

## Performance Improvements in Schools with Adaptive Learning and Assessment

Raghu Raman, Prema Nedungadi  
School of Engineering  
Amrita Vishwa Vidyapeetham  
raghu@amrita.edu prema@amrita.edu

**Abstract**— This paper presents Amrita Learning, a web-based, multimedia-enabled, Adaptive Assessment and Learning System for schools. Computer-based adaptive assessments aim to use an optimal and individualized assessment path to determine the knowledge level of students. The new goal for adaptive assessment is based on educational outcomes, which describe what learners must be able to do as a result of items studied. Assessment based on outcomes creates the initial roadmap for the educational model, ensuring that students are not learning items that are already mastered. Learners and instructors can accurately determine their areas of strengths and weaknesses, and use this to determine future instruction.

This paper explains the underlying principles used in the initial adaptive assessment followed by evaluation that is closely interwoven with learning. An expert module continuously adjusts the content and method of presentation based on the sequence of learner's recent responses and prior knowledge. The system maintains and updates both the individual learner profile and group profiles.

Amrita Learning, targeted to school students, is built upon the principles of spiral learning with mixed presentation from multiple skill areas, thus providing continuous reinforcement in all skill-areas.

The proposed competency model has been pilot tested in both city and rural area schools. In the majority of cases where students used it consistently, there were quantifiable improvements in learning levels and performance in schools. Summaries of the results and recommendations are included in this paper.

**Keywords:** *Adaptive Learning, special needs; ICT; Assessment; Continuous Evaluation; individualised instruction; Intelligent Tutoring Systems Spiral Learning; Mixed Presentation; Interactive; Flash Animations; Mastery Learning;*

### I. INTRODUCTION

Rural India has many challenges for education and assessment. A large percentage of the kids here drop out or are unable to cope with studies in middle and high school and hence we see a great need for intervention at the formative years. Intervention starting when they are young should increase the percentage of those going for higher education. There is very little technology enabled content that is context sensitive and language specific for these children.

Students learn in different ways and at different rates. Some students may be very strong in one academic area, but weak in others. Therefore, the weaker student or the student

who learns in a different way, and even some of the most creative students, fall behind and often drop out of the educational system. The teacher is unlikely to have the time to work with students and to individually assess their level of understanding or find out why they aren't learning properly.

A challenging goal is to study the effectiveness of an advanced, research-based adaptive and intelligent educational system to such learners. This paper describes the principles behind Amrita Learning, and the results of our pilot study with students in different states in India.

### II. ADAPTIVE LEARNING SYSTEMS

There is a great need for individualized courseware to provide educational content that fits to the learner's learning style and current knowledge base. Many researchers have addressed effectiveness of adaptive learning supported by student's profiles [10] [2].

Amrita Learning attempts to emulate a one-on-one motivating teacher who understands a student's knowledge level and learning speed, effectively responds to a student's needs and provides feedback to the class teacher and the student [5].

Intelligent class monitoring is used to identify the students who have learning records that are different from those of their peers [1]. These students may be different from others in many ways. They could be progressing too fast, or too slow, or simply need different tutoring. These students will get individual attention from the software.

We evaluated CD based programs and also looked at web sites with different types of adaptation frameworks. However, we were unable to find one that was suitable to the specific needs of over fifty Amrita Vidyalyam schools in India. This set of schools included leading schools in large cities, and small schools in rural villages with low parent literacy and lack of good teachers. The user interface had to be child friendly, the content needed to follow the National Standards but chunked and made culturally appropriate to fit the diverse types of backgrounds. The software was built in a web based model so that all student data and performance can be permanently tracked.

Generally Adaptive systems do not support free learning, whereas learning environments do not support intelligent environments. To make the system as flexible as possible, a blended model was offered, with the educator determining the mode of learning for a class or a student.

### III. AMRITA LEARNING - ADAPTIVE ASSESSMENT

A computer based Adaptive Assessment provides highly accurate results that can:

- Identify skills individual students have mastered
- Diagnose instructional needs
- Monitor academic growth over time
- Make data-driven decisions at the classroom, school, and district levels
- Place students into appropriate instructional programs

Amrita Learning uses an adaptive assessment algorithm to determine a student's prior preferences, knowledge, skills and attitudes. Questions from various subareas are presented to the students. Within each subarea, adjustments are continuously made based on accuracy and speed of response. Assessment ends when the right level has been found for each subarea. The time required for assessment is directly proportional to the deviation in learning level from the start of the test, i.e. it takes more time for the advanced and the weaker student and less for the student performing at the grade level.

### IV. AMRITA LEARNING – CONTINUOUS EVALUATION AND LEARNING

Intelligent tutoring systems study the challenges in developing an Adaptive and Intelligent Educational Systems [4]. Various types of Adaptive support have been used, such as adaptive navigation of education hypermedia [8] or adaptive ordering of content [9].

Amrita learning uses a student's data and preferences, builds an individual model based on the individual's preferences and knowledge, applies adaptive methods to accommodate each individual based on the student model, and monitors student performance and actions to update the student model, resulting in a more accurate and efficient model.

Amrita Learning continuously evaluates student performance, interaction, errors, updates the student model determines content and adjusts the pace of learning.

Studies [3] have shown that adaptive presentation increases student performance. Amrita Learning adapts

- the content by selecting the format or content
- order of content
- look and feel of screens and navigation flow
- feed-back loop including thinking clues, help, step-by-step hints, tutorials, pre-requisite and so on

Studies have shown positive results with adaptive ordering [6]. Amrita Learning uses automatic generation of unique learning path based on multiple factors including performance to provide much better individual instruction:

- Intelligently classified and graded content, to fine-tune the level of adaptation.
- Review of content based on performance and pre-requisite mapping
- Mastery learning.
- Spiraling of concepts.

With Amrita Learning, for every distinct sub-area, the students progress at their own pace and can either advance to topics ahead of their grade level, learn at the grade level, or learn remedial pre-requisite materials where mastery is needed for effective learning of current level. For example, a student could be at grade level in geometry, above grade level in multiplication and below grade level in word problems involving multiplication. Additional time and emphasis is automatically provided to the learner's lower level.

#### A. Key Features of Amrita Learning

With Amrita Learning the students progress at their own pace and can either advance to topics ahead of their course, learn at the course level, or learn remedial pre-requisite materials where mastery is needed for effective learning of current course. Teachers have complete control in creating, modifying, or choosing from an existing course curriculum.

The following are the key features for Amrita Learning.

- Supplements class room teaching
- Web based
- Adaptive Assessment
- Adaptive Learning after completion of Assessment
- Feedback mechanism for improvement
- Content aligned to National Standards

#### B. Technical Architecture

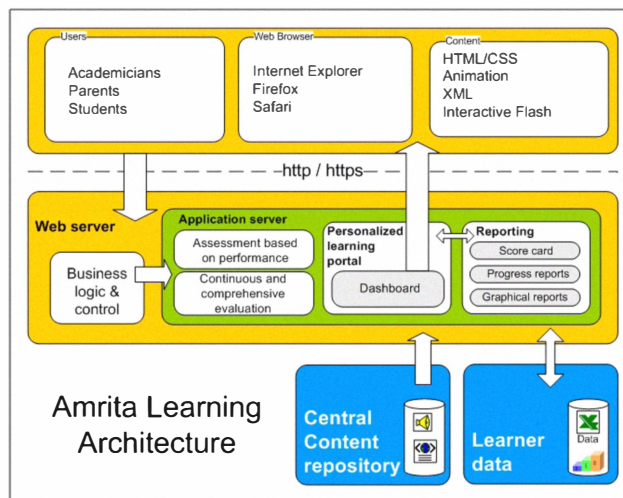


Figure 1. Amrita Learning Architecture

Amrita Learning has a modular design, where content, display and logic are cleanly divided. The front end is designed as flash pages, and users can access the system through them. The intelligent pedagogy modules use information about a student from the current student model and determine the content to be shown. The metadata for the content is stored in MySQL. Any learning objective can belong to multiple courses.

It is an extension of the basic intelligent tutoring model where knowledge about the domain, teaching and student profile is tracked and used [7].

The robustness of the Adaptive Learning platform refers to the complete system functioning with minimum downtime. The graphical user interface of the system is intuitive and easy to use. The scalability aspect refers to the fact that the system can easily extend to cover more content. It can also support 1000s of concurrent users under different bandwidth conditions. The portability of the system addresses the ease of extension of the system to various domains and systems.

**C. Learner Model**

The Learner Model includes the learner’s knowledge and may include characteristics and preferences of the learner. The aim of the model of the student is to get information about the user’s knowledge with respect to the topic the user wants to learn. This is evaluated by an initial adaptive assessment and updated with every session.

Amrita Learning tracks the learning style and state of knowledge of the learner.

**Content and Learning Object Design**

Amrita Learning content is designed by curriculum developers and subject matter experts to present the structure and content appropriate for a specified subject, level, and the pedagogical approach and content are tailored to be culturally appropriate for Indian schools.

Knowledge base consists of Learning Objects which are the content based on the subject and section and includes concepts, examples and tutorials. Learning objects include text, audio, video, graphics, animation or simulation. It also includes the Problem Base, which is the question bank, milestones and other criteria necessary for the adaptive assessment.

*1) Adaptive Learning as a classroom supplement*

Amrita Learning classroom resources help teachers directly apply test results to instructional planning. It helps teachers cater to the individual needs of each student. It can be used to assess or practice students’ understanding of various topics. They can easily verify whether the concepts taught are clear to the students.

The reports allow teachers to get information about the class, for example, the skill area that was difficult for the majority of the class, average improvement in skills from previous period.

Amrita Learning	Classroom Teaching
Tutorials (video, animation, text) introduce new concepts relevant to student.	present material that is class curriculum and applies to syllabus and average class level.
Practice various types of problems	Static tests applicable to class curriculum
Initial assessment of learner level and evaluation of ongoing learner performance	Assessment limited to class curriculum
Mixed presentation of materials that are being mastered.	Sequential Learning and Presentation
Modifies materials to learners’ responses	Modify materials based on classroom needs
Provides the teacher with detailed reports about the performance of each learner	Reports for tests based on class curriculum

**V. PILOT STUDY**

**A. PILOT STUDY - Evaluation Criteria**

The pilot schools evaluated Amrita Learning based on improvement in grade level, technology, product specification and ease-of-use.

Amrita Learning is available anytime, anywhere. With the SaaS model, the cost and speed of support is minimized. The student may use it on any type of computer using a browser.

**B. Pilot Objectives**

The pilot objective was to answer the following questions with a computer-based Adaptive Assessment & Continuous evaluation that was integrated with learning.

- How much improvement can be achieved?
- Make learning a joyful, self paced and interactive process?
- Support independent learning by students?

**Mathematics - Skill Areas Assessed**

Number Sense	Word problems
Addition	Measurements
Subtraction	Problem solving
Division	Geometry
Multiplication	Decimals
Equations	Fractions

**C. Teacher Training**

A two-phase training was provided to the teachers. In the first phase teachers were guided on various topics such as

- Diagnose instructional needs
- Monitor academic growth over time
- Make data-driven decisions at the classroom, school, and district levels
- Place students into appropriate instructional programs

**D. Pilot Findings.**

Though we have used Amrita Learning at multiple schools, we have chosen limited locations and student data for the data analysis.

**Students**

Students were highly motivated by the sense of achievement and repeated successes. (Figure 2) They liked success and they worked hard to earn it. They kept trying when they otherwise might give up in another context.

The majority of the students indicated that they were able to use the system almost immediately. The students from Class I and Class II needed some initial hand holding in using the headphones and operating the mouse. Students worked independently on the subject, and teachers were asked to encourage students to use the help or tutor.

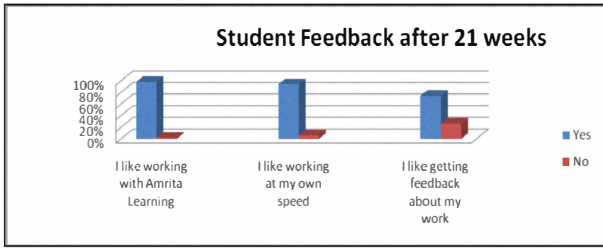


Figure 2. Student Feedback

Students and Teachers were enthusiastic about the ways in which the results were recorded and reported. Students really liked the fact they could see their own scores at any time. Students find it useful to know their areas of strengths and areas that need improvement.

1) Performance Tracking

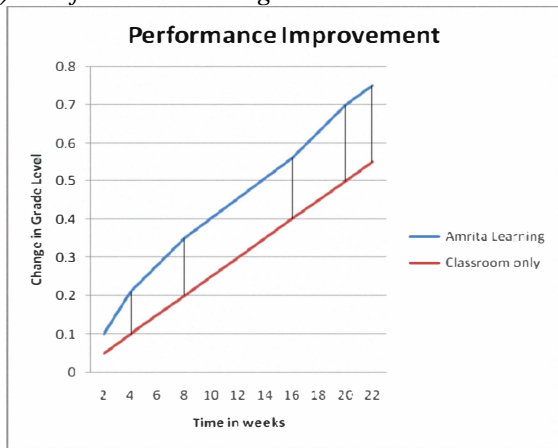


Figure 3. Grade Level Improvement

The grade level taught in the classroom based on curriculum was used as a baseline for increase in performance. The average increase in performance for the pilot students is shown below. Amrita Learning usage was based on 15 minute sessions, with 2 sessions every week. Classroom instruction was as in the weekly timetable of the school and based on the prescribed class syllabus. A school year consists of 10 months, and we assume that an average of .1 grade level of the curriculum is covered each month in class.

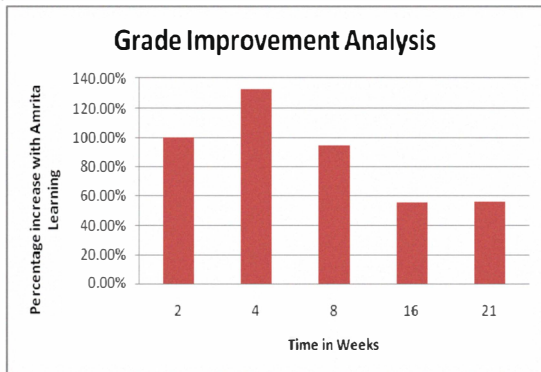


Figure 4. Amrita Learning compared to just classroom instruction.

It was observed (Figure 3) that the increase in grade level based on student usage of 2 sessions a week of 15 minutes each was consistently more than with just the classroom. It was further observed that in the 21 weeks of the pilot, the average increase in grade level from the baseline determined for the student was 87.92%.

Teachers

There was enthusiasm for Amrita’s Adaptive Learning Approach – the way in which the system breaks the learning down into skill areas and provides detailed reports at the class level and also on individual student levels. Teachers were enthusiastic about the ways in which the Assessment reports pinpointed areas of strength and areas that need improvement.

- Surveys showed positive response about the adequacy of initial training and on-going support during implementation.
- A majority of teachers indicated the use of the program modified their instructional strategies, especially to examine instructional sequences and modify them based on data.
- Teachers reported improvements in motivation, self-esteem and confidence in previously under-achieving students.

E. Challenges encountered in the Pilot

Adaptive Learning requires one computer per student. Pilot schools were provided with additional computers and broadband. These schools were required to add Amrita Learning in the class timetable as part of the weekly or biweekly schedule.

In most cases, the computer teacher along with the subject teacher provided the support for the pilot. There was resistance by some teachers to moving to computer-based technology. ICT training to the teachers was needed to overcome this obstacle.

VI. CONCLUSION & FURTHER RESEARCH

In this paper, we have presented the results of Amrita’s adaptive assessment and learning pilot study. Based on this, we have shown the effectiveness of the adaptive program with a large number of real users. In the majority of cases, we can see that it can improve learning levels and school performance if used in consistent manner.

We have shown that young learners enjoy the interaction with Amrita Learning and that it can be used to supplement classroom learning.

The main design considerations of our research work and pilot that were discussed in the paper are:

- Initial adaptive assessment provides an accurate estimation of the learner’s knowledge base in a quicker and less tedious manner by self adjusting to ask questions at the correct level.
- Ongoing learning is tightly integrated with continuous evaluation.
- Learning at the correct level motivates learners to move at a faster level than traditional learning.

- Offering extensive feedback enhances the learning process.

Future plans include evaluating the effectiveness of the adaptive learning for specially challenged students and enhancing the content and format to their special needs. A complete teacher authoring module where a teacher can add content and define the adaptive behavior and rules is being developed.

Also planned is an adaptive collaboration support which will use the student profiles to recommend groups either to teachers to group students at a similar level or even for online collaborative work.

#### VII. ACKNOWLEDGMENT

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