Intelligence Explorer (IE): An Agent-Based Tool for E-Learning

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***Abstract*—Although the theory of multiple intelligences was developed several years ago, unfortunately, many educational based societies and institutions did not utilize the beneficial outcomes generated by the theory. The Intelligence Explorer (IE) is an agent-based tool that is developed to model cooperative complex interactions and hence provides valuable measurements of various intellectual characteristics, recommends possible improvements in particular intelligent category and thus offers guidelines and future career-based decisions. The tool was implemented using JADE, a FIPA compliant platform.**

Keywords— multiple intellegence; cooperation; agent technology; E-learning

I. INTRODUCTION

The goal of E-learning is to facilitate education and learning through the use of the state-of-art available technologies. It is arguable evident that the E-learning new approaches and initiatives become explosive, unprecedented, amazing and disruptive as well. The widespread growth of these approaches has clearly contributed to enhance learners' intelligence. However, the word "intelligence" has been prone to many misconceptions.

For example, a common old understanding is that people with high math grades are considered to be intelligent, while students who show other gifts do not receive the same recognition. However, this view does not contain the wide variety of abilities that humans display. The theory of "multiple intelligences, MI" [2] claims that all humans have multiple intelligences that can be strengthened or weakened. Dr. Gardner appointed seven intelligences: Verbal-Linguistic, Mathematical-Logical, Musical, Visual-Spatial, Kinesthetic, Interpersonal and Intrapersonal Intelligences.

Although the theory was developed several years ago, many societies do not take its benefits as a measurable guideline. The academic institutions that implemented the theory have reported considerable improvements in various educational aspects. The issue is that the theory should have a greater popularity and acceptance among people especially the educators.

A thorough survey was conducted in the College of Information Technology in the United Arab Emirates University to test people's knowledge on critical-decision-making venues. Interestingly enough, the surveys' results confirm the importance of having a tool that can advise about the different aspects of multiple intelligences and the possible improvements guidelines. Many people wonder about the right criteria to follow when taking important decisions such as choosing the track, a suitable career, the best learning style, a research area, or other matters that are related to the intelligences that each person possesses.

It was clearly evident from the survey's statistics that people need to be more aware about the fact that each person has different kinds of intelligences that need to be explored, thus might be strengthened and enhanced.

In this paper, we present the "Intelligence Explorer, IE" which is a tool that is fully designed and developed to allow different users who possess various competences and abilities to explore the seven types of intelligence by examining their capabilities and accordingly provides appropriate feedbacks about the measured intellectual levels.

As a result, the tool recommends and suggests possible improvements and outlines the levels that possibly need more attention. Section 2 discusses the MI theory, exhibits the relationship between the theory and the E-learning paradigm and the potential impact on the E-learning activities. Related work is discussed in section 3, the proposed architecture and design is illustrated in section 4. Implementation directions are presented in section 5 and finally the work results are discussed and the concluded in sections 6 and 7 respectively.

II. MULTIPLE INTELLEGNECE DEFINED

A. An overview of the Multiple Intellegence Theory

The theory initially described seven basic intelligences. They are [14]:

- "Linguistic intelligence: demonstrating abilities with spoken and written language".
- "Logical-mathematical intelligence: the capacities to analyze problems logically, carry out mathematical operations, and investigate issues scientifically".

- "Musical intelligence: skill in the performance, composition, and recognition of music, patterns or rhythms".
- "Kinesthetic intelligence: using the body or parts of the body to solve problems; learning by doing".
- "Spatial (or visual) intelligence: interpreting, recognizing and using visual cues such as images and charts and the ability to perceive objects in space".
- "Interpersonal intelligence: the ability to understand the intentions and motivations of other people. It allows people to work effectively with others".
- "Intrapersonal intelligence: the capacity to understand oneself, appreciating your own feelings, fears and motivations".
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B. *The MI and E-learning*

As the current accessible trends of the online services provided by the Internet and the Web have become more available, vast number of individuals has increasingly become familiarized of using these services as invaluable means of education and learning.

Accessing online educational services doesn't mean that all users astonishingly learn in the same way. There is no reason why multiple intelligences theory should not be catered for the E-learning paradigm.

The strong bond between E-learning and MI theory provides a well artifact means for various types for mutual collaboration. For instance and given the wide range of different types of online activities, the Web encourages collaborative work and hence supports learner's specific learning styles.

We believe that the MI theory becomes more understandable and fruitful when applied to practice. E-Learning designs and products often include many of the multiple intelligence-based activities that in many cases are not especially unique. It is noteworthy that E-learning systems could not only support the teaching and learning process, but also rather support intelligence interaction among collaborative participants in dynamic and heterogeneous environments. However, applying an MI perspective to learning activities ensures that learners have the chance to optimize their experience based on their individual MI strengths.

It is noteworthy that one of the biggest challenges in E-learning is to grant learner some degree of autonomy and independence in performing education based activities.

III. RELATED WORK

The growing complexity of contemporary societies does not allow us to reduce this process to a matter of sharing information, rules, and goals. This is because information, rules, and goals are created and modified in the same process. Different methods have been proposed in the managerial literature to deal with this complexity (e.g., business process reengineering, organizational learning, empowerment, knowledge workers and professionals, and network organizations).

Despite their relevant differences, all of these methods agree on the necessity of enhancing performance effectiveness, learning capability, and communication competence of individuals and groups.

Different agent based approaches were proposed for E-learning systems [1][5][9].

Another approach focuses on providing on course selection recommendations based on the user's stated preferences [3]. In [6] the approach discusses some basic applications of semantic web and agent-based technologies that are geared towards the adaptation of E-learning systems. In [11] the blackboard agent architecture is used.

Other approaches focus on personalizing resources based on learner's potential, evaluating the learner's performance, offering feedback to the tutor and reliable query-response system that would improve the efficiency of E-learning environments [12] [13].

A broad range of numerous technologies supports e-Learning interactions were proposed in the literature. Web conferencing, online chats, blogs, discussion boards, interactive games, and Internet resources are among the online options available to instructional designers. Many of these solutions have the assumption that the computations take place with the existence of a completely trusted third party. Additionally, none of the above-mentioned approaches have treated the multiple intelligent as an architectural element within the E-learning systems.

IV. PROPOSED ARCHITECTURE AND DESIGN

A. *Modelling E-Learning Environment*

The dynamic nature of the entities participating in E-Learning scenarios requires that they are able to change their configuration according to their designated roles. In such environments, an application is usually constituted of geographically distributed and decentralized entities that engage in various complex interactions.

As shown in [10], we strongly believe that "agent-orientation is an appropriate design paradigm for providing coordination services and mechanisms in such settings. We define an agent as an individual collection of primitive components that provide a focused and cohesive set of capabilities. We focus on the notion of agenthood as a metaphorical conceptualization tool at a high level of abstraction (knowledge level) that captures, supports and implements features that are useful for distributed computation in open environments. These features include cooperation, coordination, interaction, as well as intelligence, adaptability as well as economic and logical rationality". [10]

B. *The Cooperative Agent (CA)*

Each part of the seven intelligence categories is modeled as an agent (called the cooperative Agent, CA), which is viewed as an entity that possesses knowledge and capability. The capability itself consists of problem solver, communication and interaction components; on the other hand, the knowledge

includes the self-model, other agent models and the domain actions. The agent's components in the proposed architecture are modeled as Unified Modeling Language (UML) packages that are possibly nested as shown in Figure 1. Each package contains an interface that is realized by its set of public classes.

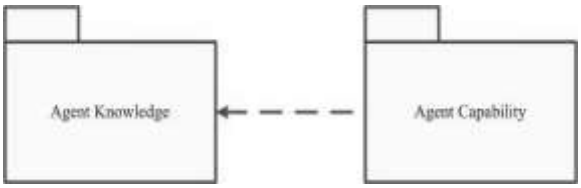

Fig. 1. Agent's Architecture

The capability package includes communication, reasoning and domain action components. The communication capability allows the agents to exchange messages with the other elements of the environment, including users, agents and objects. The communication component of the agents is equipped with an incoming message inbox, and message polling that can be both blocking and non-blocking, with an optional timeout. The reasoning component is further decomposed into the problem-solver component and coordination component.

The problem solver component inherent three main parts: (1) *Skills*: which includes the characteristics that match a specific kind of intelligence, (2) *Careers/typical roles:* which includes a list of suggested careers or suitable roles in the life that are more appropriate to the person's measured intelligences and (3) *Test:* which includes several questions to help the user to know the degree of his/her of the tested kin of intelligence. The design of relevant intelligence modules was designed as per the following:

- "Linguistic: Conversation-style scenarios with the utilization of additional information pop-ups, crossword puzzles, online discussion boards, email, or online chats".
- "Logical-mathematical: The tool exhibits problem-solving activities, which are arranged carefully to test multiple various skills. This includes arranging the steps in a diagram or finding out the correct answer using a series of clues and representations or using mathematical and logical diagrams such as Venn diagrams, charts, graphics or tables that encourage analysis of information in a logical manner".
- "Musical: mnemonics were used to solidify learning for individuals with musical intelligence. Audio sounds and music that are relevant to the learning were included as well as the possibility of musical transcripts for those learners who prefer to read instead".
- "Kinesthetic: the tool provides interactive drag and drop interactions, matching activities, and games that challenge hand-eye coordination to kinesthetic learners to explore virtual environments and perform activities that require them to get physically involved.
- "Spatial (or visual) intelligence: Using graphics and images to back up the information. The tool asks involved users to choose the correct image that represent the answer to a particular question".
- "Interpersonal intelligence: using well-constructed scenarios stimulates this kind of intelligence. The user is asked to act upon a real-life scenario by either generating a relevant decision or providing advice accordingly".
- "Intrapersonal intelligence: Intrapersonal intelligence focuses on the internal aspect to learning and using reflective exercises to engage these individuals by asking them to think about how they can apply what they've learned to their specific circumstances".

The CA capability component (problem solver) recommends the beneficial course of actions that can strength specific learner's level intelligence. The CA uses data mining techniques (association rules mining) to build a user's personal model based on the generated test results and accordingly suggests topics, subjects and online resources relevant should improve their skills competence.

C. *The Interface Agent(IA)*

The interface agent's (IA) is a domain-specific agent that acts on behalf of the user. It receives the user's requests, queries, and answers and directs them to the relevant corresponding CA. Note that the interface agent fulfills the user's preferences and assigns the appropriate test level needed, methods of testing and forwards back the result along with the possible recommendations or guidelines to the user. The interface agent builds up a knowledge base for users (self-profile) and dynamically stores the relevant conducted test results for each user to be used for future evaluations and comparisons.

V. IMPLEMENTATION

The tool was developed as a distributed power network using coordinated intelligent, rational agent (CIR-agent) model [10] by using JADE [4], which is a software framework to develop agent-based applications in compliance with the Foundation for Intelligent Physical Agents (FIPA) [8] specifications.

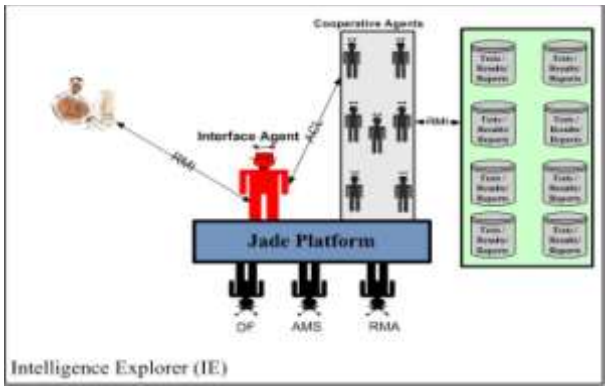

Fig. 2. Implementation Architecture

As shown in Figure 2, a dedicated, autonomous and cooperative agent receives a test request and consequently selects the applicable test scenario that fulfills the request's

preferences implements each corresponding intelligence type. Upon completion of the conducted test, the agent evaluates the user responses and assesses them based on the results monitors the corresponding status of the substation operation.

Agents communicate by formulating and sending individual ACL (Agent Communication Language) messages. The consumer and service provider agents register their presence and their capabilities along with the preferences parameters. The communication component is implemented as a set of classes that inherit the *jade.Core.Agent* and *jade.lang.acl.ACLMessage* existing classes of the jade platform. These classes provide means to construct, send and receive messages via several FIPA performatives such as REQUEST, INFORM, INFORM-DONE, QUERY-IF, etc. The messages exchanged in the interaction protocols are implemented as per the structure defined as FIPA ACL Messages specifications [7]. Each message contains a set of one or more message elements. The elements vary according to the interaction scenarios; the only element that is mandatory in all ACL messages is the performative, although most of the ACL messages will also contain a sender, receiver and content elements. The communication component utilizes the Jade class ACLMessage which implements an ACL message compliant to the FIPA ACL Message Structure Specification.

Agents are able to get contents and set the content of a particular message by overriding the methods *setContent* and *getContent*.

Each Agent manages its own database (implemented using MySQL DBMS), which contains users' profile, users' responses and answers, previous users' results that are classified for ranking purposes, and the test questions along with weighted score of a related skill. Ten questions that are randomly generated are available in every test.

The user has the option of viewing previous test results and thus prints the associated report, the rank or may conduct a particular test. Four qualitative evaluation classifications are used as follows: excellent, good, satisfactory or non-satisfactory.

Another feature provided by the tool is the comprehensive test ability in which the user can conducts all kinds of intelligences in one session. The interface agent's problem solver component coordinates all interaction pasterns with the cooperative agents (CA) by utilizing a set of Jade behavior classes (*simpleBehaviors* and *cyclicBehaviors*) that handle the incoming and outgoing messages.

The cyclic behavior class equips the CA agent with ability to check for test requests, notifications and result conditions. Once the compressive test is completed, the user will be able to view all his/her intelligences' evaluations sorted from the highest to the lowest one.

A "*complete later*" possibility is also available for those users who prefer to interrupt the test session and continue it on a later time. In this case the corresponding agent will update the knowledge component and store any relevant information accordingly.

VI. DISCUSSION

Fifty eight randomly selected participants with various levels of inherent skills (both genders) were asked to use the tool and conduct the comprehensive test. All participants were given an oral description of the tool and its associated procedures prior to performing any test. Upon completion of the test, the participants were asked to provide feedbacks about the accuracy of the result with respect to the participants'' conceptual understanding, knowledge and kind of intelligences they possess.

Very interesting findings were obtained. An interesting result shows that most of the participants (78%) were not able to recognize their various types of skills. One important result is that the majority of the participants (76.4%) have strongly agreed that the generated results were a true reflection of their own capabilities and skills and 18.6% believe that the results indicate partial indication. Around 88% of the participants have agreed that the tool has successfully identified the areas of weakness that need to be worked on.

VII. CONCLUSION

The main objective of the work presented in this paper has been directed to provide a fundamental utilization of the multiple intelligence theory in E-learning. In this paper, we have proposed an agent-based tool that provides seamlessly coordination solutions and presents intellectual educational evaluations of the multiple intelligences inherent in human species. By addressing the directive guidelines generated by the tool, learners can improve each kind of intelligence.

Architecturally, the architecture is viewed as a layer of services where different interaction patterns can take place. Each intelligent category is modeled as an agent with a specific architecture and an interaction protocol that is appropriate to support a required level of intelligence.

The tool has provided very noticeable results in increasing the level of motivation and interest for various types of learners and has facilitated collaborative learning abilities.

We believe that the tool is very beneficial in academic and professional domains in the sense that it exposes various people with different skills to realize the inherent level of intelligence and consequently can be considered as a valuable assist to:

- Help people to know their highest intelligences, improve their weaknesses and accordingly take the appropriate decisions.
- Inform parents about their kids' intelligences in early ages.
- Assist businesses and industrial firms to accordingly select employees with the suitable talents and capabilities that fulfill the requirements of a particular job.

By utilizing the Agent-Oriented paradigm, the multiple theory perspectives are is modelled at a high level of abstraction, in which the environment is viewed collectively as a coherent universe of interacting and collaborative agents and

consequently provides high degree of decentralization of capabilities, which is the key to system scalability and extensibility

In conclusion, there are many resources that provide considerable amount of information; however, these resources tend to be very sophisticated with many inherit complexity. The IE is a user-friendly, reliable and easy to use tool that can be utilized by different stakeholders.

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