A Multi-Agent Approach to E-Learning
1Asma Moubaiddin and 2Nadim Obeid

1Department of Linguistics, 
Faculty of Foreign Languages, 
The university of Jordan, Amman, Jordan.

2Department of Computer Information Systems, 
King Abdullah II School for Information Technology, 
The university of Jordan, Amman, Jordan 
obein@ju.edu.jo

Abstract: - Timely and appropriate Knowledge/information Communication between a tutor, whether human or a software agent, and a student is a prerequisite for successful E-learning activities. A successful E-learning model is expected to provide the E-Tutor with an insight of what students need and students with the knowledge, experiences and insights which they need to achieve their learning objectives. In this paper we make a first step towards developing an E-learning system. We propose a multi-agent system that assists in the process of E-learning. We discuss the notion of a successful E-learning system and the need for communication. We also discuss some of the aspects of knowledge representation for an E-learning system. We present a formal model of dialogue and argumentation.

Key-Words: - Knowledge, Information, E-learning, E-Tutor, Communication, Multi-Agent System, Knowledge Representation, Dialogue, Argumentation.

1 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 [15]. In fact, E-Learning practice has achieved some impetus and it may have some considerable effect on future education.

The employment of CICT have changed the way by which knowledge is exchanged. In this regard, a considerable amount of research and effort in e-learning initiatives is going on at the level of developing teaching material (courses, Powerpoint slides) and the required resources (web pages, online conferencing systems).

It may be necessary to note that there is a need for a system view on E-learning where the teaching/learning process is embodied in a system that encompasses a number of interrelated sub-systems that have to work together in harmony. In other words, the use of CICT does improve teaching/learning if both concepts are properly tuned.

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 students need and students with the knowledge, experiences and insights which they need to achieve their learning objectives.

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 dialogue and argumentation.

2 An E-Learning System
E-Learning involves the use of a number of CICT-based tools [1, 4,16] 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 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 students 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 a dialogue and argumentation framework between the knowledge brokers/agents. This should aim to facilitate communication between the E-Tutors and/or students.

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.

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.

3 Communication in E-Learning

Communication is an essential issue. It involves [2] 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.

4 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 [13] 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 [3], 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.


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 understanding of the different patterns and characteristics of a situation, and naturally supports cooperative work.

Effective cooperation is essential in learning situations which:

1. allows the transfer (e.g. exchange between an 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.

5 A Dialogue and Argumentation Model Framework for an E-Learning System

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 [13, 14]. The core of a E-learning system is a dialogue and argument model [12] that allows dialogue participants to communicate effectively; convey information, generate appropriate questions that express the needs of the represented groups, annotate responses (e.g., in the form of arguments) and judge their suitability and quality [7, 8]. 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 [17, 18, 15, 11]. 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-Tutor 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 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.

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 [5, 6, 9]. 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. We employ, for representing and reasoning about PISs, a three-valued based nonmonotonic logic, NML3 [9] which is both sound and complete. NML3 formalizes some aspects of revisable reasoning [10].

5.1 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. 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.

5.2 Need for an Argumentation Framework

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 context 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.

4 Conclusion

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

References: