INTELLIGENT E-LEARNING SYSTEMS
An Intelligent Approach to Flexible Learning Methodologies

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Abstract: The evolution of the educational industry from adoption of classroom training methods to e-learning systems has been remarkable and has satisfied its purpose of existence. However, it has not been able to address issues faced by students who do not want to be constricted with a set pattern of progress. Hence, an Intelligent e-Learning Systems (*IeLS*) framework that facilitates flexibility and maximum learners' satisfaction, was developed. The framework consists of a presentation component, a data mining component, a business logic component, a content management component and a database component. The data mining component uses techniques such as association rule discovery and conceptual clustering to generate recommendations for students, course coordinators as well as the institute.This framework was implemented using PHP and MySQL with various components such as registration, entry test, tutorials, guest-book and bulletin boards. This system allows flexibility in terms of choice of learning path, change in direction of learning path and change of learning approach. In this paper we discuss the role that such an intelligent e-Learning system plays in satisfying the diverse needs of students.

1 INTRODUCTION

Evolution of educational systems has been a dynamic process influenced by the subject matter being taught, the audience and the dynamics of the learning environment. Of all the factors that have helped in molding its form, *technology* has been considered as the primary factor. Prior to the boom of personal computers, instructor - led training was the primary training method. These systems allowed students to interact with their instructor and classmates. However, they led to high costs and downtime in terms of travel. Educational systems developed subsequently shifted to ones that were powered by multimedia whose delivery was by means of CD-ROMS. The anytime, anywhere availability of CD-ROM provided time and cost savings that the instructor-led educational systems could not, and helped to reshape the educational industry. Despite the benefits, the courses powered by multimedia lacked instructor interaction and dynamic presentation making the experience less than satisfying and slower and less engaging for students. Subsequent advancement in technology gave rise to e-Learning systems that facilitated live instructor led training via the Internet which could be combined with real-time mentoring and improved learner services.

The e-Learning industry by itself has also experienced various stages of transitions. Early forms of e-Learning were the result of material being transformed into the electronic medium. Its benefits in terms of flexibility, self-paced learning as well as savings in terms of cost could not be overlooked. As e-Learning began to mature, critics pointed out issues such as isolation and importance of interaction in the context of learning. Evolution of e-Learning into Learning Management Systems addressed some of these criticisms (Wesley, 2002). However, apart from being adaptive, such systems needed to combat challenges such as curricula development, quality assurance, continuing professional development, and mutual recognition (Enemark, 2005). Moreover, we notice that increase in sophistication of management of the e-Learning system does not necessarily address

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all needs of the students.

Let us imagine a scenario of a student using the conventional e-learning systems where he enrolls for a course say, 'algorithms' and opts to receive a 'certificate' for it. He is compelled to study all parts of algorithms although his specific interest lies in dynamic programming, which he wanted to study at an advanced level. He would have preferred to study parts of the course using practical working examples. He would want to know about the preferred job opportunities, interest areas as well as learning approaches associated with the course he is pursuing, about which he does not have information.

Conventional e-learning systems do not attempt to satisfy these diverse needs of the students. These needs manifest themselves in terms of flexible ways of pursuing courses that encompass design and delivery of courses.

2 OBJECTIVE

Considering the needs of students, approaches adopted by current e-Learning systems and also the challenges faced by them, we highlight the two main objectives for our work:

- To propose a framework which structures course contents that facilitate flexibility as well as maximize learner's satisfaction. The proposed framework would facilitate flexibility and be adaptive to all prevalent scenarios. It would also use inputs such as expertise, interest and job preferences entered by students during entry tests in order to counter challenges imposed by planning the modularization of courses.
- To enable such a system with Data Mining which employs predictive analytic techniques to generate recommended Student preferences, Institutes partnerships and Course coordinators' content design functions.

3 COMPARATIVE STUDY OF EXISTING E-LEARNING SYSTEMS

A number of e-Learning systems exist and we present a comparative study of four of the more prominent of these, namely VirtualU [1], LearnLoop [2], WBT Systems [3] and NETg [4]. This study brings to the forefront that these applications, while maintaining high levels of quality in provided content, have issues that remain unsolved.

The systems being compared in Table 1, display various inabilities on the basis of attributes of comparison such as flexibility, technology used and cost. The systems also exhibited other flaws:

- The systems that act as Internet Application providers do not provide the client with control. The client manages hosting of e-learning systems through back-end administration site using standard web browser. Flexibility of the systems is also handled by the provider so may not meet desired standards of the clients and would not be easy to modify.
- For open source systems, maintenance is questionable. Since multiple people are involved with its development, authenticity of source code is questionable. Moreover, the systems that are built on integration of components face issues of efficient information exchange between the various components.

These limitations lead us to propose an Intelligent e-Learning Systems (*IeLS*) framework as described in the following sections.

4 *IELS* FRAMEWORK

IeLS adopts a component-based approach for both design and development. It consists of a presentation component, a data mining component, a business logic component, a content management component and a database component as illustrated in Figure 1.

4.1 Role of Data Mining Component

Data Mining is performed by analyzing the data related to students, course coordinators and the institute, as depicted in Figure 2. This is done to generate recommended preferences for all the above actors of the *IeLS*.

4.1.1 Students' Perspective

Association Rules would be employed to organize historical data collected by the *IeLS* with respect to the students for:

- Predicting interest areas for a particular course based on analysis of past preferences.

[1]http://www.virtualsystems.com

[2]http://learnloop.sourceforge.net

[3]http://www.wbtsystems.com

[4]http://www.netg.com

Table 1: Comparative study of Existing e-Learning Systems.

	VirtualU	Learnloop	WBT Systems	NETg
Technology	Internet App Provider, use clients site to enable VirtualU features. Client uses browser for back-end administration.	Server side -PHP. Client -JavaScript MySQL-database stores information.	Learning Object Architecture using TopClass e-Learning Suite.	KnowledgeNet Platform integrates learning & content management.
Flexibility	At discretion of VU, not the client.	More flexibility, no requirement for plug-ins.	Provides modular flexibility. Enables integration with authentication policies.	Enabled by features like Interact Now & Search Now.
Cost	Faculty pages :$750 Student pages :$550 Password protect :$250	Freely available.	Depends on Implementation.	Depends on Implementation.

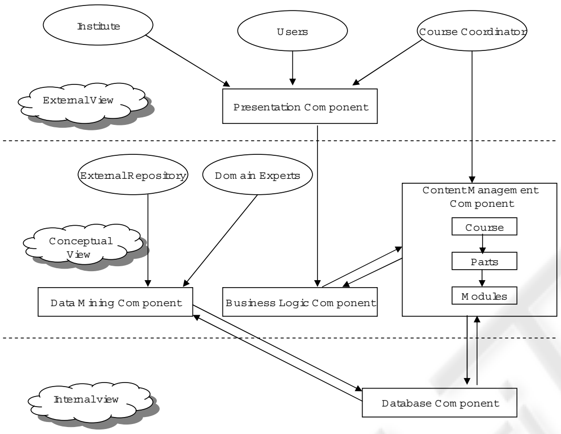

Figure 1: Framework of *IeLS*.

- Predicting of job opportunities for a particular course based on analysis of data on industry needs, quality of students who have pursued such courses in the past as well as economic policy prevalent in the country.
- Prediction of learning approach that could be adopted by the students based on past data on preferred learning methods for those courses.

Association Rule Discovery

Association rule discovery finds relationships or affinities between item sets. Each transaction consisting of a set of items could be considered as an item set. Here, the action of a student selecting a particular course is considered to be a transaction. The Association rule is composed of two item sets called the Antecedent and a Consequent. The rules are displayed with an arrow leading from the Antecedent to the Consequent (Ye, 2003). In this case,
$\{Course\ Name\} \rightarrow \{Job\ Opportunity\}$
$\{Course\ Name\} \rightarrow \{Interest\}$
$\{Course\ Name\} \rightarrow \{Learning\ Approach\}$
This association rule is accompanied by two statistical terms to describe it, namely *support* and *confidence*. These can be defined as follows:

Example 1: Let D be the database transactions of selecting the course 'Computer Science'. Let N be the number of transactions in D. Each transaction in D is an item set. Let X be the event of choosing of Job Opportunity as 'Software Architect' by the student choosing 'Computer Science' as his course. Then Support(X) is the proportion of transactions that contain item set X, i.e. $Support(X) = |\{I|I \in D \wedge I \supseteq X\}|/N$, where I is an item set and $\|.\|$ denotes the cardinality of a set.

The Support of an association rule is the proportion of transactions that contain both antecedent and the consequent. The Confidence of an association rule is the proportions of transactions containing the antecedent that also contain the consequent (Ye, 2003).

Example 2: For an association
$\{Course\ Name\} \rightarrow \{Job\ Opportunity\}$, i.e., $C \rightarrow J$
$Support(C \rightarrow J) = Support(C \cup J)$
$Confidence(C \rightarrow J) = Support(C \rightarrow J)/Support(C)$
Hence the Institute would set minimum bounds on support and confidence measures. If the support for the job of software architect crosses the minimum bounds then it would get listed as the one of preferred job opportunity.

4.1.2 Course Coordinators' Perspective

Association rules would again be employed by the *IeLS* to organize historical data for Course Coordinators. Here they would analyze preferences of students with respect to difficulty levels that they opt for a particular module. Hence it can suggest to the Course Coordinator to deliver modules at the most preferred

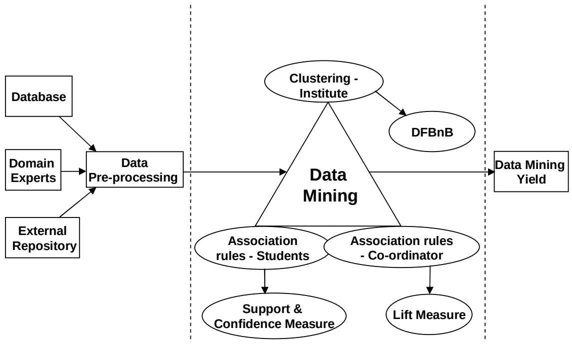

Figure 2: Data Mining Layer Functionality.

level of difficulty.

Measure of Interestingness: In this case, in order to study the difficulty level preference, a finer level of granularity is being adopted; we need to reduce the number of association rules identified so that only the most interesting ones are analyzed. This is done by employing a popular measure of *interestingness* called 'Lift' (Ye, 2003).

Lift: Lift is defined as the ratio of the frequency of the consequent in the transactions that contain the antecedent over the frequency of the consequent in the data as a whole.

Here the association rule would be, $\{Module\ Name\} \rightarrow \{Level\ of\ Difficulty\}$ i.e. $M \rightarrow L$

$Lift(M \rightarrow L) = confidence(M \rightarrow L)/support(L)$

With this we would be able to determine the preference of students with respect to levels of difficulty for particular courses.

4.1.3 Institutes' Perspective

Conceptual Clustering would be employed to organize the historical data collected by the *IeLS* with respect to the Institute for:

- Designing of Marketing strategies to be employed for the launch of new courses.
- Studying performance of students belonging to various streams as well as thee economic trends prevalent in the country to decide the Institutes partner both other educational institutes as well as organizations.

Conceptual Clustering: This could also be applied in the case of decisions regarding partnerships. The conceptual clusters would be the groups of target audiences for whom the new courses would be launched. We would then use *partitional* clustering algorithms on the conceptual clusters hence developed to partition them into mutually exclusive clusters (Jain and Dubes, 1988).

Depth First Branch and Bound Searching: We would then use the cluster generated by conceptual clustering which is most appropriate for that particular new course to be launched.

Starting at an initial node which is associated with a global *upper bound*, which is the cost of implementing the marketing strategy on that space. DFBnB, selects the node generated next or the deepest node to be expanded next. Whenever a node is reached whose cost is less than the *upper bound*, the latter is revised to the cost of this new leaf.

Hence we reach an optimal target audience group, the cost to implement a marketing strategy for who would be minimal.

4.2 Role of Other Components

The Presentation component is accessed by the users of the *IeLS*, namely students, the Institute and course coordinators.

The Business Logic component is the Controller component of the framework. It serves as the logical connection between the user's interaction through the presentation component and the database component.

The Content Management component plays the role of a centralized repository to handle all content related information of courses, parts and modules. This also archives references materials that are indexed by keywords.

The Database component is fragmented into student database, coordinator database, institute database and a database to store course related information.

5 *IELS* IMPLEMENTATION

The Intelligent e-Learning System was implemented using PHP as the front end and MySQL to manage the database. The most important feature of the system is modularity. Various functionality such as Registration, Entry Test, Tutorials and Guestbook facility have all been designed and implemented as individual modules. Hence scalability as well as extensibility in terms of performance of the system is very sound.

5.1 Course Design

Course Path is chosen by the student initially when he tailors his course by giving his preference regarding various parts and choosing various modules based on his preferred level of difficulty. This could be altered by him at any point of time through the duration of the course.

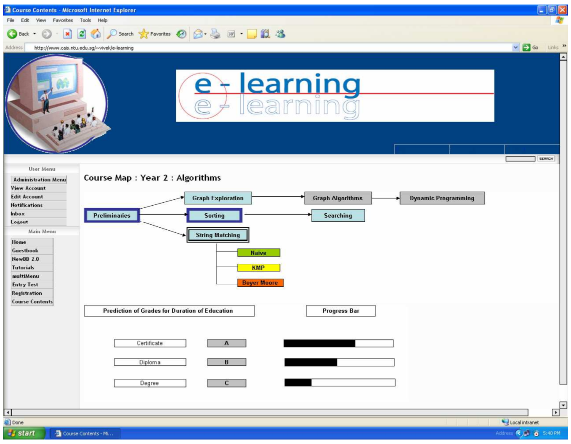

Figure 3: Intelligent e-Learning System Implementation.

The screen-shot in Figure 3, depicts the Course Map of a student who has chosen the course Algorithms. It consists of various Parts, the arrows depicting the direction of *temporal dependency* between the various parts. Here, the parts in blue that have been bolded indicate they have been pursued. The other parts in blue indicate ones that could be pursued at that point of time. The parts that have been grayed out indicate ones that could not be pursued as the parts on which these are dependent temporally have not been covered yet. The one with double border indicates the students' current selection. The sub components of the currently selected one are the Modules which have been categorized as Basic, Intermediate and Advanced.

5.2 Evaluation Mechanism

The System also predicts the grades associated with the kind of award he would obtain, which could be a Certificate, Diploma or Degree. There is a hierarchy in the awards and the grades predicted follow the same hierarchy which is monotonically non-increasing. The system also generates a *progress bar* associated with very kind of degree. The progress bar indicates the threshold in terms of completion of required parts for a particular course or completion of required courses for the entire duration of education.

5.3 Learning Approaches

Education would be delivered to students using either synchronous or asynchronous modes. For students who are not connected to the system at all points in time, teachers and students may communicate asynchronously (at times of their own choosing) by exchanging printed or electronic media or when they use technology such as Internet that allows them to communicate in real time then it would be using the synchronous mode. The e-Learning system may use two innovative approaches in order to impart education to the students.

The Interactional approach requires the student to form peer communities with other students pursuing similar courses. They could then use e-bulletin boards to post their queries which would be answered by students themselves. Alternatively, the interactional approach could also be followed when the student communicates with the course coordinators for queries and problems.

The motivational approach in turn consists of two ways which are reward motivated and recognition motivated. Reward motivated would consist of a system where the student would be incentivized with reward points for the successful completion of every module test.

For high aspirers, the system could award them with relevant diploma or certificates for the completion of each part of that particular course. This would be the recognition motivated approach.

6 EVALUATION OF *IELS*'S FUNCTIONAL EFFICACY

Success of the implementation of any e-Learning systems would be determined by the degree to which structural and technological issues have been overcome (Nunes and McPherson, 2006). Here we evaluate the design and delivery of the *IeLS* learning system by judging how it has supported an efficient learning process. We use the famous taxonomy devised by Benjamin Bloom which is considered an extremely valuable attempt at classifying the learning process (Bloom, 1956). It lists four major categories of learning. We then map features of *IeLS* that satisfy Bloom's categories, and evaluate the framework with respect to some quantifiable parameters.

6.1 Cost

The costs are estimated with a fair degree of accuracy and are done in the following categories:

- Implementation costs: These are calculated by considering the cost involved with *IeLS* with existing educational systems in the institution. Since *IeLS* is very modular and exhibits low cohesion it

Table 2: Evaluation of Functional Effectiveness of *IeLS* based on Bloom's Taxonomy (Bloom, 1956).

Category	Bloom's context	Mapped Feature of *IeLS*
Knowledge	Ability to recall facts, rules and concepts.	Periodic Evaluation tests for both Modules and Parts.
Comprehension	Ability to understand facts and concepts.	Adopting Learning Approach as per the requirement of the Course content or need of student enables understanding.
Application	Ability to use facts and concepts to solve problems.	Case studies, lab sessions, bulletin boards enable putting the gained knowledge to use.
Synthesis	Ability to integrate components into whole.	Ability to choose components of diverse backgrounds, mapping to student's interest.

is very easy implementable and these costs are estimated to be negligible.

- Start up costs: These are estimated to be zero as there is no requirement of purchase of external components either in the form of software plug-ins or hardware devices for the implementation of *IeLS*.
- Operating costs: These are estimated in terms of the maintenance costs of a workable system, and are negligible, since *IeLS* is developed using open source components such as PHP and MySQL.
- Expenses incurred by Course coordinator: Staff involved with development of the course content would not put in any time that are not budgeted for in the instructional costs (Knapper, 1980) as they would simply be providing the URLs of their course material as values to the relevant column of the course content database.

6.2 Time

- Learning Time: This would vary with the speed adopted by the student and the nature of education he wishes to pursue.
- Accessibility Time: This is considered to be zero as the entire system is Web based and hence the students could reach both instructors as well as Course content at any time they wish to.
- Evaluation Time: Periodic Tests that are conducted to evaluate the students could be done so at the initiation of the student, and he could also choose to end the test as per his convenience after which he would be evaluated based on the Parts covered.

6.3 Acceptance Criteria

The *IeLS* Framework was constructed based on the study of student preferences regarding the most desired features of an ideal e-Learning system and hence it conforms well to their requirements. So acceptance of such a system can be estimated to be over 95%.

7 CONCLUSION

The framework of *IeLS* was developed that structures course contents to facilitate flexibility as well as maximum learners' satisfaction. This framework is adaptive to technological advancements. It is enabled with data mining functionality that uses predictive analytic techniques to generate recommended student preferences, institute partnerships and course contents.

REFERENCES

Bloom, B. S., editor (1956). *Taxonomy of educational objectives: The classification of educational goals. Handbook I, cognitive domain*. Longmans, Green, New York.

Enemark, S. (2005). Global trends in surveying education - and the role of FIG. *Azimuth*, 43(3):19–21.

Jain, A. K. and Dubes, R. C. (1988). *Algorithms for clustering data*. Prentice-Hall Inc., NJ, USA.

Knapper, C. K. (1980). *Evaluating Instructional Technology*. Croom Helm, London.

Nunes, M. B. and McPherson, M. (2006). Organisational issues for e-learning: Critical success factors as identified by HE practitioners. *International Journal of Educational Management*, 20(7):542–558.

Wesley, D. (2002). A critical analysis on the evolution of e-learning. *International Journal on E-Learning*, 1(4):41–48.

Ye, N., editor (2003). *The Handbook of Data Mining*. Lawrence Erlbaum Associates.