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EXPERT SYSTEM FOR AUTOMATED MEASUREMENT OF LEARNING OUTCOMES- AN AI MODEL

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ABSTRACT

In today's world, shaped by socio-economic diversity and growing globalization, higher education is not merely an option but a critical factor for the economic development of any nation. The shift from an industrial economy to one driven by information technology, as represented by Industry 4.0, has integrated various fields of learning through digital platforms, all underpinned by the overarching influence of artificial intelligence. Advanced technologies such as AI are vital for fields like defense, strategy planning, manufacturing, and space science, where precision and accuracy are essential. According to the latest data from UNESCO, approximately 220 million students are enrolled in higher education across various disciplines, with a significant proportion in STEM fields. The strength of STEM education is reinforced through rigorous academic audits, which lead to continuous improvements in teaching methodologies. This paper proposes the development of an expert system as a supplementary tool for teaching modules. The system aims to help communicate the prerequisites for new credit courses or the post-requisites for completing credit-based projects to students. It will also capture and preserve the knowledge from outgoing professors or department heads, supporting the learning process. The architecture of the expert system is designed on a Virtual Private Cloud (VPC), which is hosted within a cloud provider's infrastructure, providing a secure, isolated environment with multiple availability zones for redundancy.The expert system focuses on areas with high attrition rates and is accessible to students for ongoing learning. The learning process is enhanced through various pedagogical approaches, such as quizzes, flipped classrooms, quality circles, and human-computer interaction. These methods help assess learning outcomes from classroom interactions and generate automated reports on both direct and indirect student assessments. Given the large datasets involved, the use of a Virtual Private Cloud architecture is necessary. The prototype expert system is built using pyknow, a popular Python library that utilizes the RETE algorithm.

Keywords: Python, Expert system, learning outcome, RETE Algorithm, Virtual private cloud

1. INTRODUCTION

Expert systems are computer-based tools designed to replicate human decision-making processes in order to solve problems or offer advice within a specific domain. These systems utilize a combination of knowledge bases, inference engines, and rule-based reasoning to analyze data, draw conclusions, and generate solutions or recommendations. An expert system is typically composed of several key components: the knowledge base, the inference engine, the user interface, and the knowledge acquisition module. The knowledge base stores domain-specific information, including facts, rules, and heuristics gathered from human experts. It is structured in a way that enables the system to apply this knowledge in decision-making or problem-solving tasks. The inference engine interprets and applies the information in the knowledge base to specific issues by using rules and algorithms to derive conclusions and generate recommendations. The user interface allows users to interact with the system and can be designed as a graphical user interface (GUI), command-line interface, or even natural language processing (NLP)-based input system, where users can provide voice commands. This NLP feature can particularly assist visually impaired students in accessing the expert system's knowledge acquisition capabilities. The explanation module provides reasoning behind the system's conclusions or recommendations, helping users understand the decision-making process, especially in cases of conflict or uncertainty in the system's outputs. The knowledge acquisition module enables the system to acquire new knowledge or update existing knowledge. This process involves engaging with domain experts to input new or revised information into the system. Expert systems come in various types, each tailored to different problem-solving methodologies:

1. Rule-based expert systems use "if-then" logic to infer conclusions from input data.
2. Fuzzy logic expert systems handle imprecise data by allowing degrees of truth, rather than binary true or false values.
3. Neural network-based expert system leverage artificial neural networks to learn patterns and make decisions based on the data they've been trained on.

4. Case-based reasoning systems retrieve and modify solutions from previous cases that are similar to the current problem.
5. Model-based reasoning systems simulate system behaviors by using explicit models.
6. Temporal reasoning systems** predict future states based on historical data and temporal relationships.
7. Hybrid expert systems combine different types of expert systems or integrate them with other AI methods to create adaptable and versatile solutions.

These diverse categories enable expert systems to tackle a wide range of problems using tailored approaches suited to different types of data and decision-making requirements.

1 Learning outcomes and scenario in accreditation of Technical Education programs in India through NBA.

Learning outcomes are defined as per the accreditation bodies of specific geographically located universities, which measure the learning outcomes of a particular course through various direct and indirect assessment tools. In India, the technical education institutions are scoped under National Board of Accreditation, in which all the courses of a given program are measured with outcomes and mapped with program outcomes. There are totally 12 program outcomes numbered as PO1, PO2 PO12, with another two program specific Outcomes defined by the program offering institute, specific to the domain of expertise.

These Learning outcomes are tabulated in a matrix for each student and evaluated at the course level, program level and institution level satisfying various criteria's as indicated in the procedures of accreditation. The criteria's of accreditation are in sync with vision, mission , program outcomes, program curriculum, student performance, faculty contribution, facilities, good governance and continuous improvement.

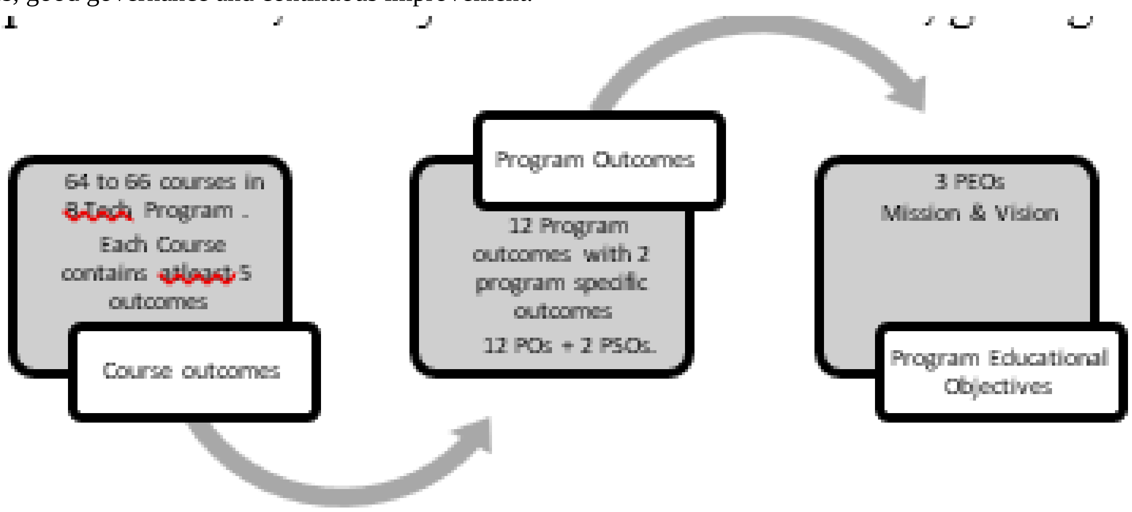


Figure 1: Interaction of PEOs, POs and COs

Course Outcomes (COs) are the statements of measurable actions that serve as evidence of the knowledge, skills and attitudes acquired by the students by the end of the course. The course outcomes are defined for each course as per Blooms taxonomy. The relevance of each course outcome is correlated to program outcomes with different mapping levels by means of performance indicators. Performance Indicators (PIs) are explicit statements of expectations of the student learning.

They act as measuring tools in assessment to understand the extent of attainment of outcomes. The procedure involves stating the course outcomes by the faculty handling the course, mapping the each course outcomes with relevant POs/ PSOs, which is done by calculating the % of performance indicators mapped or addressed for each PO. The levels of significance with quantification of level-3, level-2,level-1 scale is devised and quantified by taking the average. The target attainment is fixed using the CO-PO articulation matrix and assessment of attainment is quantified with internal examinations, External examinations, Internships, Project works etc. The Outcomes are measured using the direct and indirect methods.

There lies a degree of dissatisfaction in measuring the outcomes by direct & indirect methods, where in 80% of the Direct assessment and 20% of indirect assessment is cumulated for total attainment. The POs and PSOs attainment tools are indicated in figure 2. The surveys, quiz, evaluation of project reports, assignments, case-study works are evaluated by individual subject matter experts and degree of evaluation varies from individual to individual. Hence, the metric is in-tangible and require a scientific process for evaluation. In the present paper, we have addressed this problem by proposing an integrated expert system which is launched on cloud with securities specific to institutional interests using virtual private cloud.

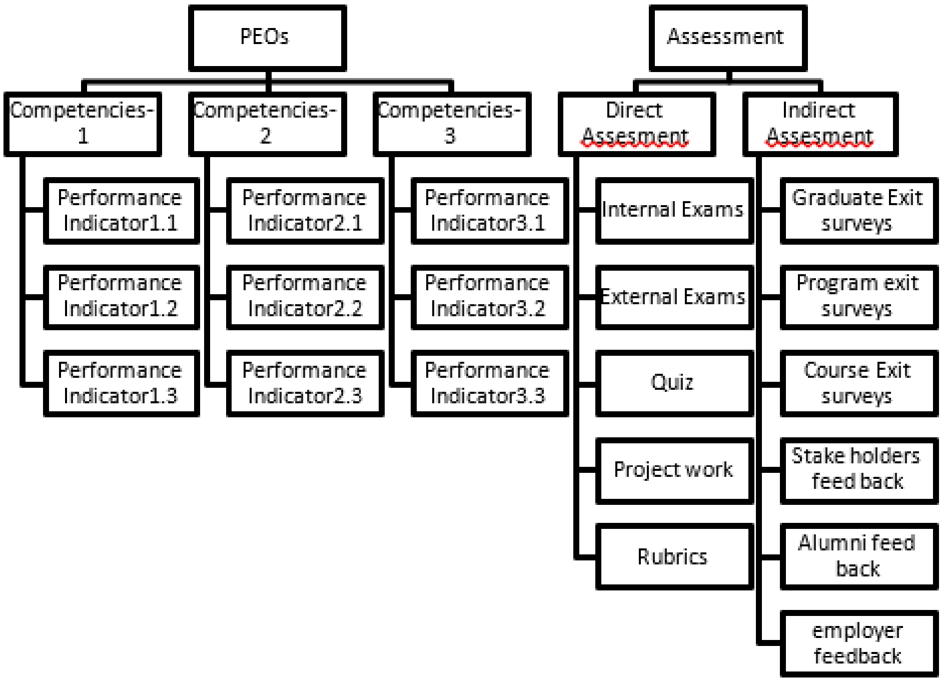
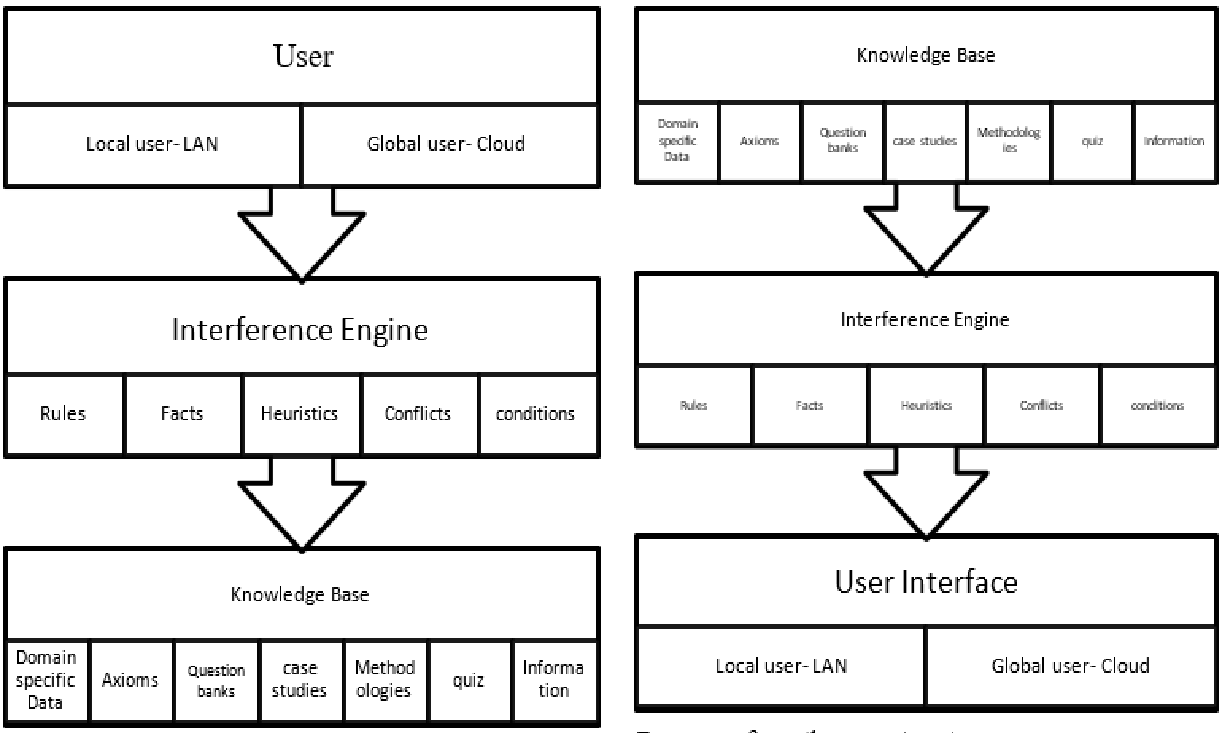


Figure 2: PO & PSO Attainment tools

2 System Architecture of Expert systems

Expert systems have the capacity to assess a student's knowledge by employing various methodologies. These systems can administer customized quizzes and assessments to gauge the student's comprehension in specific subjects or domains. Through adaptive learning techniques, they adapt the learning material's complexity based on the student's performance, providing tailored educational paths. Additionally, diagnostic systems within expert systems identify knowledge gaps by analyzing the student's responses, pinpointing areas that require further attention. Offering personalized feedback, these systems recommend study materials and strategies for improvement. Furthermore, by analyzing learning patterns and performance trends, expert systems generate valuable insights for educators, aiding in the understanding of individual student learning trajectories and facilitating informed decision-making in teaching-learning process.



Query from the user

Response from the expert system

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The interference engine is based on rules and knowledge is retrieved through queries from the user. In the flip mode, the expert system will ask the queries and validate the knowledge of the user.

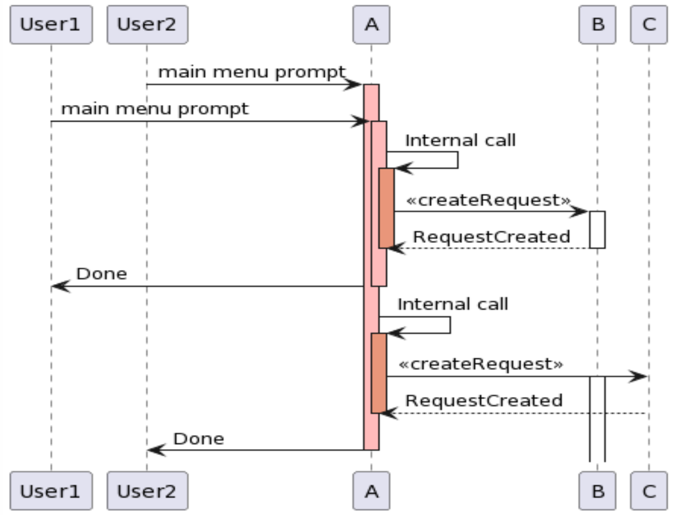
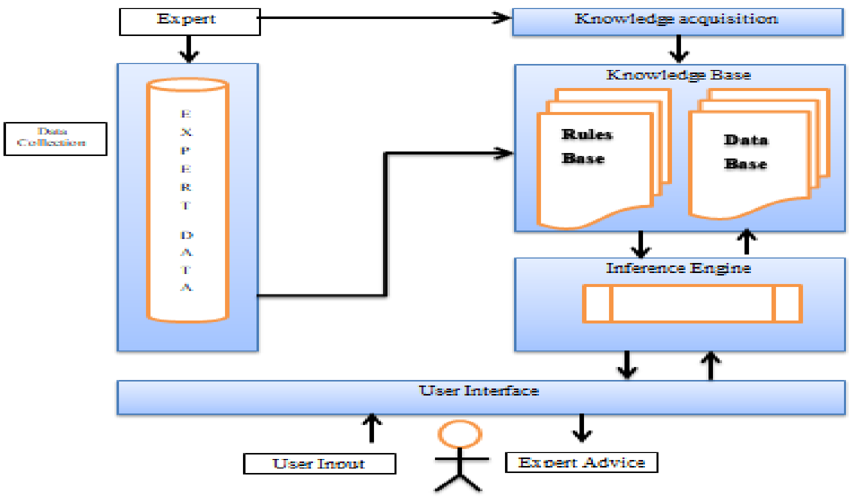


Figure 3: UML for accessing the expert system for various components A: concepts B: Quiz C: Case studies

3 Measuring Outcomes through fuzzy- Expert System



The above described expert system which helps in learning case studies, trouble shoot critical problem associated in skill associated learning, which is always a person centric. The evaluation of learning outcomes is always discussed from degree of correctness. We cannot evaluate the correctness with a score of 0 or 1, ie., if response from the user is completely true then it is 1, else 0, but should be evaluated with a degree of fuzzification. The fuzzification table will help us in evaluating the student/ user knowledge with reverse work flow. The below mentioned fuzzification table provides the metrics of evaluation.

Type of Response	Award	Grade	Type of learner
Exact as per rule base	Level completed	A+	Advanced
Deviation of 10% from rule base	Level completed	A	Advanced
Deviation of 30% from rule base	Level completed	B+	Intermediate
Deviation of 40% from rule base	Level completed	B	Intermediate
Deviation of 50% from rule base	Level completed	C+	Slow
Deviation of 60% from rule base	Level completed	D	Slow
Deviation of 50% from rule base	Level Incomplete	E	slow
Complete deviation from rule base	Level Incomplete Course repetition	F	slow

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The expert system application is deployed on cloud architecture where in, the number of user will be more in number and can access the expert system from recognized DNS. The user credentials will be provided to the user and application is deployed on various cloud platforms such as AWS, AZURE, IBM Cloud, GOOGLE Cloud etc., which can be launched as software as a service (SaaS). With the introduction of AWS private link, we can provide services to AWS customers directly into the virtual private cloud. The cross account private SaaS on private IP addresses rather than on internet will give full privacy and security to the expert system. The services we offer benefit from the traffic flowing through private AWS networking instead of the Internet. This not only enhances security and performance but also offers added convenience. Private Link seamlessly integrates with the AWS Marketplace, streamlining learning and providing users with a straightforward consumption model.

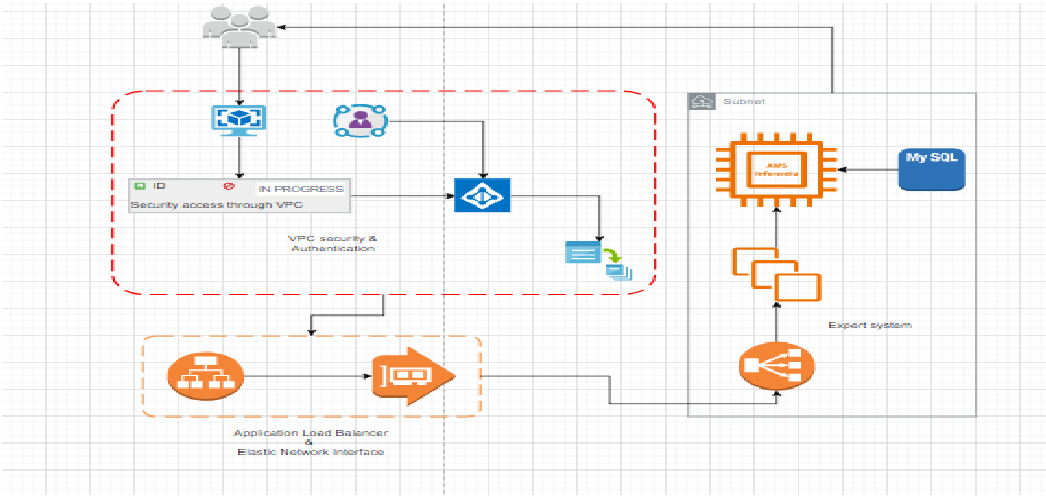

Figure 5: VPC Architecture for Expert system

Sample code in Python for Expert systems development

```
class LearningOutcomeExpertSystem:
def __init__(self):
self.learning_outcome = None
def evaluate_learning_outcome(self, correct_answers):
if correct_answers >= 8:
self.learning_outcome = "Excellent"
elif 6 <= correct_answers < 8:
self.learning_outcome = "Good"
elif 4 <= correct_answers < 6:
self.learning_outcome = "Satisfactory"
else:
self.learning_outcome = "Needs Improvement"
def get_learning_outcome(self):
return self.learning_outcome
# Example of using the LearningOutcomeExpertSystem
if __name__ == "__main__":
# Instantiate the expert system
expert_system = LearningOutcomeExpertSystem()
# Assume the learner got 7 correct answers in the quiz
correct_answers = 7
# Evaluate the learning outcome
expert_system.evaluate_learning_outcome(correct_answers)
# Get and print the learning outcome
learning_outcome = expert_system.get_learning_outcome()
print(f"Learning Outcome: {learning_outcome}")
```

2. CONCLUSIONS

The expert system presented in this paper concludes the following:

1. In the learning mode the Expert System will help the user in learning critical case studies.
2. In the evaluation mode the user is to be tested hence, the expert system uses fuzzy logic to access the grade point values.
3. The presented model is bi-directional, and in the learning mode it is strict rule based and in evaluation mode it is fuzzy-expert system based on stochastic nature, which is described by the membership functions of the fuzziness.
4. Virtual Private cloud architecture is proposed for application deployment for better security and privacy protection of intellectual property.

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