A framework of Intelligent Tutorial System to incorporate adaptive learning and assess the relative performance of adaptive learning system over general classroom learning

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Abstract

This paper presents a framework of intelligent tutorial system to incorporate adaptive learning and assess the relative performance of adaptive learning system over general classroom learning.

In conventional classroom teaching and in distance learning the students may be from different backgrounds, their need of study and goal may be different; above all their ability to learn may not be similar. So teaching style and fitting teaching material may differ from student to student.

A layered architecture of an Intelligent Tutorial System [ITS] for adaptive learning is proposed that assess the requirement, goal and capability of a student and dynamically sets a path for study, the instruction materials are dynamically selected as per the student's level of understanding from a given set of instruction materials. The system monitors the student and changes the path of study automatically as per the performance. Formative and summative test are taken by the system for decision making – as to which material is best for student and for assessing student's understanding level. The system also intelligently helps the user to overcome the misconceptions, as human teacher.

Experimental results show the impressive improvement of the performances of students in distance mode learning using ITS following the proposed framework.

Keywords: *Adaptive Learning, Distance Learning, Intelligent Tutorial System [ITS].*

1. Introduction

In recent times due to increasingly rapid technological and social change, a lifelong education is needed by the society. With increase in number of students in comparison to number of teacher and due to limited education facility and to cope up with the different social needs and challenges education requirements are increasing day by day. Many a times, it becomes impossible for face to face learning to provide proper guidance to all. The society requires changes in educational process, and introduces new form of education, training and new skills, so a demand for non-traditional learning environment arises. The new mode of education – Distance education which has been introduced few decades ago plays a very

important role in imparting education to the present society by giving lifelong education as it makes learning and training more accessible, convenient, effective and more cost efficient for learners and for education providers.

Of the many ways of distance education, computer based [standalone or server – client based] learning has proved to be the most effective one, in which human teaching styles can be incorporated in computer based tutoring. Computer based learning is self-based and self-paced learning. Computers have been used for educational purpose for over four decades. The terms computer aided instruction (CAI), computer based training (CBT), web based instruction (WBI), and web based learning has emerged. They are all computer based learning supports. A computer plays the role of instructor and delivers the knowledge in different formats such as texts, animations, simulation and multimedia to the learners in some sequence.

Though these computers based systems help in learning, but they have some drawbacks. These systems are not concerned about student's needs, goal and ability. Different students have different background, individual knowledge, different learning styles, learning rates and various needs. So the way of teaching and learning are different[6]. To understand students and to make teaching more like human tutoring, intelligence and pedagogy are put in the computer based tutorial system

A framework based on adaptive learning on Intelligent Tutorial System [7] is proposed here. A comparative study with adaptive learning [4] and general classroom teaching has been carried out.

The work is focused on building an Intelligent Tutorial System [ITS] which uses a layered architecture[5] of adaptive learning to address some of the problem/drawbacks in traditional computer based learning system in conducting one-to-one learning. Pedagogy and intelligence are being tried to incorporate into the Intelligent Tutorial System. Using this the ITS will evaluate individual student's merit and accordingly serves the proper material to the student. This continues until the performance level of the student becomes satisfying.

The system takes information regarding the knowledge level of the student, if possible a pre-test. Based on the result of pre-test the system decides what category of material need to be served to the student. Each instruction material are designed and developed into number of forms – categorized into levels. Based on the category / level an instruction material of a module may be described from very elaborately to a concise form. The student studies the material of a module which comes in frame by frame covering one or more topics.

The system monitors the performance of the students. The performance evaluation is done time – to – time and according to the performance, the system rethinks about the way of teaching [3]. Different tests are being taken by the system in the entire course of learning to judge the student's performance. They are pre-test, formative test, and summative test. Pre-test are taken to assess the knowledge level status and thus deciding the level of material to be delivered/provided to the particular student. Formative tests are taken after each frame is completed by student and before moving to the next frame. The summative tests are taken at the end of each module. The tests are based on Bloom's taxonomy [2]. According to Bloom there are six classification of learning – Knowledge, Understanding, Application, Analysis, Synthesis and Evaluation. But the system uses only three levels of Bloom's taxonomy, they are

Knowledge, Understanding and Application. Thus the questions checks knowledge level, understanding level and application level performance of the students.

The system assesses the performance of the student by a formative test after each frame is completed and before going to the next frame. After assessing the result, system rethinks on whether to continue with same frame or move to the next frame and with what level or category of material is to be provided. The category of the material may be changed if the system thinks that the current category of material does not suit the student. But before continuing students' misconceptions are cleared. In this way the student completes the module.

At the end of module a final or summative test is taken by the system. Taking the summative test result together with formative test results the system evaluates the performance of the student and decides whether to continue with the same module or move to the next module and with what category of material.

In this way the system tries to overcome some of the problems faced by the students using an adaptive learning. Studies indicate that this way of teaching is more effective than general sequential classroom teaching by comparing two standard deviation and performing t-test on the final test in both the systems.

2. Layer Architecture of ITS

The framework is focused on building of an Intelligent Tutorial System [12][11] which uses Layer architecture[10] of adaptive learning. Using this it will evaluate individual student's merit and accordingly serve proper material to the student. This continues until the performance level of the student is satisfactory.

Layering allows the implementing system to be likely to guarantee the end-user quality of service while taking advantage of adaptability and interaction support. Level-based decomposition allows functional separation and allows adding new functionality to the system whenever necessary.

This Layer architecture has been created to deal with problems faced by the students and to guide them in a way, so that they can find the proper path of solution and can smoothly complete their learning to increase their knowledge.

The different layers are:

- Information Gathering Layer
- Decision Layer
- Tutorial Layer
- Assessment Layer
- Analysis and Evaluation Layer

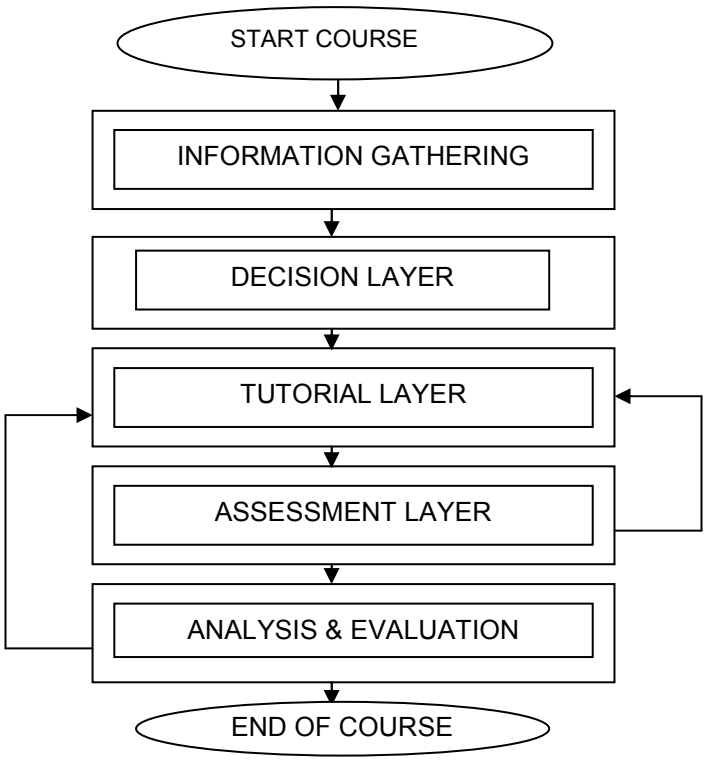


Figure 1. Basic LAYER architecture of the proposed ITS

2.1. Information Gathering

This layer assesses the status of student's prior knowledge by taking student's feedback followed by an optional test. The student's feedback is taken to know whether the student is having any prior subject knowledge or not. Student having prior subject knowledge are taken a pre-test to measure the knowledge level. The questions of the pre-test are composed and arranged based on Bloom's taxonomy (knowledge and understanding level). Students obtaining more the *x*% marks in pre-test are considered to have prior knowledge or otherwise not. Where *x* is variable whose value set by the instructor/teacher or expert.

2.2. Decision Layer

Information obtained from Information gathering layer such as student feedback and the results of pre-test are analyzed in Decision layer to decide what type of tutorial will be served to which student.

All the modules of the tutorial are made up of more than 3 different categories/types. These categories are formed according to easy to advance learning. Assuming the categories / types are of 5 levels as level-1, level-2, level-3, level-4 and level-5. Where level-1 is very easy and level5 is advanced level. The easy and advanced are distinguished according the way the instruction material is written and designed.

Here level-1 materials are very atomic, very illustrated and simple and where as level-5 category materials have instructions in advanced mode. In the same way level-2, level-3, level-4 category tutorials are increasingly higher standard. Level-2 is assumed to be the beginning level module for students with no subject knowledge, whereas level-3 is assumed to be the beginning level module for students with prior subject knowledge.

Thus student having prior knowledge as decided in previous layer, are provided with level-3 category material. Others (with no prior knowledge) are provided level-2 category material.

2.3. Tutorial and Assessment Layer

After making a decision in decision layer, the material of the decided category or level is provided to the student. The deliverable modules of learning material are divided into number of frames. Each frame consists of one or more small related topics. Each frame is built on the rules of programmed instruction [PI], as:

- The content is presented in small chunks.
- Content is organized in a simple to complex chunks
- The learner responds and receives feedback.
- Correct response can set his/her own pace.
- The path of instruction is linear.

The learner progresses by responding correctly, receiving feedback, and moving forward. If the response is incorrect, the learner repeats the instruction until there are no mistakes. This allows the learner to set his own pace. The instruction is linear with no path diversion from the directed instruction.

After completing each frame of module, the system assesses the student at frame level with a formative test. The formative test contains mostly knowledge level questions, this is because knowledge level test confirms that whether the student can recall a fact or not, but as the study proceeds the student must have to face understanding and application level questions. And while assessing, it should be keep in mind that, if a student get very less marks in knowledge level, he should not be get passed to next frame though he got higher marks in understanding level as performing poor in knowledge level questions assures that the student has not studied the frame properly. Obtaining marks less than y% (y is variable set by the teacher/instructor, and must be less than 90%) will be supplied by the same frame again of the easier level. For example if a student fails in a level-3 frame, he/she will be supplied level-2 frame of the same topic. Students of level-1 frame, will be supplied with the same frame again as no other easier category frame exists.

Student obtaining more than y% are provided with the frame of next topic of same module from the same or higher level depending upon the decision parameter P. Where P is decided by the instructor / teacher which can be the marks obtained in the previous test/s.

In either cases of obtaining marks more than or equal to *y*% or less than *y*% each mistake[1] done in the formative test is explained very elaborately with maximum number of examples if possible, before moving next.

After all the frames are completed, the student is taken for a summative test. The summative test contains questions, which checks the knowledge level, understanding level and application level of the student.

2.4. Analysis & Evaluation Layer

In this layer student's formative test (frame test) and summative test (module test) results is collected. If the summative test result is less than *z*%, it is assumed that, some misconceptions are still present in student's mind. Thus the same module is provided to the student with an easier category. Otherwise the student is provided with the next module with category as decided by the following decision parameters:

- If average of the percentage of collective formative test marks and percentage of summative test is less than equals to *S*% and $N >= L$ then next module with one level easier category than current one is provided.

- If the present module's category is the beginning one or the easiest level, then next module is provided with the same category.

- If average of the percentage of collective formative test marks and percentage of summative test is more than *T*% , and having similar test records in the immediate previous consecutive few modules with $N < L$, then next module will be provided with higher category.

Other than these the student will be provided next module with same category.

z is summative test passing parameter, whose value is set by the author/instructor/expert.

N = Number of formative test appeared / Total number of formative test.

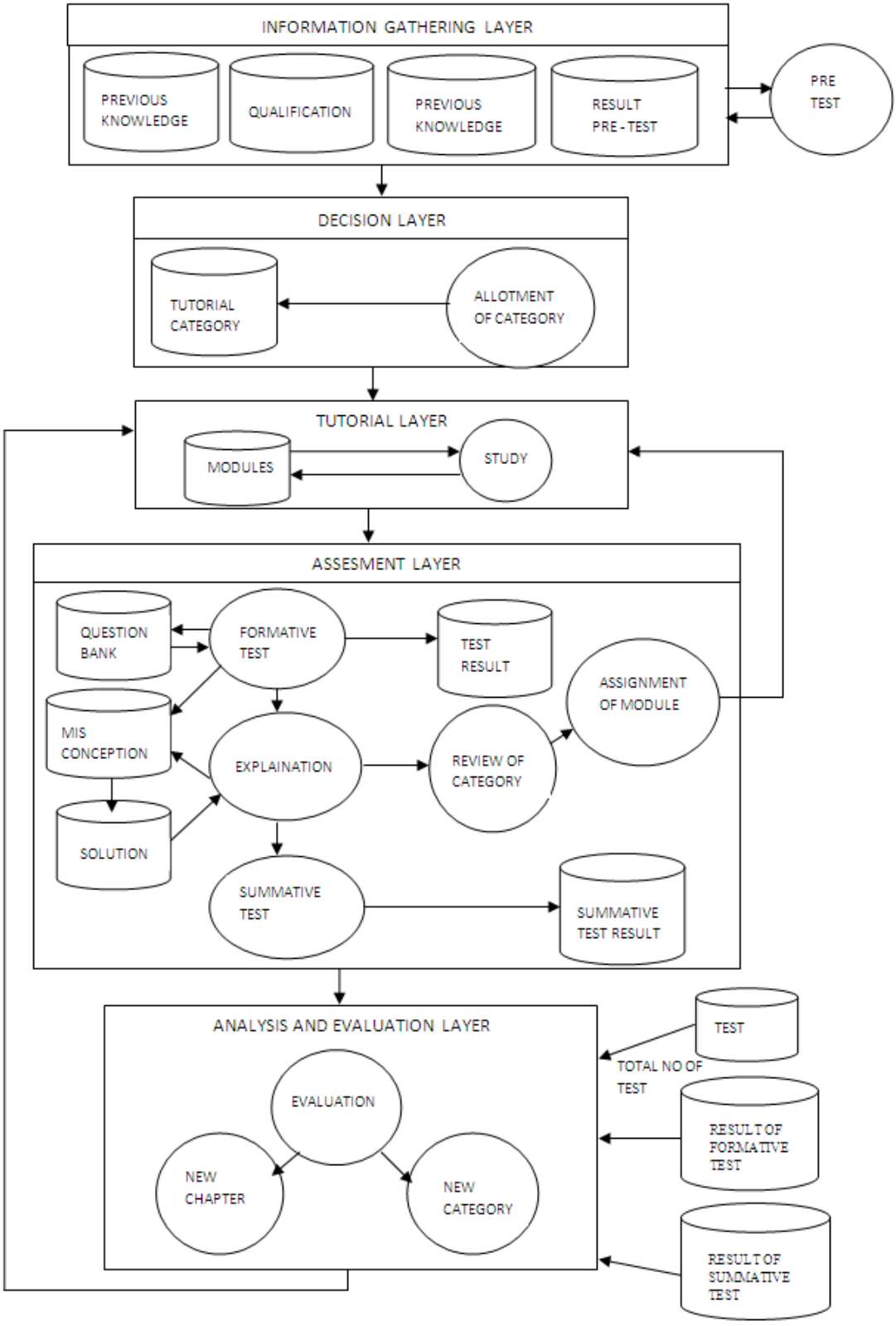
L is a variable, whose value is set by the author/instructor/expert, and must be greater than 1.

S is the average percentage marks of both collective formative test marks and summative test percentage and is set by the author / instructor / expert.

T is the average percentage marks of both collective formative test marks and summative test percentage, it's a high value percentage (assuming 80%-100%), that decides the obvious change of deliverable module category to a higher order. The value of *T* is set by the author / instructor / expert.

In all the cases, before moving to the next module or continuing with the same module, each mistake done in the summative test is explained very elaborately with maximum number of examples if possible.

3. General Architecture of ITS



4. Comparison of Adaptive Learning [Using Layered ITS] over Conventional Learning

Student of strength twenty are taken class on two modules on a technical subject, using both classroom teaching method as well as ITS with layered architecture (Adaptive learning). Among the two, one module is taught in face-to-face mode and the other module is taught using ITS. The module delivered using ITS system was categorized in to five levels as Level-1, Level-2, Level-3, Level-4, Level-5. Each are further divided into multiple frames. At the end of completing the modules, tests are taken on the modules. In case of classroom teaching it is class test and in case of ITS it is formative tests after completion of each frame in the module followed by a summative test at the end for the entire module.

4.1. Class Test Performance

Range of Marks	Number of Student
>=60%	2
50% - 60%	2
40% - 50%	8
30% - 40%	6
<30	2

Highest marks – 74%

Lowest marks – 26%

The above data shows that, marks are very scattered and most of the students are in lower range of marks.

4.2. Summative Test Performance (using ITS)

Range of Marks	Number of Student
>=90%	6
80% - 90%	11
70% - 80%	2
60% - 70%	1

Highest marks – 96% , Lowest marks– 66%

The data set shows that the level of performance of same student has been improved a lot. The results of different category students are very close enough.

Thus analyzing the result of general learning and adaptive learning [8][9], it is found that, the results of the two differ vastly.

Now the question is – Did the adaptive learning approach results in better learning.

From the results it can be seen that marks are in scattered form [huge gaps between marks] in general learning system. This is because general classroom teaching does not able to reach every students' full understanding due to the presence of different category of students having different understanding, ability, background, learning styles, different level of concentration and attention to the teaching. There may be problem in lecture delivery, way of teaching or understanding the lecture. But after adaptive learning all the students' performance level increases, as a result almost all students obtained higher range marks.

The standard deviation obtained in the two mode of learning Class room teaching or general learning vs. Adaptive learning is as:

General Learning	Adaptive Learning
11.9572	7.7289

The comparative result of standard deviation shows dispersion of marks has been reduced in adaptive learning. By applying adaptive learning most of the students scores marks in the higher range, thus less dispersion between marks obtained and hence less deviation.

The mean value of test data result set obtained from Class room teaching and Adaptive learning is as:

General Learning	Adaptive Learning
43.35	84.5

Increasing mean of marks in case of Adaptive Learning substantiates overall improvement of score.

The mode value test data result set obtained from Class room teaching and Adaptive learning is as:

General Learning	Adaptive Learning
48	82

It indicates that maximum number of occurrence of marks has increased.

The median value of the test data result set obtained from Class room teaching and adaptive learning is as :

General Learning	Adaptive Learning
43	86

The median value of scores has changed from General Learning – 43 to Adaptive Learning – 86 indicates that the middle most score has increased from lower half to upper half of the range of score.

4.3. t-Test

Paired t-test has been performed since the respondents are same for both the learning process. So traditional t-Test cannot be applied.

$t = \overline{d} / (S . e.(d)/\sqrt{n})$

$= 41.42/ (8.51/\sqrt{20})$

$= 21.99$

The tabulated value for 99% confidence interval (0.01 significant level), value of t is 2.54. As the calculate value > the tabulated value. So in this case we are rejecting Null Hypothesis. Hence we can say that Adaptive learning has beneficial effect.

Now it requires analyzing why this large difference of result happened. This is because of adaptive learning. The same groups of students are taught in two different ways. While one module has been taught by using adaptive learning method and another is by general learning.

In the beginning of study by using adaptive learning the category of module to be delivered is set and which in terms decides how to teach, where as in face-to-face mode all the students taught in the same teaching style.

While using adaptive learning a module is taught until the performance of the student is satisfactory. The way of teaching varies with the modules depending upon the student's level of understanding. At the end of the module the conception level of the student increases and so his performance level.

5. Conclusion

Conventional or face-to-face learning mode was considered as main mode of teaching. As the demand of the learning increases new mode/techniques was required beside the conventional way of teaching and hence distance mode of education came up. The Intelligent Tutorial Systems available generally have limited teaching styles and thus stand no contrast against the varying teaching styles a teacher adopts on assessing the students' reaction in a conventional classroom teaching. A teacher adopts various ways with various examples to make his/her concept clear to student. This very idea is framed in the layered framework for the ITS system, where the teaching styles/instructions are dynamically varies, based on the students' reaction. This framework on implementing proves to be very efficient in teaching process to the students of different background and ability and hence proved to be better than other mode of distance education.

But the question is whether it is better than general classroom teaching. Perhaps the answer is more arguable. The general classroom teaching is always better as it motivates the students, but when student-teacher ratio increases, the teacher can not reach each student and thus often

fails to reach the goal. In other cases like due to the presence of different category of students having different ability, understanding, background, learning styles, different level of concentration and attention to the teaching, language problems in lecture delivery, lack of teaching skills or other difficulty of understanding the lecture the general classroom teaching does not meets every students' full understanding.

In these situations the students' feel frustrated and bored and often try to skip the learning chapters and hence gaps in education do come in. The Intelligent Tutorial Systems with the layered framework if run along with class room teaching in controlled manner as an aided tool will help to reach the education to each student with no matter what background s/he may have. This makes student more interested in study and will stop skipping the classes and teaching.

It can be concluded that Intelligent Tutorial System with layered architecture can be effectively used in distance education and as well as aided tool along with conventional class room teaching.

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