may initiate the legality of other moves which E-Tutor can employ as legal reply moves. For instance, if it is a request to repeat a previous slide or video clip show, the E-Tutor could make a request to the appropriate agent to do so. If it is more complex, the E-Tutor may need to ask for help from other specialized agents and the agents (E-Tutor with the other agents) may need to enter into a dialogue before an appropriate answer could be passed back to the learner.

The idea of a dialogue between agents may go as follows: a move by an agent G is generated on the basis of some enabling conditions which G needs in order to satisfy some goal(s). The effect of this move after being interpreted by the other participant G1 is that G1’s information state may/will undergo some change. This move may initiate the legality of other moves which G1 can employ as legal reply moves. It may also terminate the legality of some other moves and render them illegal reply moves. The initiation and termination of the legality of moves is a dynamic process. The legality of moves could partly be determined by a reply structure, i.e., a protocol.

Dialogue protocols provide a lower bound on the conditions needed for dialogue coherence.

In the next turn G1 may adopt the sender's role and, subsequently, its changed information state may lead to the inference of the enabling conditions for the next move. Dialogue relevance of subsequent moves is established by the initial information states of the participants, the update rules associated with each of the primitive types of dialogue moves locutions that change a particular PIS and the rules for cooperative behavior, by the participants. Dialogue coherence relations are mainly driven by dialogue history and the dynamics of the participants' PIS with respect to the main goal of the dialogue. The coherence of a dialogue moves is tied to local interactions that are dependent on the agent's particular situation reflected in the changes in its information states and intermediary goals judged by the agent to contribute towards the main goal. Thus, the reasoning abilities and specialized knowledge available to the agents do play an important role as they do capture the agent's problem-solving and strategic reasoning ability that may affect the selection of the most appropriate legal move.

Within the framework of NML3, it is possible to formalize dialogue moves and the rules of protocols of the required types of dialogue. The rules of a protocol are nonmonotonic in the sense that the set of propositions to which an agent is committed and the validity of moves vary from one move to another.

Let L_{Com} specifies the locutions which the agents participating in a dialogue are able to express or say to each other. We will assume that every agent has adequate understanding of L_{Com} and has access to a common ontology, so that the semantics of a message is the same for all agents. Every dialogue system specifies its own set of locutions. There are, however, several basic types of locutions which are used in many systems:

(1) Assert A: An agent G can make the move "Assert A" in one of the following cases:
  (A1) if A is derivable from G's knowledge base and its knowledge base is not inconsistent.
  (A2) A is not inconsistent with G's knowledge base and it needs some confirmation that another agent G1 that G1 accepts A or G1 could derive A from G1's knowledge base.

(2) Retract A: this move is a countermove to "Assert A". An agent G1 can only make the move "Retract A" as a reply to a "Assert A" move made earlier by another agent, say G. An agent G1 that makes the move "Retract A", in NML3, is not committed to "Assert ~A".

(3) Accept A: this move can be made by an agent G to signal that it accepts/concedes a proposition A. It has to be a reply to a previous "Assert A" made by another agent G1. An agent G can make the move "Accept A" if A is not inconsistent with its knowledge base, otherwise the agent knowledge will be subject to revision.

(4) Reject A: a countermove to "Accept A". It is important to note that in NML3, "Reject A" by G does not commit it to "Accept ~A".

(5) Question A: An agent G questions/asks from another, G1, for information concerning A (e.g., whether A is derivable from the knowledge base of G1).

(6) Challenge A: This move is made by one agent G, for another G1, to explicitly state that G1 has to provide a proof for (an argument supporting) A.

A dialogue consists of a course of successive utterances (moves) made by the dialogue participants. Let PM be the set of possible moves which agents can make in a dialogue. Let $PM_{\varnothing} = PM \cup \varnothing$ where $\varnothing$ stands for the empty sequence of moves.

A Dialogue Move (DM) $M \in PM_{\varnothing}$ can be defined as a 5-tuple as follows:

M = <ID(M), SEND(M), LOC(M), TOPIC(M), TARG(M)>
where

(DM1) ID(M), the identifier of the move M. (i.e., ID(M) = k indicates that M is the k^{th} element of the sequence in the dialogue).

(DM2) SEND(M) is the agent /dialogue participant that utters <δ(M), TOPIC(M)>.

(DM3) LOC(M) ∈ {Assert, Retract, Accept, Reject, Question, Challenge}.

(DM4) TOPIC(M) denotes the sentence which an agent/dialogue participant wants to communicate to the another agent participating in the dialogue.

(DM5) TARG(M) is the target of the move; the earlier move to which M is a reply. If M is the first move in a dialogue, then, TARG(M) = 0.

For instance,

M = <3, G2, Assert, "The value of Cost on the previous slide should be 25", 2>.

states that M is the 3^{rd} move in a dialogue where G2, asserts that "The value of Cost on the previous slide should be 25" and it is G2's reply to an earlier move M_2 made by another agent say G1.

Rules of Protocols of Some Types of Dialogue

Information-Seeking: Assume that the information seeker is agent G and the other agent is G1. The steps in a successful information seeking dialogue are as follows:

(IS1) G makes a *Question* move such as
  M_i = <i, G, Question, A, l>
  where M_l is a move made earlier by G1 and $l < i$.

(IS2) G1 replies with the move M_k where the identifier is k and its target is the move M_i, where $k > i$, as follows:
  (i) M_k = <k, G1, Assert, A, i> or

(ii) M_k = <k, G1, Assert, ~A, i> or
(iii) M_k = <k, G1, Assert, UA, i>.
UA means that for G1 the truth value of A is undefined.

(IS3) G either accepts G1's response using an *Assert* move or challenges it with a *Challenge* move. UA initiates an *inquiry* sub-dialogue between the agents or the information-seeking dialogue is terminated.

(IS4) G1 has to reply to a move "Challenge A" with a proof S using a move M_r = <r, G1, Assert, S, k> where S is a proof of A based on the knowledge base of G1.

(IS5) For each sentence B employed in the proof S, either G accepts B using a move such as "Assert B" or "Accept B" depending on whether it is derivable from, or it is not inconsistent with, its knowledge base. Otherwise, it may challenge B, in which case G1 has to provide a proof for B.

Inquiry. The following is an inquiry-protocol about a proposition A involving G and G1.

(Inq1) G seeks a support/proof for A. It begins with a move such as "Assert B →A" or "Assert B ⇒ A", for some sentence B if G believes that B →A or B ⇒ A should be derivable but it needs some confirmation and that will happen if G1 accepts the assertion. Otherwise, G will use a move such as "Assert UA".

(Inq2) G1 could reply following in one of the following ways:

(I1) accepts B →A or accepts B ⇒ A as appropriate using an "Accept" move. If an accept move is made, then either the inquiry terminates successfully or G could go on asking G1 to provide a proof for B. This case is similar to one where a student asks for a clarification regarding some issue.

(I2) accepts B →A or accepts B ⇒ A as appropriate, but G1 seeks a support/proof for B, i.e., it could reply with an "Assert" move that asserts E → B or asserts E ⇒ B, as appropriate, for some sentence E or a move that asserts UB.

(I3) challenges B → A or B ⇒ A as appropriate with a "Challenge" move.

(Inq3) If a challenge move is made as in step (I3) by G1, Then G has to reply to the challenge with an "Assert P" move that provide a proof derived from the knowledge base of G of the last proposition challenged by G1.

(Inq4) For every sentence C in P, G1 may either accept C with an "accept" move or may challenge it with a "Challenge" move.

(Inq5) When both agents accept A, the dialogue terminates successfully.

It is important to note that the agents could switch roles and either of them could seek a support/proof for a sentence or challenge a sentence when appropriate.

Persuasion. The following is a persuasion protocol where agent G is trying to persuade agent G1 to accept a proposition A.

(P1) G begins with a move where it asserts A.

(P2) G1 may reply with one of the following three moves:
(i) "Accept A"
(ii) "Asserts ~A"
(iii) "Challenge A".

(P3) There are three possibilities depending on G1' reply:

(1) If the answer of G1 in the previous step (P2) is (i), then the dialogue may successfully terminate.

(2) If the answer of G1 in the previous step (P2) is (ii) "Asserts ~A", then go to step (P2) with the roles of the agents switched and ~A is put in place of A..

(3) If the answer of G1 in the previous step (P2) is (iii) "Challenge A", then G should reply with a move that provide/asserts a proof P of A derived from its knowledge base.

(P4) If G has replied with a proof P of A, then for every proposition B employed in P, G1 may seek a proof/support from G1 (i.e., may invoke step P2 for B).

The use of PIS allows an agent to expand consistently its viewpoint with some of the propositions to which another agent involved in a dialogue is overtly committed.

V.3 Modeling Argumentation

The use of arguments allows agents to justify their decisions and actions, and to engage in different dialogues, and situations, and provide support for what they infer or decide. Arguments have an essential role to play in situations of conflict between communicating agents. They can be used by an agent to increase the degree of compatibility between its knowledge/beliefs and those of other agents; one agent can persuade another to adopt one or more propositions that it accepts by presenting proofs/support for those propositions. Arguments allow an agent to critically question the validity of information presented by another participant, explore multiple perspectives and/or get involved in belief revision processes. In an E-learning context, the learner could ask for a support or proof of a certain proposition in order to develop its knowledge of a particular topic. Depending on the learning setting and on the topic being learned, a leaner could use arguments to engage the E-Tutor in a dialogue in order to check her/his understanding of a particular concept/topic.

An Argumentation Framework (AF) system should capture and represent the constituents of arguments (e.g., the propositions which are taken into consideration). These may include facts, definition, rules, regulations, theories, assumptions and defaults. They can be represented as (possibly ordered) sets of formulae. It should also capture the interactions and reactions between arguments and constituents of arguments such as undercutting. Furthermore, some notion of preference over arguments may be needed in order to decide between conflicting arguments.

A proof method for the logic NML3 has been successfully implemented as an automatic theorem prover. The tableau method employed to implement the theorem prover allows an agent absolute access to every stage of a proof process. We believe that such access is useful for constructive argumentation.

VI. Conclusion

In this paper we have made a first step towards developing a multi-agent based model of argumentation and dialogue for E-learning. We have discussed the notion of a successful E-learning system and the need for communication, argumentation and dialogue in E-Learning. We have also discuss some of the aspects of knowledge representation for an E-learning system. We have finally presented a formal model of argumentation and dialogue.

The models treat dialogue participants as equal partners, i.e., each can take control of the dialogue, introduce new topics and so on. An Agent is assumed to be capable of reasoning about its knowledge and can easily be extended to make use of other agents' commitment sets and knowledge base. The system can easily be customized to handle problem-solving tasks which usually involve some degree of cooperation between the participants and a rather sophisticated argumentative and dialogue control mechanism.

The model is being applied to capture some learning activities with the aim of acquiring knowledge via collaborative argumentation and dialogue. On the argumentation side, it is worthwhile investigating further the subtleties of each type of dialogue in relation to different tasks and/or activities that may be accomplished by an agent, whether a leaner or an E-Tutor. We believe that it would be beneficial to further investigate and embed in the model strategic and tactic reasoning for rational communicating agents. On the logic side, there is a general tendency to consider inconsistency, in the theory of an agent G, to be a problem that concerns only G. However, in cooperative activities that involve more than one agent and in deliberation, inquiry and persuasion dialogue, it may be of interest to the other agents to know about, or minimally to be aware, of the way inconsistency is dealt with by G. Furthermore, in a context of *learning,* it matters to other agents, how G handles inconsistency or deals with exchanged information.

References

[1] F Alonzo, G Lopez, D Manrique, F Sorlano, E-Learning Instructional Approach with Learning Objects, 6th WSEAS International Conf. on E-Activities, 2007, 244-249.

[2] T. Bench-Capon, Specification and implementation of Toulmin Dialogue Game, In: *Proceedings of JURIX 98*, GNI, Nijmegen, 1998, 5-20.

[3] T. Bench-Capon, P. Leng and G. Standford, G., A computer supported environment for the teaching of Legal argument, *Journal of Information, Law, and technology (JILT)*, **3**, 1998.

[4] Z Biocca, and F Biocca, Building Bridges Across Fields, Universities and Countries: Successful Funding Communication Research Through Interdisciplinary Collaboration, Journal of Applied Communication Research, 30(4) 4, 2002, 350-357.

[5] R Davis R., Shrobe H. and Szolovits P., What is a Knowledge Representation? *AI Magazine*, 14(1), 1993, 17-33.

[6] D Garrison, T. Anderson. And W Archer, Critical thinking, cognitive presence and computer conferencing in distance education. *American Journal of DistanceEducation 15*(1), 2001, 7-23.

[7] E Ginters, I Cirulis and , V Akishin, Virtual Environment Use in E-Learning, 6th WSEAS Int. Conf. on E-Activities, 2007, 12-16.

[8] F. Grasso, A. Cawsey and R. Jones, Dialectical argumentation to solve conflicts in advice giving: a case study in the promotion of healthy nutrition, *International Journal of human computer studies*, **53**, 2000, 1077–1115.

[9] C. Haythornthwaite, and M. Kazmer, (Eds.). *Learning, culture and community in online education*, New York: Peter Lang, 2004.

[10] P. Kirschner and J. Van Bruggen, Learning and Understanding in Virtual Teams, *CyberPsychology & Behavior, 7*(2), 2004, 135-139.

[11] P. Knight, (Ed), *Assessment for Learning in Higher Education.* London: Kogan Page SEDA Series, 1995.

[12] N. Mercer, *Words and Minds: How we Use Language to Think Together.* London: Routledge, 2000.

[13] M. Moore, Theory of transactional distance, In: D. Keegan (Ed*.), Theoretical principles of distance Education* (pp. 22-38). London: Routeledge, 1993.

[14] A Moubaiddin and N Obeid, Partial Information Basis for Agent-Based Collaborative Dialogue, Journal of Applied Intelligence, Available Online: DOI [10.1007/s10489-007-0108-5], 2008.

[15] A Moubaiddin and N Obeid, Dialogue and Argumentation in Multi-Agent Diagnosis, In: *New Challenges in Applied Intelligence Technologies*, N T Nguyen and R Katarzyniak (Eds.), 2008, 3- 22, Springer.

[16] A Moubaiddin and N Obeid, Towards a Formal Model of knowledge Acquisition via Cooperative Dialogue, In: Proc. 9th Int. Conf. on Enterprise Information Systems, 2007, 13-22.

[17] A Moubaiddin and N Obeid, The Role of Dialogue in Remote Diagnostics, In: Proc. 20th Int. Conf. COMADEM, , 2007.

[18] N Obeid, Three Valued Logic and Non-Monotonic Reasoning, Computers and Artificial Intelligence*,* Vol. 15, No. 6, 1996, pp. 509-530.

[19] N Obeid, A Formalism for Representing and Reasoning with Temporal Information, Event and Change, Applied Intelligence, Special Issue on Temporal Uncertainty,, Vol. 23, No. 2. Kluwer Academic Publishers, 2005, 109-119.

[20] N Obeid, Towards a Predictive Multi-Agent Model-Based Diagnosis, *WSEAS Transactions on Systems*, 3(5), 2004, 2194-2200.

[21] N Obeid, Towards a Model of Learning Through Communication, *Knowledge and Information Systems,* Vol 2, 498-508, 2000, Springer-Verlag, USA.

[22] D O'Leary, Enterprise Knowledge Management, Computer, Vol. 31, 1998, 54–61.

[23] J. Petraglia, J., *The rhetoric and technology of authenticity in education,* Mahwah, NJ: Lawrence Erlbaum, 1997.

[24] R.M. Pilkington, Dialogue games in support of qualitative reasoning, *Journal of Computer Assisted Learning*, **14**, 1998, 308–320.

[25] R.M. Pilkington, and C. Mallen, Dialogue Games to Support Reasoning and Reflection in Diagnostic Tasks, In: P. Brna, A. Paiva and J. Self (Eds.) *Proceedings of the European Conference on Artificial Intelligence in Education*, September 1996.

[26] A. Ravenscroft and R. Pilkington, Investigation by Design: Developing Dialogue Models to Support Reasoning and Conceptual Change, Int. J. Artificial Intelligence in Education,11(1), 2000, 273–298.

[27] A. Ravenscroft, and Matheson 'Developing and evaluating dialogue games for collaborative e-learning', *Journal of Computer Assisted Learning*, 18, 2002, 93–101.

[28] A. Renniger and W. Shumar (Eds.), *Building virtual communities: Learning and change in cyberspace*, Cambridge: Cambridge University Press, 2002.

[29] L. Rourke, T. Anderson, R. Garrison and W. Archer, Assessing Social Presence in Asynchronous Text-based Computer Conferencing, *Journal of Distance Education,* 14(2), 1999, 50-71.

[30] G Rzevski, P Skobelev, Emergent Intelligence in Large Scale Multi-Agent Systems, Int. J. Education and Information Technologies, 1(2), 2007, 64-71.
[31] M. Scardamalia and C. Bereiter, Technologies for Knowledge-Building Discourse. *Communications of the ACM,* 36(5), 1993, 37-41.
[32] M. Scardamalia and C. Bereiter, Computer Support for Knowledge-Building Communities. *The Journal of the Learning Sciences,* 3(3), 1994, 265-283.
[33] M. Scardamalia and C. Bereiter, Student Communities for the Advancement of Knowledge. *Communications of the ACM,* 39(4), 1996, 36-37.
[34] A. L.Veerman and T. Treasure-Jones, Software for problem solving through collaborative argumentation, In: P. Coirier & J.E.B. Andriessen (Eds.), *Foundations of argumentative text processing* (pp. 203-230). Amsterdam University Press, 1999.
[35] A. L. Veerman, J. E. Andriessen and G. Kanselaar, (1999). Collaborative learning through computer-mediated argumentation, In C. Hoadly & J. Roschelle (Eds.), *Proceedings of the third conference on Computer Supported Collaborative Learning*, 1999, 640 - 650), Palo Alto, California: Stanford University.
[36] A. L. Veerman, (2000), *Computer-supported collaborative learning through argumentation,* Enschede: Print Partners Ipskamp. Available at: http://eduweb.fss.uu.nl/arja/
[37] D. Walton, Types of dialogue, dialectical shifts and fallacies, In: F. H. Van Emeren, R. Grootendorst, J. Blair, and C. Willard, editors, *Argumentation illuminated*, 1992, 133–147.
[38] D. Walton and E. Krabbe, *Commitment in Dialogue: Basic Concepts of Interpersonal Reasoning*. State University of New York Press, Albany, NY, USA, 1995.
[39] M Wooldridge and S. Parsons, Languages for negotiation, Proc. of ECAI, 2000, 393–400.
[40] N Zoghlami, S Hammadi, Organization and optimization of distributed logistics: estimation and patrolling approach based on multi-agent system, Int. J. Mathematics and Computers in Simulation, 1(1), 2007, 73-80.