A PROTOTYPE DECISION SUPPORT SYSTEM FOR OPTIMIZING THE EFFECTIVENESS OF E-LEARNING IN EDUCATIONAL INSTITUTIONS

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ABSTRACT

In this paper, a prototype of a Decision Support System (DSS) is proposed for providing the knowledge for optimizing the newly adopted e-learning education strategy in educational institutions. If an educational institution adopted e-learning as a new strategy, it should undertake a preliminary evaluation to determine the percentage of success and areas of weakness of this strategy. If this evaluation is done manually, it would not be an easy task to do and would not provide knowledge about all pitfall symptoms. The proposed DSS is based on exploration (mining) of knowledge from large amounts of data yielded from the operating the institution to its business. This knowledge can be used to guide and optimize any new business strategy implemented by the institution. The proposed DSS involves Database engine, Data Mining engine and Artificial Intelligence engine. All these engines work together in order to extract the knowledge necessary to improve the effectiveness of any strategy, including e-learning

KEYWORDS

DSS, E-learning, knowledge, Database, Data mining, Artificial Intelligence.

1. INTRODUCTION

In this section we describe the motivation and the main objectives of Decision Support System (DSS)[1] supporting decision making by providing necessary information needed to be known by decision makers in order to optimize any new adopted strategy related to learning systems in educational institutions. E-learning is a new education paradigm used in many educational institutions across the world. According to the rapid development of digital media technology, it is normally most of the educational institutions tending to employ this technology for delivering the learning to the students. So adopting the e-learning as new education strategy is an important decision in the institution life. If an educational institution adopts the e-learning as a new strategy,

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it should be applied as experiment and an initial evaluation should be carried out to determine the success rate and the pitfalls of this experiment. When this evaluation is done manually, it would not be an easy task to do and would not provide summary information (knowledge) about all pitfall symptoms. So without that knowledge, there is a risk and the managing of the institution workload, which E-learning is part of, is always difficult and complex task. To achieve that task, the institution managers need current, consistent, reliable information and knowledge about areas of pitfalls and success for the institution workload. Large amounts of data are collected by running the institution to its workload. These huge amounts of data, coupled with the need for powerful computer-based systems for exploring the knowledge helping the institution managers in making decisions, has been described as a "data rich but information poor" situation [2]. Building such systems is very important key in providing the required knowledge for developing and optimizing institution strategies alignment with the institution goals.

Optimizing an e-learning strategy requires discovering the knowledge which pitfall symptoms greatly contribute in the failure of the e-learning. The required knowledge should contain complete information about the following :

- Who are the frequently failing students in the e-learning courses?
- What are the characteristics of those students?
- Who are the inactive students in using e-learning course means?
- How do we find clusters of student with similar learning characteristics?
- Is there association between student's exam results and student's visiting times for a courseware in web-based educational system?
- Is a particular means of e-learning would be suitable for teaching a specific course for a target group of students holding certain characteristics?
- What are the reasons of noticeable difference in the success ratios for teaching some courses by the same teacher or different teachers?
- Are these reasons related to the students, or the teachers, or the course curriculums and its assessment ways, or to the used e-learning means?
- Is there big negative deviation in e-learning courses enrollment?

These above questions are part of what the educational institution managers need to know, if the questions answers are completely known, the institution mangers will be able to overcome the founded pitfalls and the e-learning can be more successful and more vital as the educational institutions move from an 'early adopter' stage to a more general offering . So to know the answers of these questions, the institution should have a computer-based system exploring this knowledge from the operating data stored in its Database system. This type of systems is known as type of Knowledge-discovery systems or in other words data mining systems, or Decision Support Systems.

The objective of this paper is to propose a prototype of Decision Support System for educational institutions. The proposed DSS is based on exploration or mining of knowledge from large amounts of data. The proposed DSS involves Database (DB) engine, Data Mining (DM) engine and Artificial Intelligence (AI) engine. All these engines work integrally together in order to extract the knowledge necessary to improve the effectiveness of any institution strategy, including the e-learning.

1.1. E-learning

Electronic learning or E-learning can be defined as learning delivered by electronic means including CD-ROM, Internet, and Intranet [3]. The two top-most used e-learning delivery methods are as follows:

i. Synchronous e-learning, such as virtual classrooms supporting on-line training.

ii. Asynchronous e-learning, such as web-based courses supporting self-study training.

There are different factors, should be considered when e-learning process is designed, including such as learning content, instructional methods, e-learning media, learner differences and environment. Designing the proper courseware specific to the desired outcome, lessons should include instructional methods suitable to learner's characteristics. The environment plays also vital role in success of e-learning, including issues technical constrains related delivery platform, network, software and cultural factors in insinuations [3]. The correct design of the e-leaning process will make it unique and more successful, so there are many sides or factors should be viewed and considered in planning and designing a proper e-learning system fitting the learner needs. So, we propose DSS for providing some of the information required in optimizing and refining the learning system, when it is adopted and applied.

1.2. Data Mining

Data mining is one of the rapidly growing fields in computer industry, according to the big size and complexity of databases yielded by running institutions to its business [2,22,23,24]. New methods for data mining in databases have been studied, which describe data exploring and knowledge extracting processes including data preprocessing, data analysis, and methods of knowledge representation. The common tasks of data mining include induction of classification models [4], association rules [5, 25], evolution and deviation analysis and making clustering for similar data objects [2]. To make data firm suitable for mining, preparing methods should be applied to it for cleansing and transforming to a format ready for the mining [2]. Educational Data mining [6, 26] is a novel research area offering solid ground for applications interested for educational environment. Educational data mining can mine information (knowledge) related to learning process activities. In this approach, for example, it is, in promising way, able to extract useful information, specifically and not to limit, about how student's exam results related to the student's visiting times for a courseware in web-based educational system. In section 3 we describe our proposed decision support system and how its data mining engine can provide such that information.

1.3. Artificial Intelligence

Artificial Intelligence (AI) systems are knowledge processing systems [7]. Knowledge representation, knowledge acquisition, and inference including search and control, are the three main techniques in AI.

- Knowledge representation. Data mining seeks to discover interesting patterns from large volumes of data. These patterns can take various forms, such as association rules, classification rules, and decision trees, and therefore, knowledge representation becomes an issue of interest in data mining.

- Knowledge acquisition. The discovery process shares various algorithms and methods with machine learning for the same purpose of knowledge acquisition from data or learning from examples.

- Knowledge inference. The patterns discovered from data need to be verified in various applications and so deduction of mining results is an essential technique in data mining applications.

Therefore, knowledge representation, knowledge acquisition and knowledge inference, the three fundamental techniques in AI are all relevant to data mining.

1.4. Decision Support System

Decision Support Systems have been studied, in the 1960s, as how to use computerized models to assist in decision making and planning [8]. A decision support system is an interactive computer-based system designed to serve the management level of the organization in performing computer generated analysis of its own business data [1]. A decision support system is a general term for any computer application enhancing the business manager's ability to make decision. DSS assists the mangers to make decisions that are unique, swiftly changing and not easily specified in advance [19]. Although DSS use internal information from transaction processing systems and management information systems; they often bring in information from external sources such as server log files. Decision Support System is designed to facilitate the input data and editing data, the execution of the required models necessary to analyze the data, and display the results in understandable formats. Developments in information science and computer industry are having a significant impact on contributing in building of decision support systems, so many of contributing discipline's approaches could be utilized in building decision support systems that are known as hybrid decision support systems of multiple approaches. Our proposed DSS hosts and combines the facilities of three distinct discipline's approaches, databases management, data mining, and AI, to develop hybrid decision-making mechanisms. So using these disciplines helps solve abroad range of the institution's problems in decision making.

2. RELATED WORK

Decision support systems play vital role in educational institutions. Sanjeev and ZythKow [9] apply knowledge discovery to data of university database, the knowledge is presented to university administrator in order to make strategic decision for the institutional policies. Luan [10] proposed using different data mining algorithms for doing a comprehensive analysis of student characteristics in order to improve the effectiveness of alumni development. Deniz and Ersan [11, 12] proposed a DSS for student, course and program assessment. Minaei-Bidgoli and Punch [13] proposed a classification model for predicting student final grades and the student attributes extracted from the logged file is used in order to build this model. Dasgupta and Khazanchi [14] described an Intelligent Agent Enabled Decision Support (IAEDS) system, which assist in making strategic decisions for scheduling academic courses. Scholl [15] presented DSS for assessing educational capacity and planning its distribution and utilization.

Nwelih, and Chiemeke [20] proposed an Academic Advising Decision Support System for Nigerian Universities. Zorrilla and others [21] described a proposal of a decision making system which helps distance instructors to know who their students are, how they work, how they use the virtual course, where they find the problems and so on, and in this way, instructors can act as soon as they detect any difficulty, for example, proposing new tasks, re-organizating the content-pages, adding new information, opening discussions and so on. Likewise they proposed some questions that, in their opinion, are of interest to teaching staff and show how the answers are very useful for improving the learning and teaching process. These answers are obtained by means of data mining techniques. Lastly, they also suggested a modular architecture for its implementation.

3. PROPOSED DSS PROTOTYPE

This section describes the architecture's components of the proposed DSS prototype and describes how these components are integrated together to perform tasks embedded in a requested user's query.

Achievement of the user's query during the proposed system is going through four phases of the work described in section 3.2.

3.1 DSS Prototype Architecture

As shown in Figure 1, the DSS integrates three main components, Database engine, Data Mining engine, and AI engine. For some tasks, including data extracting, transforming, and loading. The DSS integrates ETL (Extract, Transform, Load) tool for extracting a task–relevant data from operational database, and transforming it to suitable formats and loading into the DSS's data store. The DSS's data store could be involved in relational database store or multidimensional database (data cube) that is the core database schema of data Warehouse [16,17].

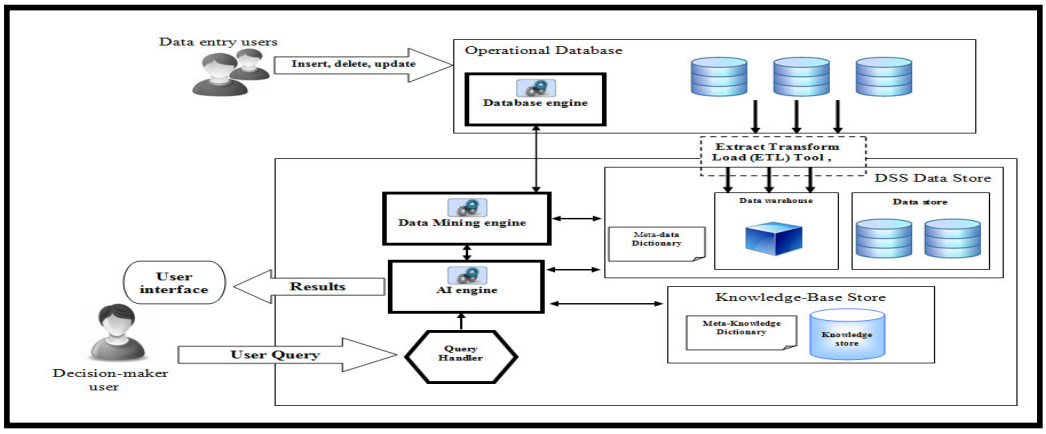

Figure 1. A chart of the major components in the proposed DSS architecture.

When a decision-maker makes his requested queries, these queries would be handled by a query handler tool that is one of the integrated DSS's components. The query handler parses and forwards the handled queries in terms of AI specifications. All information and requests about DSS tasks to be performed are placed on a knowledge-base store managed by the AI engine, where the AI engine can view them. The AI engine coordinates the tasks of requests, and utilizes the knowledge-base to justify whether a particular request is AI task or it is data mining task. The AI engine forwards the data mining tasks to the data mining engine for processing, the data mining engine delivers results of its assigned tasks to the AI engine to deal with these results later.

AI engine treats the results of the executed tasks as possible as follows:

i. Converting the results to AI facts and storing these facts in a knowledge-base store.

ii. Presenting the results on user interface in intelligence user-preferable format.

3.2 DSS Prototype Architecture Phases

The DSS prototype architecture includes four phases: initial, justification, execution, and presentation phases. Figure 2 depicts these phases and their functional steps.

i. Initial phase: in this phase, the query handler converts user query to query in terms of AI specifications, and sends it to AI engine.

ii. Justification and creation phase: the AI engine justifies the assigned query to identify it whether it is AI task or it is mining task. The justification result is used to create AI task, or data mining task. The created task is assigned to the corresponding engine to execute it.

iii. Execution phase: AI engine and data mining engine achieve their assigned tasks. The executed task results are stored as knowledge facts in the knowledge-base store, or sent to a presentation module in the fourth phase to create the proper interface to show them.

iv. Presentation phase: in this phase, AI presentation module generates the proper interface for the executed task results.

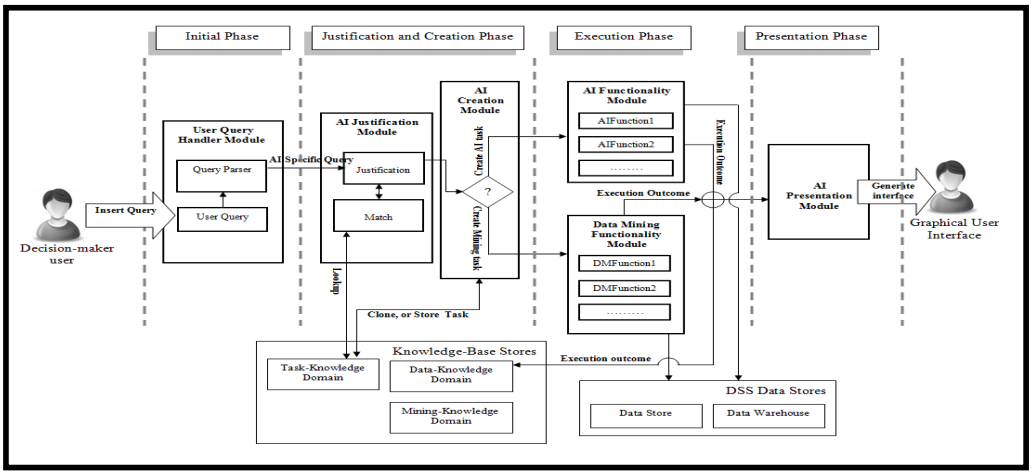

Figure 2. The proposed DSS architecture phases and their functional steps.

Different software modules should be designed in order to perform the procedures of the fourth phase that are illustrated in Figure 3.The details for functional steps of these modules, and DSS stores are summarized in Table 1.

Table 1. The Functional steps of modules and DSS stores

Module	Functional steps
User Query Handler Module	User Query Handler Module through its GUI enables the User to enter the required query. A query parsing is achieved to convert the user query into a specific query in AI syntax, and then the User Query Handler Module forwards the parsed query to justification module to validate it.
AI Justification Module	A justification module justifies the query to validate its consistency, and for identifying the query's task functionality by matching the query specification with task specification rules stored in the Task-knowledge domain. as well, Justification Module lookups in Task-knowledge domain to detect previously created task with similar to the requested functionality in the current query. The Justification outcome is sent to AI Creation Module for creating the query's functionality task in a proper way.

AI Creation Module	A creation module creates a task for performing the specific functionality requested in the query. The functionality of the query could be AI functionality, or data mining functionality, so the creation module could create an AI task, or a data mining task corresponding to the requested functionality. A creation module, before the task creation, utilizes justification outcome, which tells it that there is found a task previously created with similar to the requested functionality in the current query, or there is not. If such that task is found, the creation module will clone it and adapt it with the new parameters of the current query. If a task with the requested functionality is not found, the creation module will create a new task and store its information in the Task-knowledge domain. According to the type of the created task, the created task is forwarded to AI Functionality Module, or to Data Mining Functionality Module for executing it.
AI Functionality Module	AI Functionality Module includes set of AI functions. The forwarded created task, from AI Creation Module, is executed by running one of these functions. AI Functionality Module includes functionalities needing to access the DSS data that is pre-prepared in advance for making it suitable for applying these functionalities.
Data Mining Functionality Module	A data mining functionality module includes set of Data Mining functions. The forwarded created task, from AI Creation Module, is executed by running one of these functions. Data mining Functionality Module includes functionalities needing to access the DSS data, that is loaded from operational database.
AI Presentation Module	AI Presentation Module generates intelligent graphical user interfaces showing the knowledge yielded from executing tasks specified in the user-query.
Knowledge-Base stores	Knowledge-Base stores contain Knowledge and rules of task, data, and data mining domains. Initially DSS developer provides Knowledge-Base stores with knowledge and rules. Knowledge-Base store is updated by adding new knowledge and rules obtained from executing the DSS tasks.
DSS data stores	DSS data stores are provided with information obtained from historical data, or from current data. The data stored in DSS data store should pre-prepared in advance for making it suitable for applying DSS tasks.

In summary of the above, the main objective of the proposed DSS architecture is to utilize and combine the advantages of AI, and Data mining functionalities in integrated and promising way. The proposed system could be developed as a four-tier architecture as shown in Figure 3.

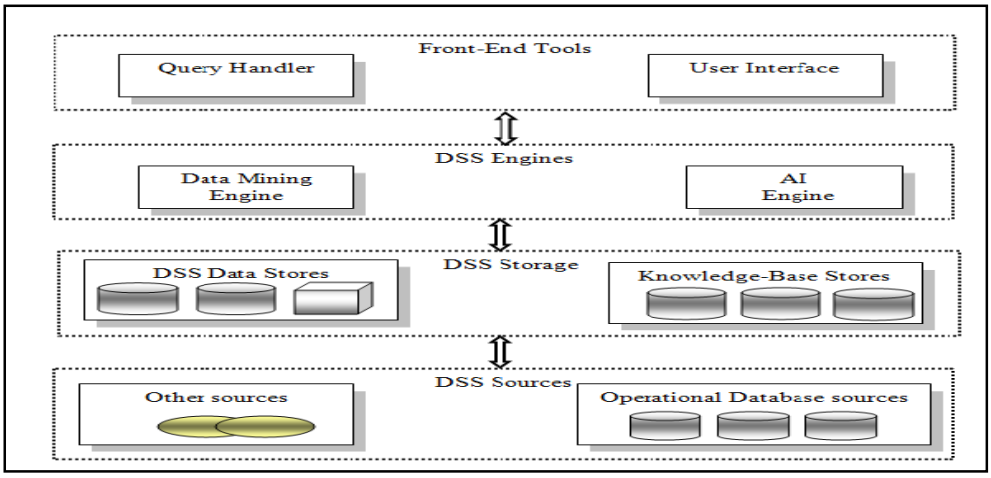

Figure 3. Four-tier architecture of the proposed DSS

4. EMPLOYING THE PROPOSED DSS IN EDUCATIONAL INSTITUTIONS

In this section, we demonstrate how the proposed DSS could contribute in providing the knowledge necessary to educational institution's managers for making the correct decisions to optimize the educational systems, including e-learning. Figure 4 shows how the usage of the proposed DSS in educational institutions forms an interactive cycle for a learning refinement.

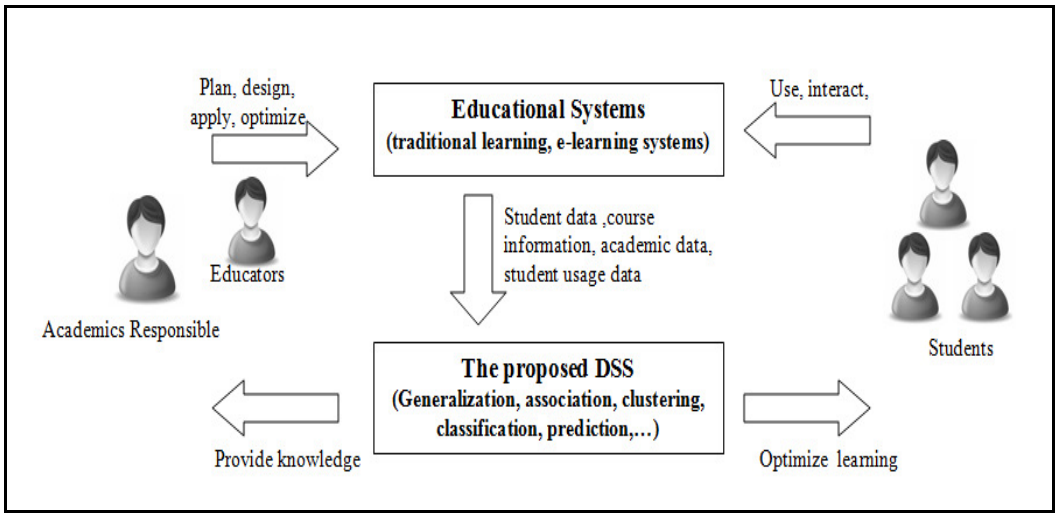

Figure 4. The cycle of employing the proposed DSS in educational institutions

4.1 Examples of Queries In The DSS

In this section, we give some examples of queries describing about requested information of what the educational institution's managers need to know, and of what the proposed DSS can provide.

Example 1: Query for describing general characteristics of students in the university database. The functionality of this query is data generalization which is most popularly used data mining function. The function collects task-relevant data to generalize it form low conceptual level to higher one. For example, the general characteristics of the student in university can be described

as a set of characteristic rules or a set of generalized summary tables. The Attribute-Oriented Induction (AOI) method [18] is one of data mining techniques used in data generalization. The AOI method collects initial task-relevant data relation as shown in table 2, and uses the knowledge base of concept hierarchies of the task-relevant attributes to generalize its concepts. Based on the analysis of the number of distinct values in each attribute, the AOI method determines generalization plan describing an attribute removal or not?, or how high to generalize the attribute if it is not a removal. The generalization's plan description is shown in the last row of table 2.

Table 2. Initial relation of query in example #1

Name	Gender	Major	Birth-Place	Birth_date	Residence	Phone #	GPA
Rami Awad	M	CS	Cairo, Egypt	8-12-85	Omar AlMuktar St., Gaza	9887-564	80.3
Ali Soliman	M	CS	Gaza, Palestine	12-4-95	Main St., Der AlBlah	7865-321	91.2
Hala Almasri ...	F ...	Accounting ...	Nablus, Palestine ...	7-3-78 ...	24 St., Nablus ...	8991-118 ...	90.5 ...
Removed	Retained	Sci,Eng,Bus	Region	Age range	City	Removed	Excl, VG,..

Based on the generalization plan, the AOI method performs generalization by attribute removal or attribute generalization, and produces prime generalized relation as shown in table 3. The AOI method applies aggregation with adjusted levels by merging identical generalized tuples, and accumulating their respective counts as shown in table 4.

Table 3. Prime generalized relation of query in example #1

Gender	Major	Birth-Region	Age-Range	Residence	GPA	count
M	Science	Foreign	25-30	Gaza	Very Good	20
M	Science	Palestine	20-25	Der AlBlah	Excellent	30
F ...	Business ...	Palestine ...	30-35 ...	Nablus ...	Excellent ...	15 ...

Table 4. High-level generalized relation of query in example #1

Birth-Region / Gender	Foreign	Palestine	Total
M	20	40	60
F	10	15	25
Total	30	55	85 ...

Example 2: Query for finding the correlations between student's exam scores and their visiting behavior for a particular courseware in the web-based educational system used in the university.

This type of queries, studying the student behavior and the usage of the web-based educational system, are often considered as starting point of evaluation an e-learning system.

The main functionality of the query is mining association [5], considered as one of the top-most used data mining functionalities. To answer this query, the proposed DSS should prepare, collect and store the data that would be mined later by analyzing and parsing the server log file of a courseware website. These prepared and collected data describing the student's visiting behavior would contain values of indicators about who, when, and how the courseware website is visited. The association mining function mines the task-relevant data derived from merging the prepared data of the web log files and the data about the student exam scores. Processing the association mining function on these data, may be present frequent and strong association rules among the browsing student behavior's indicators and the student exam scores.

Example 3: Query for presenting usage statistics of the web-based educational system.

The proposed DSS may be process statistics, evolution and deviation analyzes on the data prepared from parsing the server log files of the web-based system. The outcome of this analyzing process could be presented in suitable and readable GUI formats. For example, some of these GUI formats:

i. Chart presenting count of the courseware's visits for each student, or course.
ii. Chart presenting count of the courseware's visits for each courseware components on the course website.
iii. Chart presenting the website usage evolution or deviation for each student, or course.

Example 4: Query for identifying the range of accumulative average score for a particular student in specific course.

The proposed DSS scans and parses the log files of an educational web-based server that is used to offer the student with all lectures of a specific subject online in a video format. The outcome of the scanning and parsing of the log files such as login id, login date, login time, time taken to view a specific video are all stored in a database. The AI engine receives the stored information as facts and matches them with the stored rules in the knowledge base to predict the range of the average score for a particular student in specific course. The knowledge base was built using the history of students in log files and grades received for the same subject.

5. CONCLUSIONS & FUTURE WORK

In this paper, building DSS for educational institutions is proposed to improve learning systems including e-learning. The building of the DSS is based on utilizing functionalities of database, AI, and data mining engines in integrated way. Integrating several AI and data mining functionalities into a single system like the proposed DSS will be promising. The main fundamentals for this integration are the rich DSS with extendable knowledge-base and internal well-prepared data model, and using self-directed distributed modules. The AI engine plays core role as coordinator and executer for the most of the DSS tasks including the presentation of the task results in intelligent format.

The foundation of such DSS systems in educational institution will provide the academic personnel responsible in that institution with the needed information necessary in optimizing the educational systems. Even though the proposed prototype is not implemented yet, we hope that our proposed system goals enable the educational institutions realize the importance of the DSS-produced information in optimizing their adopted learning strategies. Moreover, we plan to

implement the modules of the proposed system in order to reach to the overall implemented system in future.

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