International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 3
***Article Received:** 02 January 2023 **Revised:** 12 February 2023 **Accepted:** 02 March 2023*

Development and Integration of Multiagent Systems in 3D Virtual Environments

Vijay Kumar Gumasa[1]
Research Scholar, Department Of Computer Science & Engineering, Faculty of Engineering & Technology,
Dr. A. P. J. Abdul Kalam University Indore, MP, India

Dr. Manoj Eknath Patil[2]
Research Guide, Department Of Computer Science & Engineering, Faculty of Engineering & Technology, Dr. A. P. J. Abdul Kalam University, Indore, MP, India
[1]vijay.gumasa@gmail.com ,[2] mepatil@gmail.com

***Abstract*:** The development and integration of multiagent systems in 3D virtual environments represent a significant advancement in the field of artificial intelligence and interactive simulations. This research focuses on designing and implementing a robust multiagent framework within a dynamic 3D virtual world, enabling realistic and autonomous interactions between agents and their environment. By leveraging advanced AI techniques and state-of-the-art 3D rendering technologies, the system provides an immersive experience with high levels of accuracy and interactivity. Key aspects of this work include the architecture of the multiagent system, the methods for agent communication and coordination, and the strategies for optimizing performance in a 3D space. The results demonstrate enhanced scalability, flexibility, and realism, making the framework suitable for various applications such as virtual reality simulations, gaming, training programs, and educational tools. This study underscores the potential of combining multiagent systems with 3D virtual environments to create sophisticated, interactive, and scalable simulations.

Keywords*: 3D,Multi-user Virtual Classroom, Virtual Museu, 3D Video Chat Room*

I. INTRODUCTION

The concept of utilizing the Internet as a learning platform holds significant appeal, especially for its convenience and cost-effectiveness, allowing individuals to attend classes from their homes. Many academic institutions globally offer online courses to enhance their curricula. Despite the proliferation of online courses, a common drawback is the perceived lack of social presence and awareness among students.

In contrast, modern service industries heavily rely on advanced technologies and skilled personnel to operate in a globally connected environment. Service skills, unlike basic scientific and technological knowledge, cannot be effectively taught in traditional classrooms without practical application. These skills often include soft skills requiring service staff to interact with stakeholders, understand the service environment, and respond to various requests based on priorities and consensus.

A 3D virtual environment, created from a computer database using computer-aided design (CAD) software, offers an immersive and interactive experience by simulating a three-dimensional space. This environment, known as a 3D Virtual Learning Environment (3DVLE) when used for educational purposes, utilizes multi-user virtual environments (MUVE) to engage students in educational tasks. Students navigate these virtual spaces, interact with digital artifacts, and use avatars for representation, facilitating real-time communication and collaboration.

Advancements in software and hardware technologies have led to increased adoption of 3D Virtual World (3DVW) technologies, which are beneficial for creating interactive and immersive learning experiences. Numerous institutions have started incorporating virtual worlds into online education, offering dynamic feedback, personalized task selection, and opportunities for creativity and social interaction. These environments help dissolve social boundaries, reduce anxiety, and enhance motivation and engagement, aligning with the learning preferences of the millennial generation.

Among various 3DVW platforms, Second Life has emerged as a popular tool for collaborative online education. Universities such as Harvard, Texas State, and Stanford have established virtual campuses within Second Life, allowing students to meet, attend classes, and create content together.

The current generation of learners, accustomed to immersive and interactive multimedia applications, finds MUVE environments particularly effective for experiential learning. MUVEs are ideal for synchronous learning among geographically dispersed groups, facilitating concrete experiences, reflective observation, abstract conceptualization, and active experimentation.

Two primary approaches to MUVEs are the virtual classroom and the fantasy world. The virtual classroom replicates a traditional classroom environment, often using platforms like Second Life, though with mixed results. Some users find Second Life challenging and not engaging, especially those who enjoy social software or gaming scenarios.

Multiagent Systems (MAS) enhance the learning environment by providing autonomous, flexible agents capable of observing and interacting within a distributed system. MAS can be designed with dynamic architectures, allowing for real-time adjustments. In educational contexts, MAS technology is applied in Intelligent Tutoring Systems (ITS) and Interactive Learning Environments (ILE), addressing the need for more intelligent tutoring systems. Pedagogical multiagent systems, such as teacher and student agents, can serve as guides, information retrieval assistants, and support systems within 3D virtual learning environments. These systems offer benefits such as interactive learning experiences, instant feedback, competitive engagement, collaboration, and self-paced progress.

The integration of New Information and Communication Technologies (NICT) is increasingly prevalent, particularly among Generation Z, who are adept at using technological devices. Traditional teaching materials are becoming obsolete for these students, who prefer digital presentations and mobile devices. Incorporating NICT in education enriches the teaching-learning process by offering learning opportunities beyond the classroom, such as remote laboratory experimentation and 3D virtual worlds. These technologies provide alternatives for schools lacking physical laboratories and promote autonomous, unrestricted learning.

In the school context, there is a continuous search for resources that facilitate knowledge construction and appropriation. Developing Virtual Learning Environments (VLE) with engaging and interactive features, such as 3D Virtual Worlds, is essential for enhancing the educational process. This paper aims to present the use of remote experimentation and 3D virtual worlds as complementary tools in the teaching and learning process.

II. LITERATURE SURVEY

S. Bronack, et al [15] utilized a social constructivist framework analysizing 3D virtual world learning environment is unlike traditional classroom- or web-based learning environments in many important ways, students should be provided more choices within the 3-dimensional world, should be aided to construct individual paths through the virtual world .

A. De Lucia, et al.[8] presents a virtual campus created using Second Life which provides four distinct types of virtual space: common student campus, collaborative zones, lecture rooms and recreational areas, they argued that, in a 3D multi-user virtual environment, learning is strongly related to the user perception of belonging to a learning community, as well as to the perception of awareness, presence and communication. They conducted an experiment involving university students aiming at evaluating Second Life synchronous distance lectures in the proposed learning environment which results are very positive.

D.C. Cliburn and J.L. Gross et.al [9] described quasi-experimental pretest-posttest comparison groups design to compare the experience of a Second Life lecture to a real world lecture, found that those who attended the real world lecture performed significantly better on a posttest quiz than those who attended the same lecture in Second Life., commented that students encountered many difficulties, such as problems viewing the lecture material, and a lack of constraints on avatar behavior in the educational setting.

P. Dev, et al[14] reported a project of developing and evaluating a computer-based simulator (the Virtual Emergency Department) for distance training in emergency medicine residency programs teamwork and leadership in trauma management which aimed not only to manage trauma effectively but also not needing practice on live patients.

L. Jarmon, et al [7] suggests that 3D virtual worlds can be well suited for experiential learning environments, they use mixed research methods of journal content analysis, surveys, focus group, and virtual world snapshots and video, empirically examines the actual instructional effectiveness of Second Life as an experiential learning environment for interdisciplinary communication.

C. M.Itin, et.al [12] describes that experiential learning is the process of making meaning from direct experience, focuses on the learning process for the individual. It engages the learner at a more personal level by addressing the needs and wants of the individual. According to this definition, we design a story script for the learning service in Second Life.

Bellifemine, F. L., Caire, G., and Greenwood et.al.,[3] described integrate a multiagent system developed on the

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 3
***Article Received:** 02 January 2023 **Revised:** 12 February 2023 **Accepted:** 02 March 2023*

Java Agent Development framework (JADE) (jade.tilab.com) with Open Wonderland (OWL), an open source 3D virtual world developed by SUN (www.openwonderland.org). JADE is the best-known and most widely used platform that supports FIPA (the Foundation for Intelligent Physical Agents) messaging [22]. Open Wonderland is a 100% Java open source toolkit for creating collaborative 3D virtual worlds. JADE is also a 100% Java open source toolkit. Since both JADE and Open Wonderland are Java toolkits, integrating these two technologies would not suffer from problems of cross platform issues.

Table-1 Literature Review Table

S.No	Author(s)	Year of Publication	Key Finding	Research Gap
1	S. Bronack, et al.	[15]	Utilized a social constructivist framework to analyze 3D virtual world learning environments, highlighting the importance of providing students with choices and aiding them in constructing individual paths through the virtual world.	Lack of empirical data on the effectiveness of individual paths and choices in virtual world learning environments.
2	A. De Lucia, et al.	[8]	Created a virtual campus in Second Life with four types of virtual spaces, finding that learning is enhanced by the perception of belonging to a learning community, as well as awareness, presence, and communication. Positive results from evaluating synchronous distance lectures in this environment.	Limited exploration of long-term effects and scalability of the virtual campus model.
3	D.C. Cliburn and J.L. Gross, et al.	[9]	Compared Second Life lectures to real-world lectures using a quasi-experimental design, finding that real-world lecture attendees performed better on posttest quizzes. Noted difficulties with viewing lecture material and avatar behavior constraints in Second Life.	Need for improved interface design and behavioral constraints in virtual lecture settings.
4	P. Dev, et al.	[14]	Developed and evaluated the Virtual Emergency Department simulator for training emergency medicine residents in teamwork and trauma management, effectively reducing the need for practice on live patients.	Further research needed to assess the long-term impact on skill retention and real-world application.
5	L. Jarmon, et al.	[7]	Suggested that 3D virtual worlds are suited for experiential learning environments, using mixed research methods to empirically examine the instructional effectiveness of Second Life for interdisciplinary communication.	Requires further investigation into the effectiveness across different disciplines and varying educational contexts.
6	C. M. Itin, et al.	[12]	Described experiential learning as making meaning from direct experience, focusing on individual learning processes, and designed a story script for learning services in Second Life.	More comprehensive studies needed to validate the designed story script and its impact on learning outcomes.
7	Bellifemine, F. L., Caire, G., and Greenwood, et al.	[3]	Integrated a multiagent system developed on the Java Agent Development Framework (JADE) with Open Wonderland (OWL), highlighting the compatibility and advantages of using Java-based toolkits for creating collaborative 3D virtual worlds.	Further development and testing required to address scalability and real-world application scenarios.

III. Design and Implementation of the Living in 3D Virtual world with Multiagent Systems

The first application has focused on virtual museum of history and culture. One of the most important challenges for teachers is the incorporation of a great number of foreign students who do not know the history and culture of the country. A virtual world has been built up to improve the historical knowledge of these students. The user can walk though this world selecting the objects in the scene (Figure 1). After selecting an object, its name is shown and its pronunciation can be heard. In this way, students obtain progressive learning based on the comprehension and knowledge of history and culture.

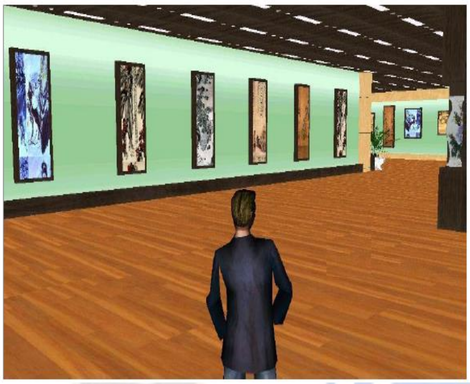

Fig.1: Snapshot of the virtual museum

The application has been developed using a database that identify basic objects(eg: poem, picture) and actions(eg: run, read). Each record in the database has the following fields: Name of the object.

- Sound
- URL of the 3D representation of the object.

Once the database has been defined, these different objects have been built up. If enter this world, system will include all objects of the database in the environments.

Multi-user Virtual Classroom is the 2nd application has focused on virtual classroom. Virtual classroom system is a multiuser application based on the standard VRML. It allows several users to share a virtual world and to interact with it as they would do in a mono-user world.

Open Wonderland is client/server architecture, whereas the JADE platform is used to create peer-to-peer systems. The link between these two separate architectures lies in the interface. The interface is actually a modified Open Wonderland module to which code has been added to start a JADE agent. The JADE agent is started via a runtime call, therefore the agent will be started on the local computer. However, the rest of the agents that make up the multiagent system (MAS) can be on other computers in the network. The agent started by the Open Wonderland module will communicate with the rest of the JADE agents using the FIPA specified protocol. One of the agents in the JADE/MAS communicates back to the Open Wonderland world by sending messages to a TCP port that has been activated on another Open Wonderland module, the Poster module.

System architecture of Virtual Classroom

The system has two parts clearly differentiated (Figure2):

· A server program that runs on a machine that acts as a Web server. The VRML and HTML files defining the world reside in this server.

·The client software is a Java applet which uses EAI (External Authoring Interface) to communicate with the VRML browser plug in that the client uses (Explorer, Netscape, etc).

The user generates two types of events through the interaction with the virtual classroom: local events, these only concern to our local world, and remote events, that are transmitted through the network to the Web server which distributes them to all the clients. These remote events offer information on the actions that other users are making in the classroom.

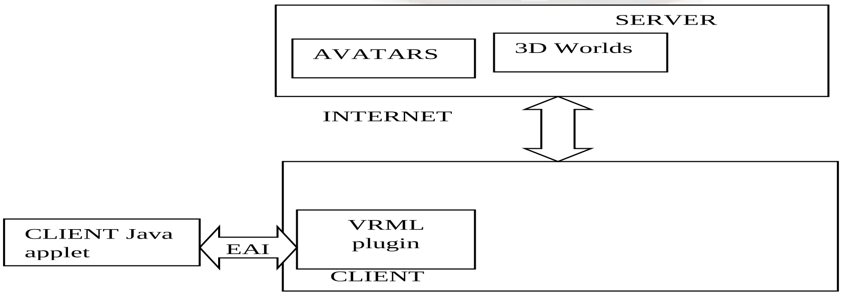

Fig.2: System Architecture Of Virtual Classroom

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 3
***Article Received:** 02 January 2023 **Revised:** 12 February 2023 **Accepted:** 02 March 2023*

Implementation of Virtual Classroom:

The world built up in this application simulates a multi-user classroom. The virtual classroom was designed as accurately as possible to emulate a real one, and the users are represented as avatars. Each avatar can interact with the others and share its experiences (Figure 3).

Specific objects have been added to the classroom, with which the user can interact: a blackboard, a laser Pointer and a slide projector.

The blackboard: It is possible to write and draw on it with some basic primitives such as: lines, circles, rectangles and ellipses. The colour of these primitives can be chosen by the user.

Fig.3: Snapshot of the virtual classroom

The blackboard: It is possible to write and draw on it with some basic primitives such as: lines, circles, rectangles and ellipses. The colour of these primitives can be chosen by the user.

· The slide projector: It works on a list of predefined images that the user can visualize in a sequential way.

· The laser pointer: It allows the users to point either in the slides or in the blackboard.

In this way, it is possible to focus the other users on this point of the classroom. This application has been developed using VRML 2.0 and the node extensions and the multi-user functionality provided by the system.

The last developed applications create a 3D virtual world where a user group can communicate by a video chat service. In that environment, each user has an own 3D representation or avatar. The application allows the user to walk through the world and to communicate with the different avatars using a video chat service.

System architecture of 3D Video Chat Room: The system has client-server architecture. The user executes a Client application that is fundamentally in charge of the visualization and the communication with two server applications. One of these servers holds the positions of all the avatars (Avatar Location Server), and the other manages the video chat service (Chat server). The system architecture is in Figure 4.

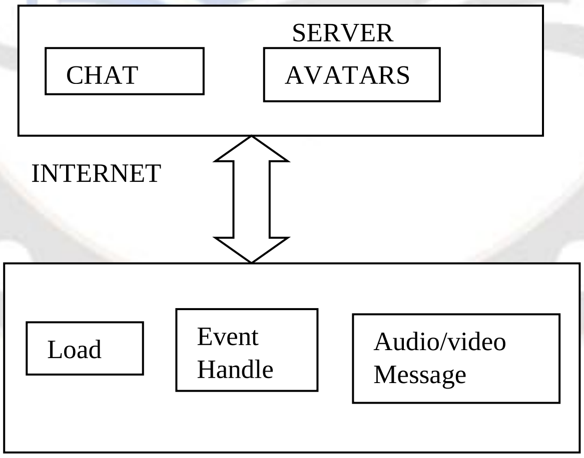

Fig.4: System Architecture Of 3D Video Chat Room

- Chat Server. We use a telnet video chat service.
- Avatar Location Server.

The server monitors the state of each client (nickname, position, orientation, time) and communicates this information to the other clients. The pseudocode of this server is :

In this pseudocode:

1. initialize_server() sets up the server and prepares it to handle client connections.
2. on_client_connect(client) handles new client connections, adding their data to client_list and broadcasting the updated list to all clients.
3. on_client_update(client) updates the state of an existing client and broadcasts the changes.

4. on_client_disconnect(client) removes the client's data from client_list upon disconnection and broadcasts the updated list.
5. broadcast_to_clients(client_list) sends the current state of all clients to each connected client.
6. find_client_data(client) retrieves the data for a specific client.
7. remove_client_data(client) removes a client's data from the list.
8. main() runs the main server loop, handling connections, updates, and disconnections.

- Client application.

The client is in charge fundamentally of the world visualization. It manages the communication with the servers in order to show the success of the video chat. It draws the avatars in their positions.

The client always maintains two states for each avatar: the state at the moment and the new state. When the avatars are drawn in the world, they are placed in a position that interpolates both states in order to obtain a continuous visualization.

Communication management is handled without using blocking communication calls. In this way, the application is simplified because it is not necessary to use threads.

The avatars have two types of animations, the movement animation and the animation that happens when the avatar is quiet. The transition from one animation to another depends only on the speed of the avatar and is solely managed by the client. Implementation of 3D Video Chat Room: In order to construct the application, a game engine has been used. This type of software incorporates the recent advances developed in the field of real-time rendering. In this way, it is possible to design more realistic environments with a great number of visual effects. BS Collaborate Server has been chosen from among the available game servers for the following reasons:

·It is a public domain server (GNU Library General Public License).

· Open source.

·Multi-platform: MacOS Classic, MacOS X, UNIX, Windows, Linux, Irix, FreeBSD, NetBSD, and Solaris among others.

· Good rendering quality either in software or in hardware mode.

· OpenGL and DirectX support.

· In continuous development and maintenance.

The world used in our application is one of the example worlds in the BS Collaborate Server. The avatars have been imported from the user's "avaters" files. The application environment is shown in Figure 5.

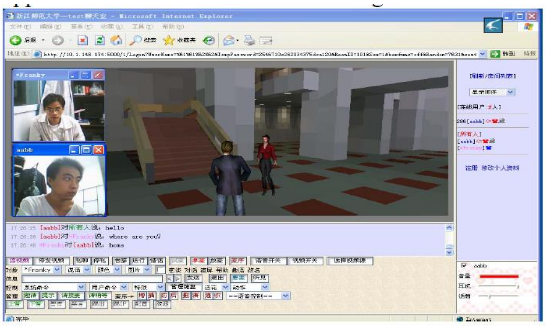

Fig. 5: A Scene Where Two Users Appear While They Are Video Chating.

In addtion, it is not necessary to have graphic acceleration in the computer to run this application, although it is recommended. But if everyone wants have a video chat, you need install a microphone and usb-camera.

IV. CONCLUSION

Utilizing virtual worlds for online teaching allows students to immerse themselves in engaging and interactive environments, enhancing the learning experience. These environments enable students to interact with the world in a realistic manner, making the learning process more enjoyable and effective. By combining the benefits of virtual worlds with the connectivity of the Internet, the learning process becomes more accessible and comprehensive. In these virtual worlds, students can learn individually by interacting with the computer, while multi-user virtual worlds facilitate interaction among users. This interaction enriches the learning experience by allowing students to share experiences and receive guidance from teachers.

While worlds created with VRML offer these advantages, using a game server to design these worlds can create even more realistic environments. Some game servers are open-source and public domain, enabling the incorporation of various desired technologies, which is not possible with VRML alone. Game servers offer modularity, and the applications developed can run on numerous platforms. However, these servers often lack proper documentation and present challenges in content generation for the environments. One of our current research directions is the enhancement and expansion of the educational applications discussed in this analysis. As students begin using these applications, their needs will be monitored, and the applications will be adjusted accordingly. For instance, the next step in the virtual classroom application is to specialize it for teaching Computer Graphics. To achieve this, 3D objects will be incorporated into the environment to teach various concepts of Computer Graphics. The 3D video chat application is designed with an open system to integrate new technologies in real-time rendering. In the future, this application will include a similar system to the virtual classroom, utilizing the latest techniques in virtual realism.

REFERENCES

[1] Molka-Danielsen, Judith; Panichi, Luisa; Deutschmann, Mats;"Reward models for active language learning in 3D virtual worlds "; Information Sciences and Interaction Sciences (ICIS); Digital Object Identifier: 10.1109/ICICIS.2010.5534711 Publication Year: 2010.

[2] Yin Bing; Lin Zhuying; Du Li; "The applications of Multi- Agent technology in distance education system "; Networking and Digital Society (ICNDS 2010, Digital Object Identifier: 10.1109/ICNDS.2010.5479221 Publication Year: 2010 , Page(s): 429 – 432

[3] Bellifemine, F. L., Caire, G., and Greenwood, *Developing Multi-Agent Systems with JADE (Wiley Series in Agent Technology)*.doi:10.3991/ijet.v5i3.1388; 2010, iJet Volume5, Issue 3, Page(s): 12-17

[4] Grieu J, Lecroq F, Person P, Galinho T, Boukachour H;"GE3D: A Virtual Campus for Technology-Enhanced Distance Learning" doi:10.3991/ijet.v5i3.1388; 2010, iJet Volume5, Issue 3, Page(s): 12-17

[5] Dutchuk M., Muhammadi K.A., Lin, F; "QuisMaster – A Multi-Agent Game-Style Learning Activity"; edutainment 2009; Page(s): 263-272

[6] Sancho, P.; Torrente, J.; Fernandez-Manjon, B.; "Do multi-user virtual environments really enhance student's motivation in engineering education "FIE '09. 39th IEEE Digital Object Identifier: 10.1109/FIE.2009.5350863 Publication Year: 2009.

[7] L. Jarmon, "Virtual world teaching, experiential learning, and assessment: An interdisciplinary communication course in Second Life," *Computers & Education*, vol. 53, no. 1, 2009, pp. 169-182.

[8] A. De Lucia, "Development and evaluation of a virtual campus on Second Life: The case of Second DMI," *Computers & Education*, vol. 52, no. 1, 2009, pp. 220-233.

[9] D.C. Cliburn and J.L. Gross, "Second Life as a Medium for Lecturing in College Courses," *Proc. System Sciences, 2009. HICSS '09. 42nd Hawaii International Conference on*, 2009, pp. 1-8.

[10] Xiao Laisheng; Wang Zhengxia; "Teaching Resource Grid System Model Based on Multi-Agent Distributed Expert System "; Computational Intelligence and Software Engineering, 2009. CiSE 2009; Digital Object Identifier: 10.1109/CISE.2009.5363001 Publication Year: 2009 , Page(s): 1 – 6

[11] Dos Santos, A.L.S.; Labidi, S.; Abdelouahab, Z.; "Information Filtering for a Collaborative Learning Environment: A Multiagent Approach "; Internet and Web Applications and Services, 2008. ICIW '08. Digital Object Identifier: 10.1109/ICIW.2008.101 Publication Year: 2008 , Page(s): 43 – 48

[12] C. Hong, "Service Design for 3D Virtual World Learning Applications," *Book Service Design for 3D Virtual World Learning Applications*, Series Service Design for 3D Virtual World Learning Applications, ed., Editor ed.^eds., IEEE Computer Society, 2008, pp.795-796

[13] Bellifemine, F. L., Caire, G., and Greenwood, D. 2007 Developing Multi-Agent Systems with JADE (Wiley Series in Agent Technology).

[14] P. Dev, "Virtual Worlds and Team Training," *Anesthesiology Clinics*, vol. 25, no. 2, 2007, pp. 321-336.

[15] S. Bronack, "Learning in the Zone: A social constructivist framework for distance education in a 3D virtual world," *Proc. Society for Information Technology & Teacher Education International Conference 2006*, AACE, 2006, pp. 268-275.

[16] De Melo, C.; Prada, R.; Raimundo, G.; Pardal, J.P.; Pinto, H.S.; Paiva, A.; "Mainstream Games in the Multi-agent Classroom "; Intelligent Agent Technology, 2006. IAT '06. IEEE/WIC/ACM Digital Object Identifier: 10.1109/IAT.2006.86 Publication Year: 2006 , Page(s): 757 – 761

[17] Fasli, M.; Michalakopoulos, M.; :Supporting active learning through game-like exercises "; Advanced Learning Technologies, 2005. ICALT 2005; Digital Object Identifier: 10.1109/ICALT.2005.247 Publication Year: 2005 , Page(s): 730 – 734

[18] Vassileva, J., Mccalla, G., and Greer, J. 2003. Multi-Agent Multi-User Modeling in I-Help. *User Modeling and User-Adapted Interaction* 13, 1-2 (Feb. 2003), 179-210.

[19] Gal A. Kaminka, Manuela M. Veloso, Steve Schaffer, Chris Sollitto, Rogelio Adobbati, Andrew N. Marshall, Andrew Scholer, Sheila Tejada; " GameBots: a flexible test bed for multiagent team research "; January 2002 Communications of the ACM , Volume 45 Issue 1

[12] C. M.Itin, "Reasserting the Philosophy of Experiential Education as a Vehicle for Change in the 21st Century," *The Journal of Experiential Education*, vol. 22, no. 2, 1999, pp. 91-98.