Original Article

Implementation of conceptual learning in STEM Technology for Higher education through JADE multiagent system

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Abstract

In the education system, teaching and learning takes place through various modes. In teaching mode, various types of strategies have been followed and in learning, various types of strategies have been followed. Generally, teaching and learning takes place in traditional modes and online modes where traditional methods of learning and teaching methods are used to share and acquire knowledge which helps the individual to organize and use a particular set of skills in the order to accomplish the task effectively and efficiently. In this paper, we focus to improve the learning capability of an individual through STEM Technology using Conceptual learning through the JADE multiagent system for better understanding of subject. In conceptual learning learner must remember less and understand more to relate different concepts. Conceptual learning encourages active participation since it requires students to participate actively in the process, whereas traditional types of learning require the teacher to explain information. The student is then expected to pay attention and practice the techniques while the dynamics remain unclear. However, when it comes to conceptual learning, both the student and JADE Multiagent play a key role; with the teacher providing tasks or difficulties that help students fully develop an idea. Thus, encouraging active participation of students. Through multiagent system, we have achieved high precision and recall.

1. INTRODUCTION

The reach of science and technology has significantly expanded in recent years. To explore information through innovation and creativity, unique teaching methodologies are required. The fundamental ideas of science and technology are explained using conventional teaching methods. Traditional methods result in unemployment and a weak global economy. This is why modern technology is used in the teaching and learning process. Hybrid learning models such as collaborative learning spaced learning, flipped classroom, Gamification, visual, audio, and kinesthetic learning are examples of modern teaching methodologies (VAK teaching). The pupils are divided into groups by the teachers during collaborative learning. This group of kids learns how to communicate with others while resolving their issues through questions, discussions, and arguments. With the help of these teaching techniques, students can learn how to collaborate and listen to others. It enables them to share their talent and

Knowledge. Teachers who use spaced learning will repeat a lesson several times and put some time in between each session. During this time, students can refocus their minds by engaging in physical activity. Students in flipped classrooms should review new information or content at home by watching video tutorials, conducting internet research, or using material that has been customized by the teacher. They practice in the classroom. Through the use of flipped classrooms, students are given additional time to study the subject. Through online self-learning, students are inspired to teach the subjects that interest them, and teachers encourage this by letting them acquire a thorough comprehension of concepts and come up with original ideas that will help their brains and learning abilities. Teachers use gamification to create projects that help students understand concepts. Puzzles, online tests, and puzzles are organized by teachers. Students pick up concepts through seeing, hearing, and feeling. In order to prepare the same content in three different formats, the teacher divides the class into three groups: kinesthetic learners, audio learners, and video learners.

STEM in higher education is achieved through modern teaching approaches. Science, Technology, Engineering, and Mathematics collectively comprise STEM. Through problem-based learning, STEM is an interdisciplinary strategy that helps students effectively complete their college degrees. STEM is defined as; Science is the study of the natural world, encompassing the physical, chemical, and biological laws of nature. Science is a process—scientific inquiry—that produces new information as well as a body of knowledge that has been gathered over time. Science-based knowledge influences the engineering design process.

Technology includes not only the actual technological items but also the entire system of individuals, groups, and institutions, as well as their associated knowledge, techniques, and tools. To fulfill their needs and desires, humans have built technology. Science and engineering are major contributors to modern technology, and both disciplines employ technological tools.

A body of knowledge about the planning and production of manufactured goods is referred to as engineering, and problem-solving techniques are also included in this field. Engineering design is governed by the laws of nature, or science, and takes into account factors like cost, time, and the availability of materials as well as ergonomics, environmental requirements, manufacturability, and reparability. Science, mathematics, and technology techniques are all used in engineering.

Mathematics is the study of patterns and connections in space, quantity, and number. Along with the claims, the logical arguments themselves are an element of mathematics. Like science, mathematics also continues to advance, but unlike science, unless the fundamental presumptions are changed, the field's body of knowledge remains stable. Science, engineering, and technology all involve mathematics.

STEM fields require significant conceptual learning understanding (Todd R. Kelley, 2016[1]). STEM education analyses barriers and establishes best practices. The conceptual framework of STEM education includes a thorough understanding of the complexity of how people acquire certain concepts through STEM. Conceptual learning refers to an integrated understanding of important concepts. STEM education incorporates conceptual knowledge by putting concepts in logical sequence and enables students to learn new concepts by combining them with previously learned concepts.

Conceptual learning is accomplished through classroom instruction, which is teacher-centric and emphasizes the main idea of the lesson. However, conceptual learning has been successfully achieved

Through current learning approaches that utilize STEM technology by grasping more concepts through video, audio, and brain games. Students may recall all of the principles and integrate them using prior knowledge of any subject.

The systematic process of concept analysis involves matching keywords to the idea being studied.

The website shows all content associated with the keyword match. Students cannot identify the appropriate domain-related documents. This can be done by using a multi-agent system in STEM education to apply the semantic relationship while searching content through ontology. Figure 1 shows the conceptual learning in STEM Technology for Higher education through JADE multiagent system

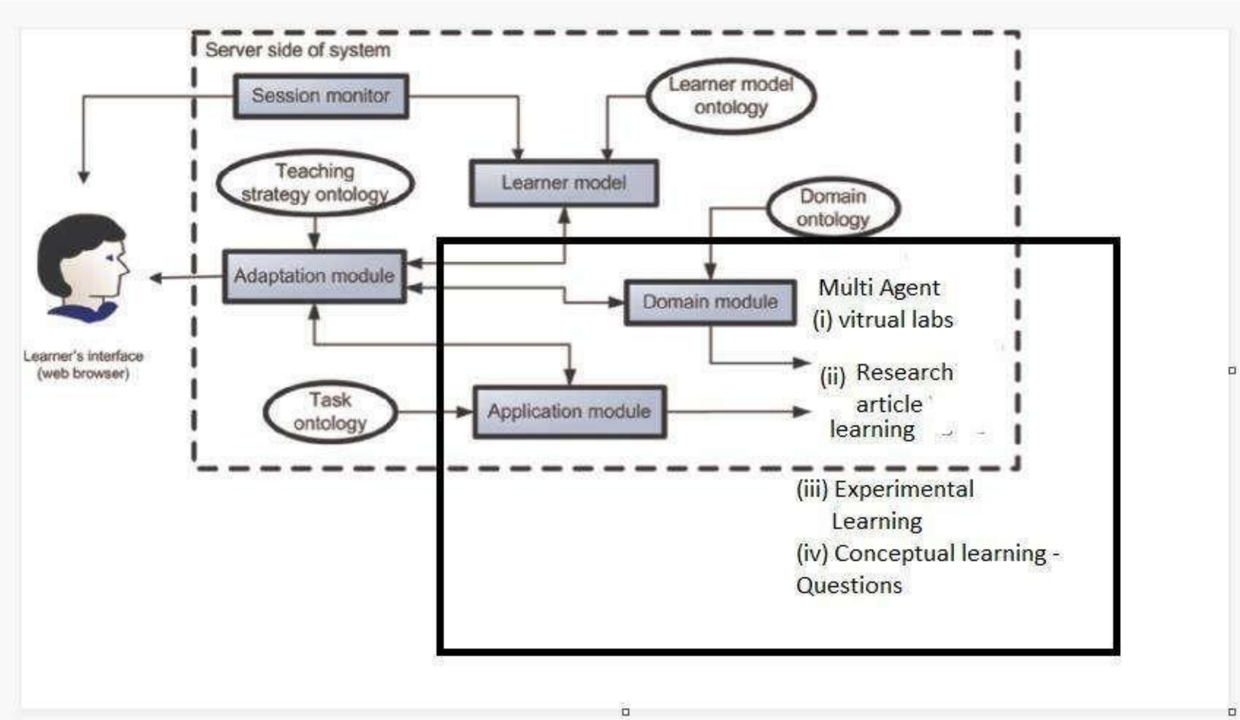


Figure 1 conceptual learning in STEM Technology for Higher education through JADE multiagentsystem

2. State of the Art Techniques

S.No	Author	Problem	Advantage	Disadvantage
1	Nada Abdullah Alrehaili [2]	Ontology based Higher Education System	The model is simple, scalable, extensible providing flexible structure to provide right source to teach acourse.	Maintenance problem, cost, Complexity in structure, decrease in performance over time.
2	Hien D. Nguyen(2020)[3]	Intelligent Problem-Solving Model	The model supports generality, usability,	ISP solves only general domain model.
			naturalness, formality.	
3	Farida Bou arab- Dahmani(2015)[4]	E-learning by doing Management System.	The model provides computational ontology.	Detailed ontology for sub domain should be included.

4	Mariela Tapia-Leon (2018)[5]	System developed to search research article in Scopus, Web of Science, and ACM digital Library.	The paper provides information about systematic study of various tools used.	More domain related operators needed to search the relevant document.
5	Valerity Khabarovsk(2022)[6]	Ontology based Service Oriented eco system in Railway transport	They include knowledge factory and multi agent System.	It is a system oriented Application.
6	Jan-Philipp Büchler(2021)[7]	Integrated case Method in Universities and Developing Ecosystem.	They follow Contextual case study approach.	
7	Sklavakis(2015)[8]	MATHESIS meta-knowledge engineering framework:	This model contains limited depth and breadth	The sub domain model needs to develop.
8	Jinyu ZHANG(2018)[9]	Multiagent Based Two way Negotiation for Hotel Reservation.	This model contains three agents such as Tennent and landlord agent, Data integrating and Result agent, Controller and selector Agent. The model supports dynamic Reservation automatically.	Communication mechanism need to be considered.
9	Dusan N.Sormaz(2018)[10]	A multiagent system for Distributed manufacturing Process planning.	The system contains two agents such as task Agent and service agent.	The model does not support semantic conversion database.
10	iliana Villa mar Gomez(2021)[11]	An ontology based knowledge management system with verbal Interaction.	Questions are formulated based on ontological assumptions.	Dynamic action should be included.
11	Lawrence Bunnell(2020)[12]	FinPathLight:	Personal financial recommender system for Ontology based multiagent	It is a system application

			Recommender system.	
12	J.Leo(2019)[13]	Ontology based Multiple choice questions.	The system selects multiple choice questions based on specification of case based questioning, Selecting suitable options in medical.	Statistical characteristics of questions are collected
13	Zouaoui Samia(2018)[14]	Multiagent ontology based smart School System	The model supports daily class room activity of students, based On ontological information.	Expand System towards automatically generating questions and answers from the lesson using context information.
14	Weiqin Chen[15]	Communication ontology	The model contains both domain and non-domain ontology for Communication model.	Multiple intelligent Agents should be included.
15	Dejan [16]Lavbič(2018)	Mobile communication system for supply of mobile phone Through Business Rules Management System.	The model minimizes the gap between agents to business system.	Little Technical Knowledge is required.

The review offered in this part demonstrates that an earlier ontology-based application model was constructed utilizing a relational model. The structured question was sent through the system with a single user. The majority of the application does not have exact relations on a certain domain. To fix the problem, they must create a sub domain, and the query must include operators such as AND, OR, and NOT. However, in a multiagent system, we can quickly add more agents whenever needed, and the procedure is also scalable, accessible, and parallelizable.

3. Methodology

A computerized system known as a "multiagent system" is made up of several communicating intelligent agents (Hu, 2021).[17] The MAS system handles an issue with several agents rather thana single agent. Three agents—an active agent, a passive agent, and a cognitive agent—make up the MAS. There are three kinds of agent environments: virtual, continuous, and discrete. This study emphasizes conceptual STEM education learning using a multiagent system and includes FIPA (Foundation of Intelligent Physical Agents) standards.

CSTEMMAS-Conceptual STEM Multiagent System

Ontology is a method of organizing concepts, information, and ideas in order to categorize and explain a certain topic in a domain-oriented environment. In today's educational system, STEM is a key component. Teachers convey information to students using a concept that is based on science, technology, engineering, and mathematics. The ontology-based multiagent system thus explains each idea. Figure 2 shows the architecture of a STEM multiagent system based on concepts.

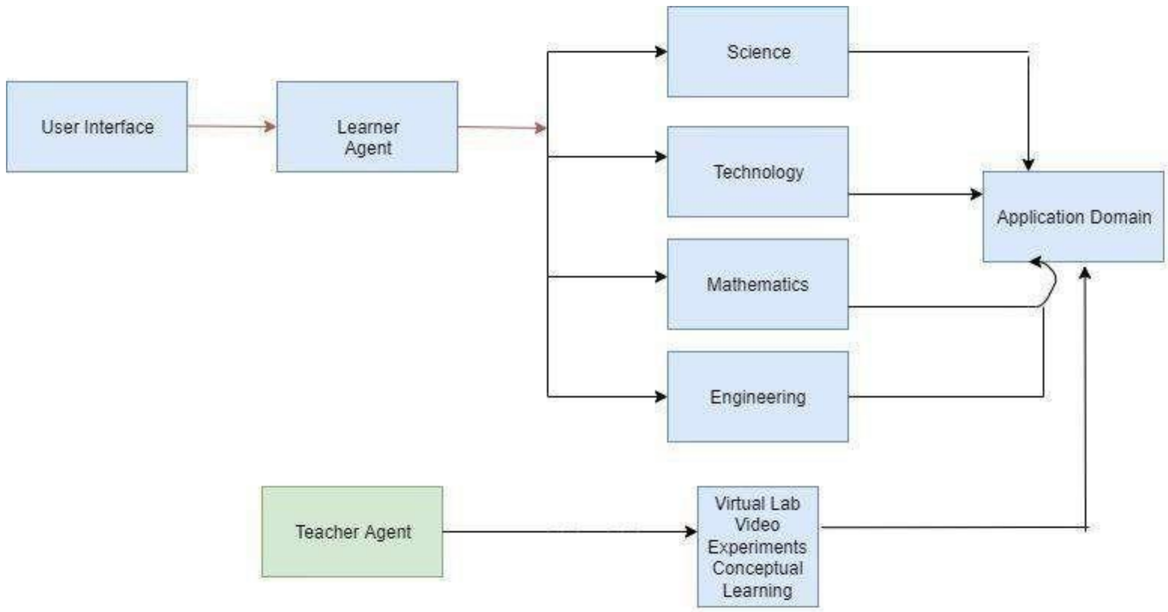


Figure 2. Proposed Architecture for CSTEMMAS

There are two agents in the architecture, a learner agent and a teacher agent. The learner agent lookup the keyword. It displays the matching domain if the keyword matches any domain. Following that, the instructor chooses which concepts to teach via videos, experiments, and conceptual learning. According to Figure 2, the CSTEMMAS architecture contains two agents. The learner agent refers to the STEM ontology, which follows the 6E+S model. The model describes as follows: engage, explore, explain, elaborate, evaluate, extend, and standards. The learner agent searches the term by using the prior knowledge, and the search engine investigates the keyword in the STEM (Science, Technology, Engineering, Mathematics) field. The keywords are thoroughly searched the content that is present in the particular domain based on the domain, and at last the keywords are evaluated the notion using a specific application. The learner agent does this activity as a one-time behavior. Each agent carries out the action using a variety of behaviors. The action is only taken once. The learner agent then sends the message to the instructor agent, who decides on the notion using any of the standards available, such as virtual lab, research paper, or experimental learning. Figure 3 represents ontology diagram of CSTEMMAS.

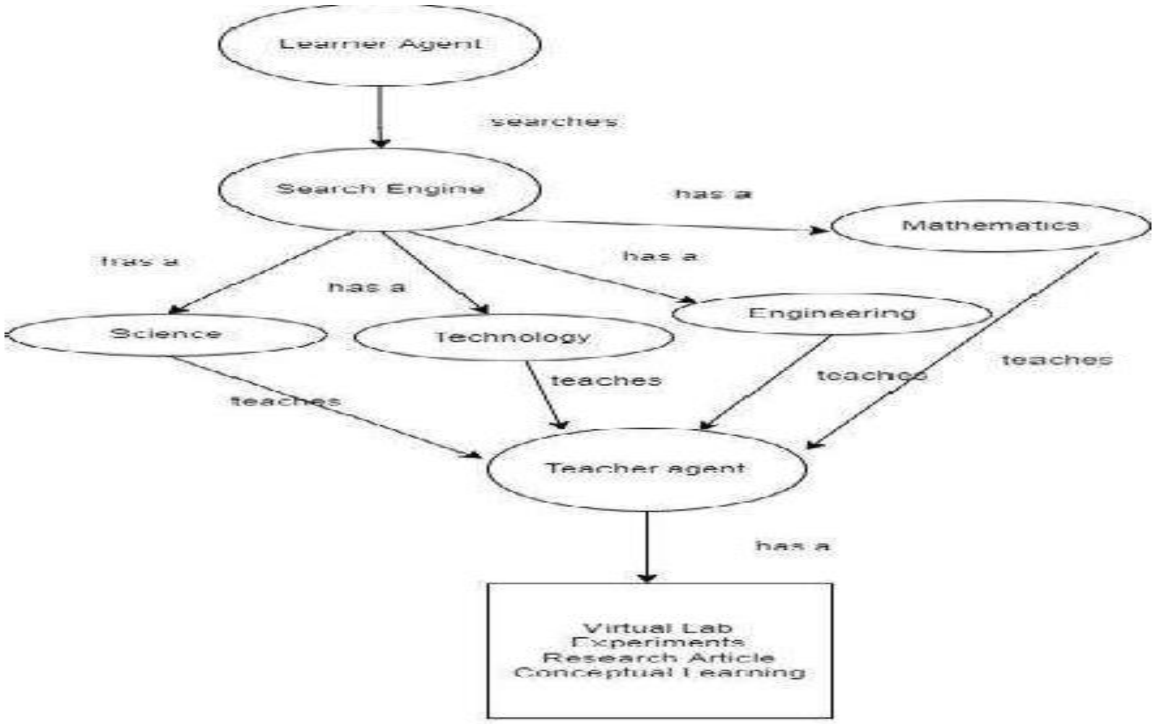


Figure 3-Ontology Diagram

4. Results and Discussions

Different keywords are provided in the CSTEMMAS and text-based retrieval systems to test the system. The results of the precision and recall of documents related to science, technology, engineering, and mathematics that were retrieved using a multiagent system built on an ontology anda text-based system are shown in tables 1 and 2.

$$Precision = \frac{TP}{TP + FP}$$

$$Recall = TP/(TP + FN)$$

Where,

TP-True Positive-Number of Documents Retrieved Correctly FP-False Positive-Number of Documents Identified Incorrectly

FN-False Negative -Number of Correct Documents Retrieved Incorrectly Table 1. Statistical Analysis of CSTEMMAS Model (Proposed)

Topics	**Precision**	**Recall**
Science	89	90
Technology	92	88
Engineering	94	92
Mathematics	96	95

Table 2. Statistical Analysis of Text Based Model [18] (Existing)

Topics	**Precision**	**Recall**
Science	82	87
Technology	86	89
Engineering	88	86
Mathematics	90	90

Table 3. Statistical Analysis of Multi-channel Convolution Neural Network approach [19](Existing)

Topics	**Precision**	**Recall**
Science	84	89
Technology	88	90
Engineering	85	84
Mathematics	92	92

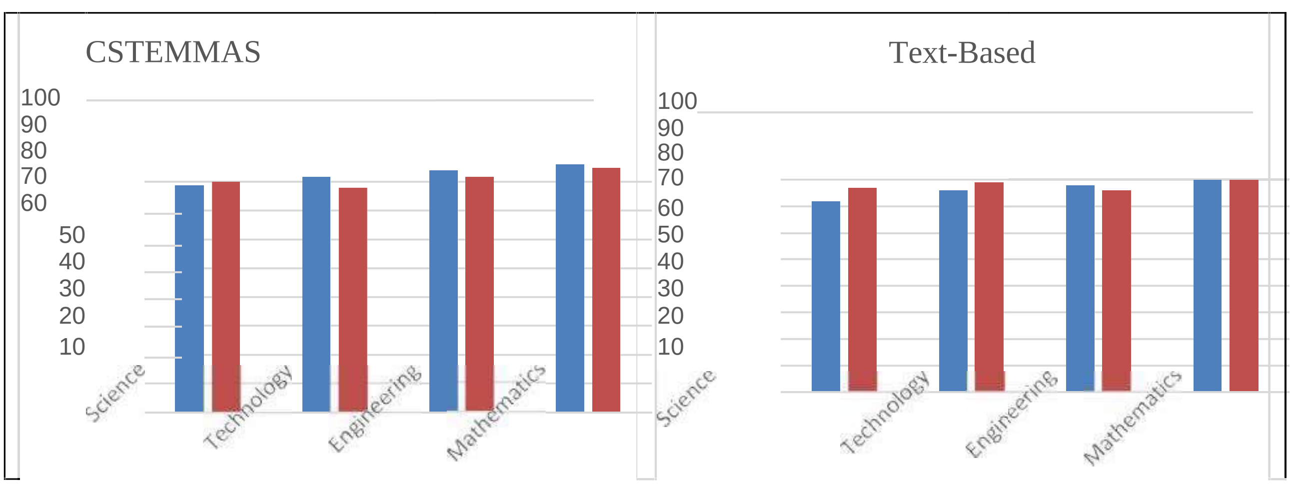
Table 4. Statistical Analysis of Monto Carlo Sampling Method [20](Existing)

Topics	**Precision**	**Recall**
Science	82	84
Technology	84	86
Engineering	83	82
Mathematics	86	86

In the fields of science, technology, engineering, and mathematics, there are 1078 documents. 258 documents in science, 250 in technology, 300 in engineering, and 270 in mathematics. In ontology- based CSTEMMAS, we have attained high precision recall. Table 3 describes precision and recall of Science, Engineering, Technology and Mathematics documents retrieved through the Multichannel Convolutional

Neural Network (MCNN). Table 4 describes precision and recall of documents obtained in Science,

Technology, Engineering and Mathematics by repeatedly generate the keywords based on term frequency factor. Figure 4 shows the statistical analysis of proposed and existing STEM Model.



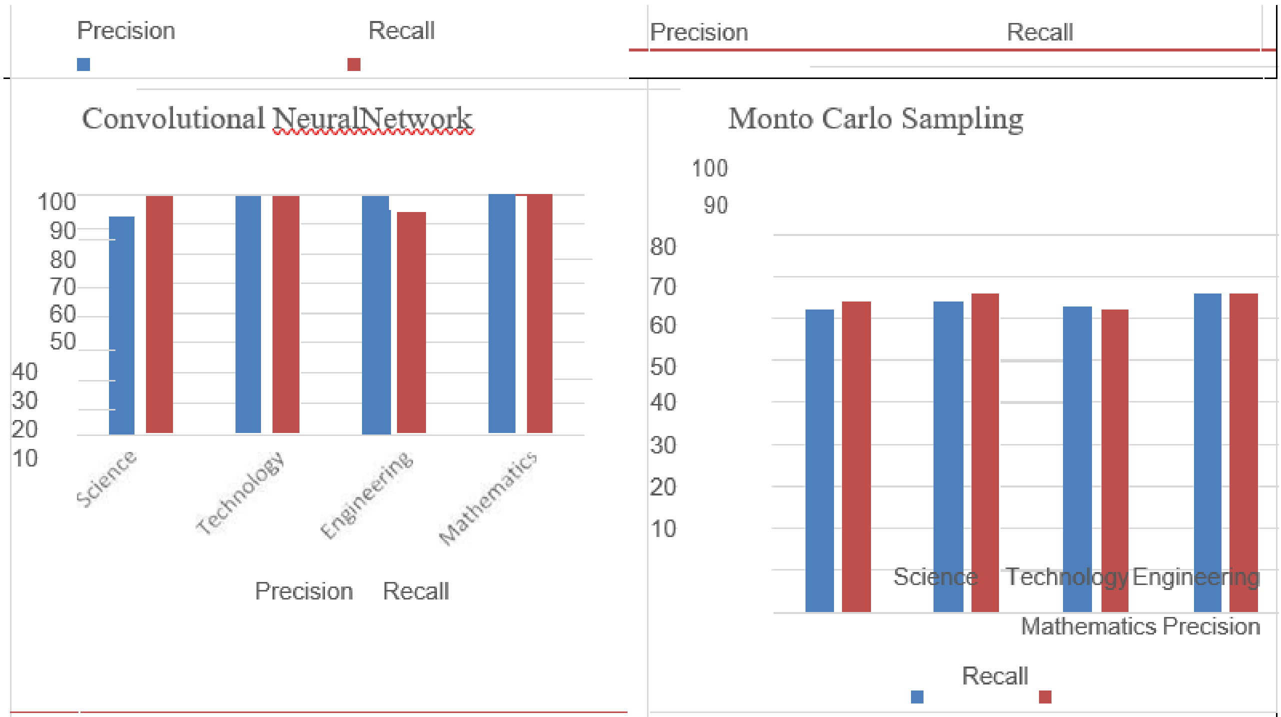


Figure 4. Statistical Analysis of Proposed and Existing System

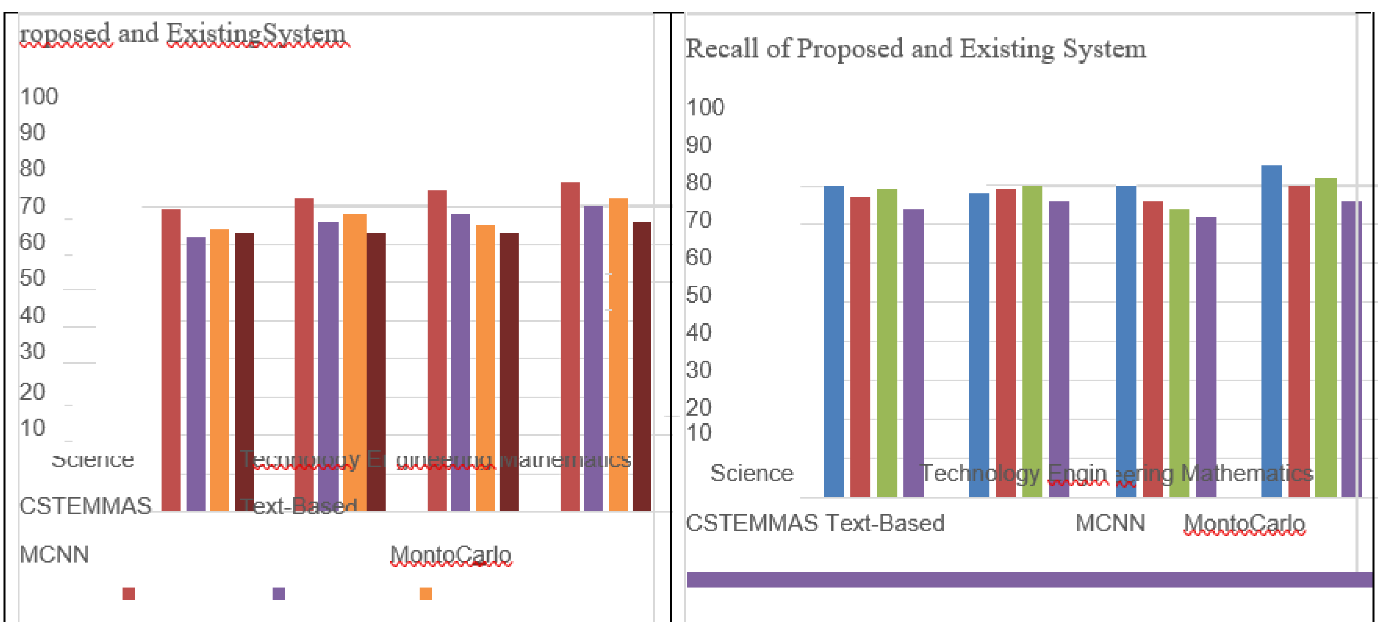


Figure 5. Precision and Recall of Proposed and Existing System.

Figure 5 shows precision and recall of ontology based conceptual frame work of proposed system and the proposed system achieves highest precision and recall for science (89%,90%), Technology (92%,88%), Engineering (94%, 92%) and Mathematics (96%,95%). Figure 6 and 7 shows the user interface of multiagent system.

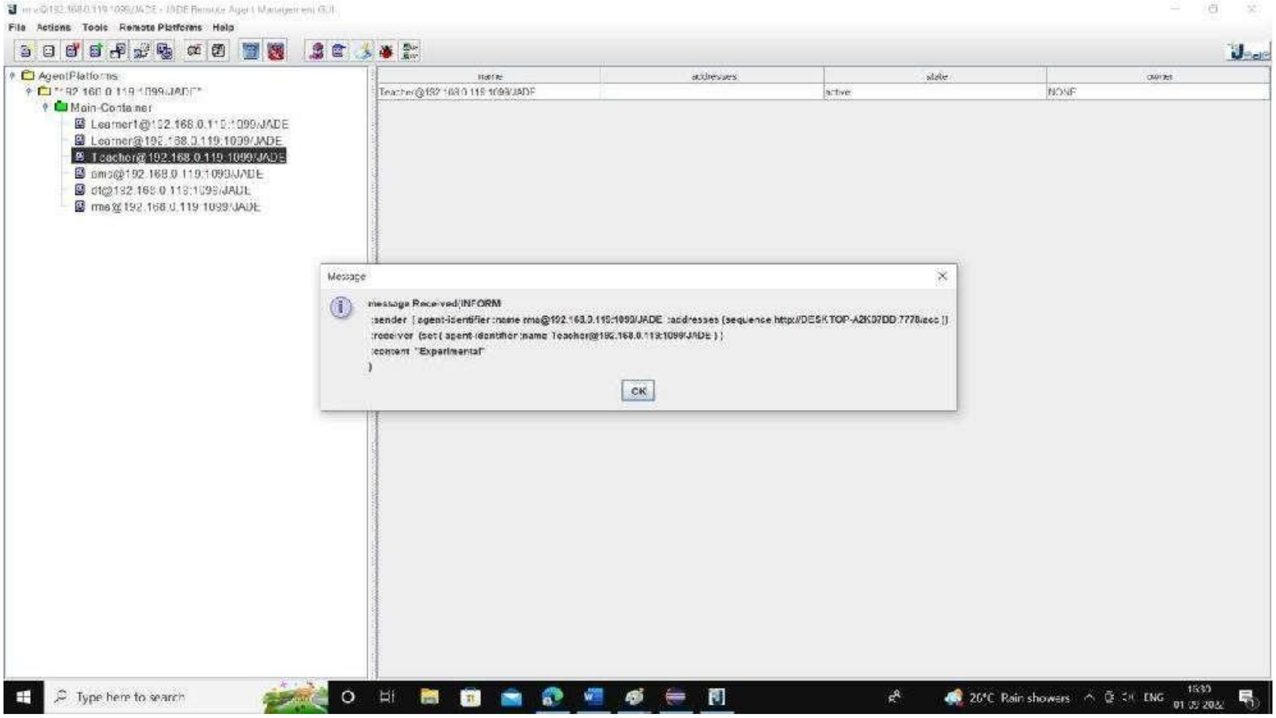


Figure 6. User Interface of Multiagent System

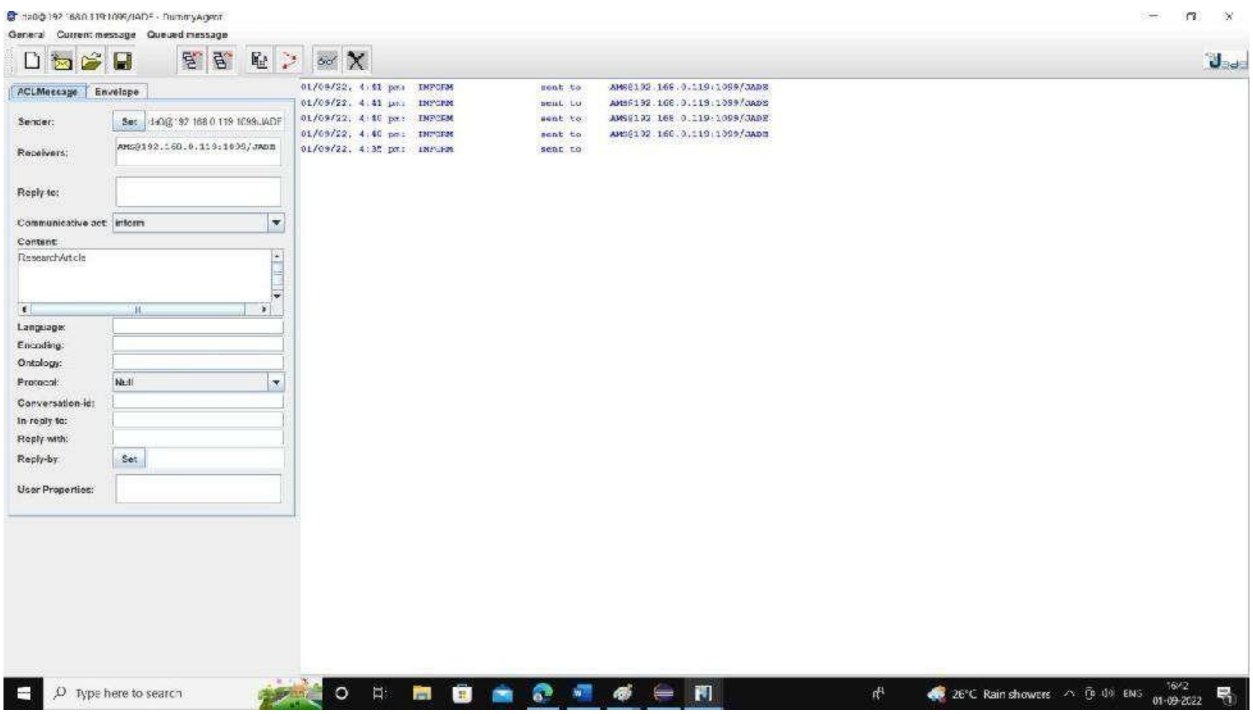


Figure 7. User Interface of Dummy Agent System.

5. Conclusion

By applying ontologies with STEM technologies, we strongly propose the theoretical and empirical discussions. This is a technology beneficial for the institutions in higher education institutions, generating key information can be leveraged those involved in the teaching and the learning process. By the application of ontology in the educational institutions to represent knowledge. In this paper, we mainly discuss about the usage of ontology in education and its application in the learning environment of an educational institutions which helps in the analysis of the knowledge of the students. Another aspect of ontology is e-learning which could be proposed with semantic web technologies. Multi Agent System has to be implemented in the future implementation of the design.

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