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A Model for E-Learning Performance Measurement and Evaluation based on Expert Systems

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Abstract— The need for utilizing Artificial Intelligence in education systems has come to the fore due to some reasons such as the inability of CAI (Computed Aided Instruction) technology such as not responding to personal learning needs, using a single teaching strategy, and being expensive. Since expert systems are proven to be capable of solving problems like human experts, they can play the role of assessors and they can make it possible to facilitate the learning of even difficult concepts by directing the learning process with a series of questions. The proposed application come to the forefront in terms of improving students' e-learning capacities by indicating the "reasoning" steps that lead to results rather than finding solutions to the problems that students encounter in the e-learning process. Thus, it becomes possible to increase the e-learning process performance by monitoring and intervening in the e-learning processes if needed.

Index Terms— E-learning, Expert Systems, Intelligent Educational Systems, Intelligent Performance Evaluation.

I. INTRODUCTION

Due to some social necessities over unexpected events such as tragedies, natural disasters, pandemic events etc., education systems are evolving towards using e-learning or distance-based learning technologies. Technological progress and improvements also encourage the implementation along this line. Although e-learning systems are becoming more widespread due to the digitalization of today's learning environments, the measurement and evaluation of the performance of e-learning systems are still open to research.

Through the instrument of expert systems, it is possible to create personalized learning paths in accordance with the student's own learning pattern and speed as a natural consequence, e-learning performance could be increased.

In the study, a systematic approach based on expert systems that can be used to measure and evaluate e-learning system performance with learning analytics applications has been presented.

II. EXPERT SYSTEMS

Expert systems are one of the most important tools of AI technology. Expert systems aim to eliminate human dependence by making it possible to add "intelligent" behavior to traditional computer programming products. It can be developed for many purposes such as planning, control, diagnosis, monitoring, and debugging, and is increasingly used. The strength of the expert system lies in its specific, refined knowledge of the subject area. Expert systems come to the fore in that deep knowledge is obtained from experts, registered, ready for use whenever needed, and can be updated. Expert systems are built via developing software from scratch, using shell which is the development environment for building knowledge-based applications. The main components of an expert system can be illustrated in below [1].

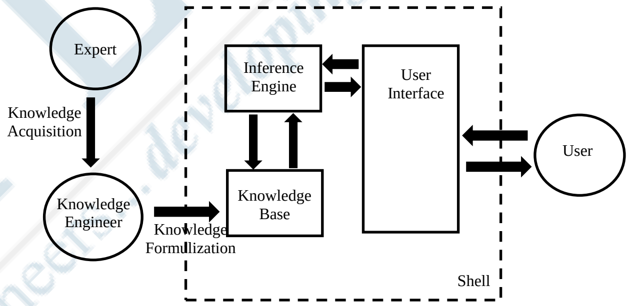

Fig1. Schematic representation of expert systems

It can be sorted the Expert System development stages in the following way.

Establishing the development team
⬇
Problem definition
⬇
Conceptual analysis
⬇
Problem formulation
⬇
Building a prototype
⬇
Implementation
⬇
Test

Fig2. Expert System Development Stages

Firstly, it should establish the development team which contains subject matter expert, knowledge engineer, software developer, users, etc. In the problem definition stage, the main features of the problem are determined and it is divided into sub-problems, if necessary. In the conceptual analysis stage, questions such as what information will be used and displayed in the knowledge base, and how to obtain precise information are answered. In the problem formulation stage, the methodology for obtaining information is determined. Here the type of knowledge plays an important role. For example, in rule-based systems, information must be organized in terms of rules. Building a prototype stage is the stage where knowledge is programmed. At this stage, when the prototype is being developed, it is possible to refine the information, make additions or changes. In the implementation stage, the knowledge engineer tests the system using examples. The results are shown to the expert or experts and the rules or frameworks are revised, if necessary. Lastly, in the test stage, the validity of the information is tested.

Knowledge presenting is one of the most important stages and the tools used can be listed as follows: Semantic Networks, Rules, Object Attribute Value Triplets, Frames, Logic Representation, Blackboard Architecture [2].

III. E-LEARNING

Distance education, which is defined as the education system of the age, has gone through various stages. The first attempts to use computers in instruction began in the early 1960s. In the mid-1960s, the CAI applications at Stanford University put forth successful materials for different areas. In 1961, with the PLATO project (The Programmed Logic for Automatic Teaching Operations), the University of Illinois' computers were used in education for the first time. PLATO project continued to develop through the early 2000s, finding a niche in military and vocational education [3].

The use of the internet and distance education technologies, from there to smart board applications and MOOCs a series of transformation processes have been experienced. And now distance education is on the agenda with internet-based mobile applications.

In the OECD 2020 report "Education responses to covid-19", the challenges in e-learning for primary and secondary education rather than higher education are emphasized. As the long-term advantages of e-learning systems are, safe e-assessment systems, exploring different schooling models, contributing to the development of teachers by actively using digital systems, and improving themselves on how to integrate digitalization in their own subject areas are highlighted [4]. At that point, the proposed model offers error-free assessment regardless of the number of students. Additionally, it provides speed, convenience and feedback in evaluation processes.

A.M. Maatuk et al. (2022) students emphasized that e-learning increases the learning burden on students as one of the important results of their studies [5].

At this point, it is important to design e-learning systems in a way that facilitates the learning process and then to monitor this process in reducing the aforementioned learning burden.

Here, in e-learning systems developed based on expert systems, it is possible to create personalized learning paths in accordance with; the student's own learning method, learning style, and speed, thus increasing learning performance.

IV. A MODEL FOR E-LEARNING PME BASED ON EXPERT SYSTEMS

Evaluating human learning is often complex and time-consuming. In addition, it is not easy to compare, measure progress or analyze other situations with the new evaluation results. In the study, an expert system-based model that can be used in e-learning systems has been put forward, starting from the ZeDes hybrid expert system developed by Ozturk and Sonmez for the air defense system [6].

The proposed system offers an advantage in terms of improving students' learning capacities in terms of showing the "reasoning" steps that lead to results in the e-learning process. Thus, it will be possible to increase the performance of the e-learning process by monitoring the e-learning performance and intervening in the e-learning processes when necessary. As a result, it will be possible to observe increases in the efficiency obtained from the e-learning system.

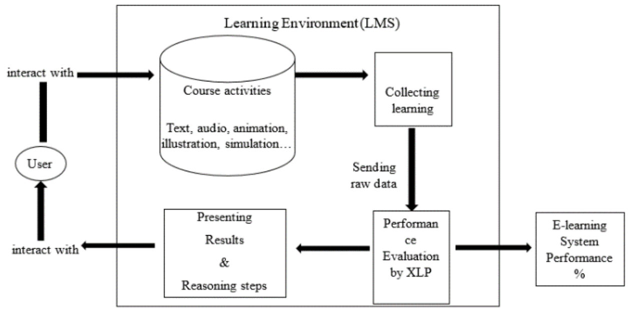

Fig3. Proposed Model for E-Learning Performance Evaluation based on Expert System

The proposed model consists of three parts:

- Collecting LP data
- Evaluation by XLP
- Presenting reasoning steps and results

The proposed model aims to intervene learning proses for the purpose of improving learning performance. Thus, system performance will be increased. The model is adapted from Kokoc and Altun (2021)'s study [7].

For the evaluation of the learner's learning performance, the main component is XLP which makes intelligent performance evaluation for learning performance. XLP details are given below.

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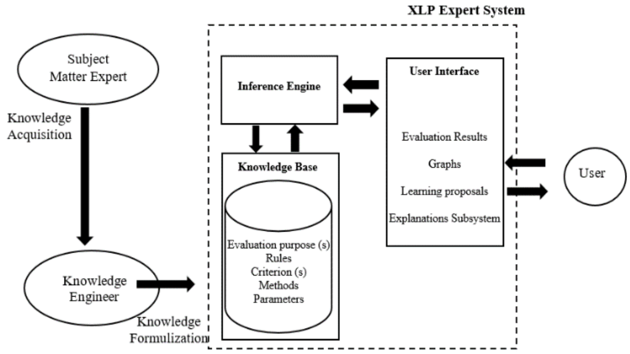

Fig3. XLP Component of the Proposed Model

XLP consists of three parts:

- Knowledge base
- Inference engine
- User interface

In the knowledge base, the rules for evaluation and the reference model (qualification framework based on learning outcomes) should be brought into an appropriate format. The knowledge base should include:

- Structured knowledge (obtained from a subject matter expert) to produce useful outputs for users
- Assessment purpose information
- Knowledge of what the success criteria are
- Knowledge of evaluation methods and rules
- Algorithms showing how to evaluate

The inference mechanism is the component required for the rules to work, with methods such as backward chaining and forward chaining. The inference engine starts with a learning goal and searches the knowledge base for identifying the respective knowledge which is necessary to satisfy the goal (if any available). Since the information needed by the student varies from student to student according to the measurement result, the XLP system inference mechanism generates personalized solutions that make different inferences according to each student's needs.

Performance Assessment

Firstly, the readiness level of each student is determined by traditional assessment tools (diagnostic assessment). This step is the first step for customization. The assessment made in the following stages is the formative assessment, which is aimed at shaping the learning process of the student, offering suggestions to the student in order to realize the learning goal, making inferences, and providing feedback to the student. This application facilitates the learning process and increases the system's performance.

One of its most important components is the Explanations Subsystem, which explains to the user the structure of reasoning carried out by the system. This subsystem explains to the user why this conclusion was reached or from what facts it was obtained, which improves the user's reasoning ability.

Lastly, when all learning tasks are completed, the result will give us learning performance. From another point of view, it shows the (teaching) performance of the e-learning system (summative assessment).

The System Principles

1) In order for the system to work, the course, chosen as the application area, must be configured first (SCORM, CISCO, etc. based…).
2) Learning objectives of learning modules must be based on the qualification framework. This is an important metric for objective measurement. Dulger (2020) in her study titled "Big Data Technology in Today's Education Systems: Learning Analytics", based on the LAID (Learning Analytics Implementation Design) approach, explained how the competency-based learning analytics approach could be implemented in e-learning platforms [8].
3) In the LAID conceptual coordination stage, the knowledge engineer can follow a flow like the one below while receiving knowledge from the subject matter expert.

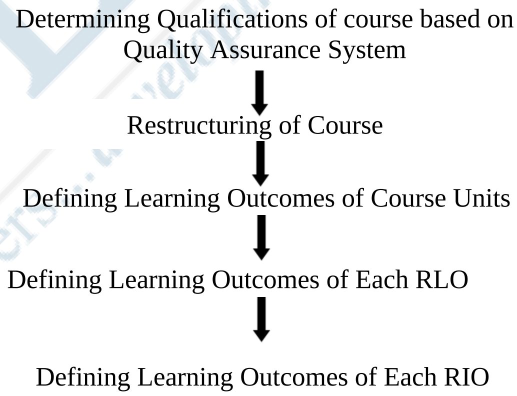

Fig4. LAID Conceptual Coordination Stages

Information Objects (RIO) can be of five different content types: concept, fact, process, procedure, and principle and they are just pieces of information. Learning objects (RLO) are formed by adding educational values, such as a general introduction of the information object, its purpose, and its place in the learning hierarchy to these pieces of information [9].

Evaluation Rule(s):

Evaluation rules contain information about the criteria to be used in the interpretation of the measurement results obtained from the applied tests.

In other words, it is the place where it is defined in which situations it will be successful and in which situations it will be unsuccessful.

Here it is weighted according to the importance of the RIO in the RLO.

In evaluation rule definition, for example RLO1;

• If the ∑ RIO test result is greater than or equal to 80%, then RLO1 is successful.

• If ∑ RIO test result is less than 80%, then RLO1 is failed, it should be repeated.

Evaluation Method(s):

It contains the algorithms required to make the measurements described in the rules. The algorithm required to run the rules in the XLP system is as follows.

(i) Calculation of individual performance on the basis of RIO
(ii) Calculating the normalized value of RIO performance
(iii) Calculating learning sub-process performance for RLO
(iv) RLO performance calculation
(v) Calculating system performance for the unit
(vi) Explanations Subsystem results, feedback, reporting
(vii) Learning recommendations

System Performance Evaluation

The achievement of the students' learning objects acquisition performance will give us the performance of the e-learning system. The factor of effectiveness comes to the fore in the performance calculation of the e-learning system. Effectiveness is calculated as result-oriented and is the degree of achieving the expected output. If we customize this definition for learning systems; It is the degree of attainment of these goals as a result of the teaching activities carried out to achieve the learning outcomes and is formulated as follows:

$$\text{Effectiveness} = \frac{\text{Learning Object Results}}{\text{Expected Learning Outcomes}} \quad (1)$$

This formula is first applied to the informatics object, which is the smallest learning unit, and then to the connected learning object. Finally, the unit performance consisting of learning objects is calculated. This process is repeated in each unit for the course covered. Thus, the teaching effectiveness value is obtained.

Since the e-learning performance of the student can be analyzed down to the smallest learning unit (RIO) with the XLP system, it is possible to present the results and make personalized recommendations with the explanations sub-system. From the point of view of the education system, both the teacher dependency problem will be eliminated and the e-learning performance will be improved. Some remedies are provided to the students through the user interface in order to improve their learning performance. User interface also have some specific screens designed to query the learning level of specific topics. With the user interface, the assessment result and learning recommendations derived accordingly may be presented to the user with graphics (for easier traceability), if demanded.

One of its most important components is the Explanations Subsystem, which explains to the user the structure of reasoning carried out by the system. This subsystem explains to the user why this conclusion was reached or from what facts it was obtained, which improves the user's reasoning ability. Lastly, when all learning tasks are completed, the result will give us the learning performance. From a other point of view, it shows the (teaching) performance of the e-learning system (summative assessment).

CONCLUSION

In the recent years, perhaps during the COVID epidemic we are still in, only the countries with the appropriate infrastructure and prepared for these systems were able to survive with less losses. In this sense, the performance of e-learning systems should be evaluated, increased and strengthened with artificial intelligence technologies. In the study, quality assurance systems were taken as a basis in determining the educational objectives, so educational activities organized around a specific and valid purpose were targeted. While the purpose of evaluation was defined in the structuring of the course, the content was structured to support the acquisition of learning outcomes from this framework.

It can be said the advantages of the proposed system from the point of view of the System/Evaluator; due to the evaluation process often varies by evaluator, with the proposed system based on expert system knowledge, it presents an objective evaluation system independent of the evaluator's comments. Secondly, experience in assessment quality is important. As expert systems are based on expert experience, the quality of evaluation increases. From the point of view of the system security; It is possible to keep the information of the experts in the subject area regularly, to be reused and updated when necessary. Additionally, it provides speed, convenience and feedback in evaluation processes. Thus, the workload of the trainer can be reduces, it is possible to allocate time for the quality of education. Lastly, it offers error-free assessment regardless of the number of students.

It can be said the advantages of the proposed system from the point of view of the students; with the proposed system, not only the result but also the process information is shared. In this way, it is possible for the student to have information about the learning process and to complete the deficiency if necessary. Proposed model provides the student with information about the learning unit, criteria, measurements, methods, parameters about the unit. So, it will be possible for them to see the source of failure, not just the result. From a student psychology perspective, it contributes to the development of self-regulation and self-motivation skills, as it makes it possible to monitor the learning process. Regarding to interpreting exam results, graphical representation of the inference of evaluation results is possible. It facilitates the analysis and evaluation of the result. Most importantly, explains how the inference is reached.

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