An Internet-Based Educational Assessment Tool

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ABSTRACT

Sustaining a continuous improvement process through assessment requires tools to automatically collect and organize outcome data and methods to evaluate the data pertinent to program objectives. To identify activities that reflect student learning and understanding, to better understand when student learning occurs and to optimize institutional and instructor-based efforts to promote student learning, we contend institutions and instructors need information about student behavior that is both timely and timed. We propose an automated, Internet-based, activity collection system that will capture student classroom activity, sequence this activity into event trails, associate these trails to learning units and connect these events to learning outcome assessment. Too often connections between program objectives, instruction and student learning are made in retrospect as supposition based only upon final outcomes and vague recollection of the events. The internet-based, client-server system will augment the classroom session by allowing the students to annotate instructional streams for personalized review, take notes, and provide real-time feedback to the instructor via a networked computer. As students perform actions during the course of instruction, both in class and as they review class instructional streams, the system collects their activities into a timed sequence. The content within the instructional streams provides the context. Student evaluation on each content area will provide the final link between instruction and student performance. By unobtrusively recording these activities as timed, synchronized events, a data trail can be created that links final outcomes to specific student and instructor activities. This rich collection of activity data can be mined to gain a better understanding of when and how learning occurs and what can be done to improve it. This paper will describe how the system will be incorporated into the learning environment and what benefits it will produce.

1. Introduction

The last several years have seen a growing trend among educators, accreditation agencies[1], and policymakers to assure that educational programs can be assessed continuously based on objectives and outcomes and further that assessment results be utilized to improve the programs in a systematic fashion. This new drive for higher quality in education will clearly require a

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concerted effort for all those involved in the process as well as implementation of some continuous assessment mechanisms. According to Reid[2], "Firstly, it is necessary to develop policy frameworks, quality processes, and online tools to provide comprehensive, timely, and appropriate information that can be acted upon in order to improve the quality of learning. Secondly, such frameworks, processes, and tools should be applied in flexible ways that reflect the nature of the learning environments that they are aiming to improve." Currently, outcomes are mainly evaluated against the general objectives at the end of the program, well after all the teaching and learning have been completed. In cases of unsatisfactory outcome, it is seldom possible to pinpoint causes or relate failures (or successes) directly to specific teaching or learning events. Rather than vague evaluation, classroom and post-classroom assessment should be done throughout the students' learning process. This assessment should be based on the objectives of all three constituents: the institutional program objectives, teacher teaching objectives, and student learning objectives.

While educational entities push for paradigm changes to more accountable programs, other major changes, due to the advancement of computer technology and the advent of Internet, are impacting the field of education and society as a whole. Traditional classroom teaching has seen great changes in style with electronic media equipments for multimedia presentations. Furthermore, both teacher and students in most of the higher educational institutions in the country are equipped with computers and Internet access in classrooms. With this world-wide interconnection among computers, a dynamic and ever growing web of information sources is now at the disposition of educational systems. The different formats of material being delivered during lectures may overwhelm students, in terms of absorption of the material or proper note taking for later review and study. Student disengagement in the classroom is an issue that may hinder student's learning in an information overload situation. Research that focuses on getting more out of the classroom experience shows that user-interaction in selecting data keeps the students interested in material[3]. These studies indicate that students' needs and viewpoints have to be taken into consideration when course material is given in technology-based classrooms.

More importantly, an internet-based platform provides a standardized means for interactivity and collaboration. This expanded capability allows for new active educational alternatives. For instance, enhancing the learning process with both synchronous and asynchronous ways of communication is now possible. This means that the teaching and learning relationship in classrooms can be viewed as a collaborative process. The educational paradigm can be switched from primarily teacher-centered to student-centered learning, and technology-assisted assessment procedures can be incorporated. The former allows students to take more action in learning. The latter provides assessment tools that can collect both timely and timed information about students' learning behavior.

Student-centered learning is accomplished with computer technology: desktops, laptops, PDAs, or tablets[4]. It is clear that technology is beneficial[5] when the tools can assist students in retrieving, evaluating, comprehending and memorizing information while performing learning tasks, especially, when students are facing the overwhelming amount of information provided by electronic media and Internet. A useful instrument for learning is an Internet-based, client-server system for 'taking notes' on lectures and a self-study helper. Each student will be able to create personal links from personal material to course material, facilitating self-directed learning. It augments the classroom session by allowing the students to annotate instructional streams for personalized review. Moreover, it allows students to take short tests for self-evaluation, and to interact with instructor by sending questions and comments to teacher via a networked computer.

For assessment, we propose an automated, Internet-based, activity collection system that will capture student classroom activity, sequence this activity into event trails, associate these trails to learning units and connect these events to learning outcome assessment and to program objectives. As students voluntarily peruse this instrument, they perform actions during the course of instruction, both in class and as they review class instructional streams, the system collects their activities into a timed sequence. The content within the instructional streams provides the context. Student evaluation on each content area will provide the final link between instruction and student performance. By unobtrusively recording these activities as timed, synchronized events, a data trail can be created that links final outcomes to specific student and instructor activities. This rich collection of activity data can be mined to gain a better understanding of when and how learning occurs and what can be done to improve it.

The rest of the paper is divided into four sections. Section 2 reviews a framework for general classroom teaching scenarios. Section 3 discusses both the rationale and the mechanisms of inserting assessment into the learning environment. Section 4 presents a framework for educational assessment, called the CaSA framework, and the GUI that will allow interactivity and show how the system outcome data are collected and analyzed. Section 5 provides concluding remarks.

2. Overview of classroom teaching and learning

The most common learning environment in schools is the scenario of one instructor/teacher (T) and many students (S) in classroom. The teacher teaches in a predominantly one-way communication fashion and, due to time and spatial constraints of the classroom, students learn passively. Although this may be a most economic way of education in a large educational system, it is not short of problems - lack of motivation, apathy, disinterest, inattention, and frustration abound in both teacher and students. Many teachers blame the students and many students feel that they have learned nothing at all and fall 'through the cracks' easily. A major flaw with this method of instruction is that there is no guarantee that the two parties are connected or engaged in the communication either intermittently or continuously. The teacher can present the material without requiring students' response or attention. Further, as passive receivers of the information, students can be occupied in many different activities not related to the class; such distractions may affect the continuity and effectiveness of learning. Without interactivity there are few effective ways to make assessment during the process, unless it is done well after the fact.

Learning is a process that takes time. It may encompass several stages and involve many factors that are both internal and external to teachers and learners. These temporal events often occur sequentially, like a row of dominoes. One event may need to be triggered to control the others that follow. A lack of one may impede the entire process. Thus, there is a need to identify all the elements of the process and correct the part that does not work properly. Consequently, the key assessment procedure is to determine when each stage begins, ends or transitions to another phase.

For instance, to evaluate the teaching effectiveness, we may need to consider the pre-classroom teacher preparation or the conditions in classroom before the lecture begins. One of the first and most important steps for a successful teaching/learning session is that both teachers and student have the right mindset, attitude, and be 'engaged' in a responsible manner[6]. That is, the teacher cannot simply cover the material then consider the teaching complete. The teacher must feel responsible for students' learning and must stand accountable for his/her influence since the teacher controls the subject, presentation style, and delivery. In addition to having the material content ready, the teacher must determine the right level of need and expectation appropriate to the audience engaging in student-oriented activities and maintaining an awareness of the students' state in order to motivate students' attention. On the other hand, students should also have the right mindset. They should be motivated by the commitment made by the teacher through his communication tone and behavior. Throughout the process, the teaching and learning relationship must engender situations for students to replace the passive learning with active learning. As a result, students should feel responsible for receiving the material and making the material theirs so that they may go out to practice and live out the things they have learned. In short, the students' performance is the final product of the educational system and teacher is responsible for it.

Learning is done incrementally, in layers. Mastery of knowledge and skill in a certain area or subject often starts from the basics, a minimum set of facts that constitute the foundation for understanding of more complex and advanced concepts and their later application. The scope of the course and the coverage of the lectures are normally specified in program description and course syllabus before the course is offered. Due to time limitations in classrooms, classroom teaching tends to focus introducing basic concepts so that students will have the tools to use when learning more complex concepts and applications later. Most of this complex or advanced learning is delegated to students outside of the class, in the form of home works and projects. Basics need to be learned well (i.e., understand, retain in memory, and feel confident and in control for tackling applications). Thus, the important role of the teacher is to make sure that the minimum set and the most important pieces of knowledge are taught such that students can retain them for use after class.

All these require that the teacher prepare well. Preparing for a lecture normally includes several steps[6]: a) Survey the subject and gather material from research, collecting as much information as possible, b) Organize material collected and rank the relevance of the material pieces (e.g., a must, helpful but not required, optional – might help, minimal help, not helpful – might confuse), c) Prepare an outline based on the time, class purpose, level of understanding expected (surface awareness, average understanding, thorough comprehension), relevance of the sorted material, and audience, and d) Adopt the most suitable presentation technique(s) for delivering the minimum set, making the essential material easy for memorization, solidifying memorization through association, repetition, and review, and e) Provide opportunities for subject mastery through indelible memorization, in-depth comprehension, intuitive integration, and independent utilization.

When the teacher prepares a thorough and complete lesson as discussed above, all the effort becomes the documented content for the course. The material, the final goal, as well as the sub-goals that support the final goal, should become explicit and well organized by the end of preparation. That is, the lesson plan, the lecture material, and explicit learning outcomes can be easily represented in a structured fashion - in distinctive modules and hierarchical layers. This structural information about the content can be easily represented in XML (extensible markup language) format and stored in XML-based files, including multimedia content and hyperlinks to external reference sources. The modules of documented content can easily be tracked during lecture and be associated directly to both home work assignments and tests.

A lecture session is a temporal event that has a well-defined beginning and ending and consists of a continuous flow of activities in a given period of time, say, 50-minutes. From an organizational point of view, the teaching and learning in classrooms can be structured into the following class segments in a lesson plan, as shown in Figure 1: (1) Starter, (2) MainFocus, (3) ExplorationActivities, (4) Discussion/Summary, and (5) TakeHomePractice/ Review.

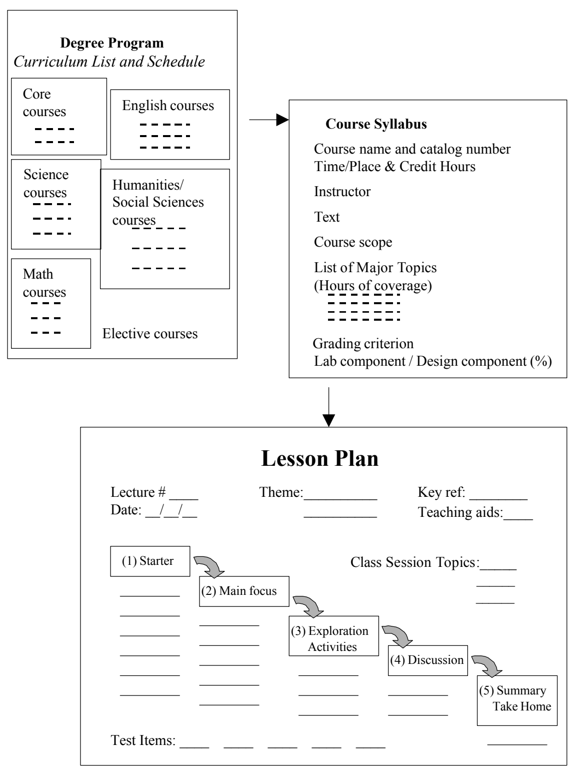

Figure 1. Organized course material and lesson plan

A Starter segment may start with a greeting and a quick survey of the students, some pre-assessment tests, starter discussion questions, basic historical background for the subject, or a brief review of the past classes. The MainFocus segment is where the new main concepts are defined, explanation given, some derivations from basics are elaborated, illustrative examples provided, key terms to be memorized are outlined and emphasized. The ExplorationActivities segment would further describe methodologies, algorithms with procedural steps in sample solved problems, activities for group or self discovery, opportunities for interaction through questions, etc. The Discussion/Summary segment provides a time to wrap up the session by discussing meaningful applications, go over some understanding checks on students. Lastly, direction homework assignments, which may include practice problems and further readings or extended discovery, is normally given at the TakeHomePractice segment.

A subject topic captured in a module can be subdivided into parts and delivered in temporal 'chunks'. The lesson plan provides, in addition to the order of the material, the timeline for the delivery of the material in classroom. Each segment will cover several module parts in chunks. Each chunk includes a set of time intervals, which can be characterized by a set of markers along the time line: a beginning, body (with specific markers indicating the material content of interest), and ending. It may also contain a variety of modes of communication: spoken word, PowerPoint slides, scribbles on the blackboard, hyper-linked Web pages, etc. The actual presentation of the lesson may vary based on the circumstances in class. Each chunk may also include side-tracks or digressions (not shown in diagram) that often occur during talks. Note that even though the flow of the presentation is sequential, there may be several threads of chunks that are going on at any instant of time. Figure 2 shows a sample flow of a lecture map.

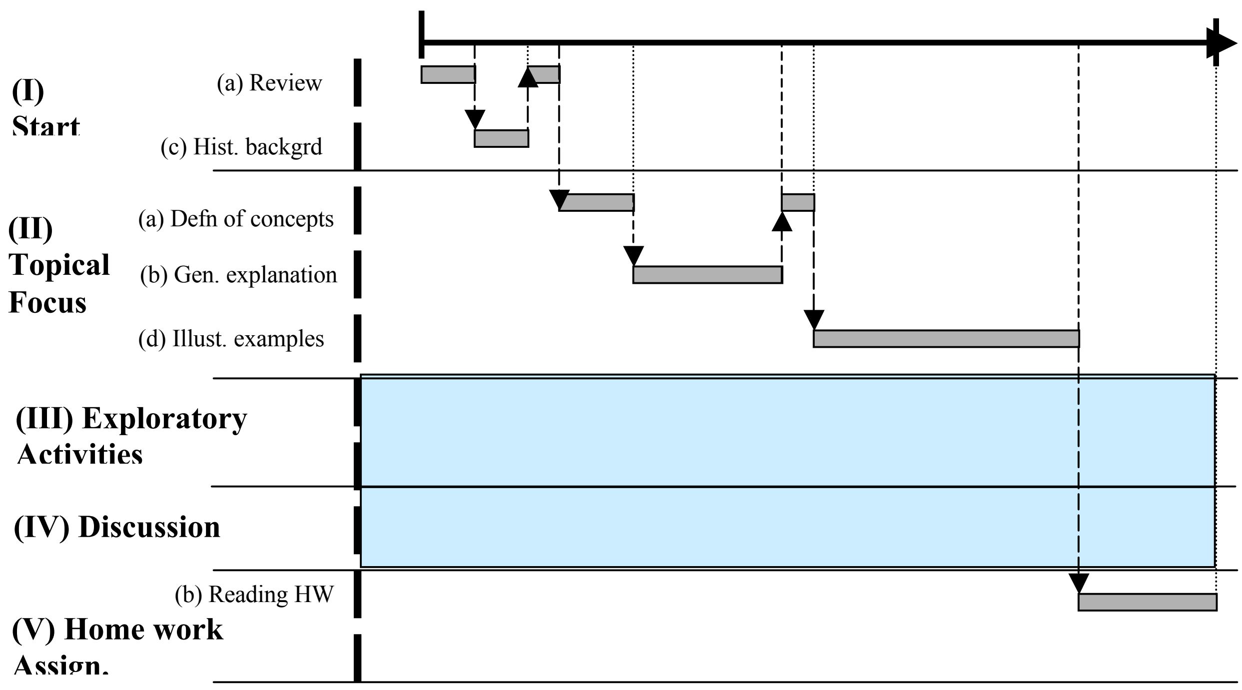

Figure 2. Lecture Map

In addition to the actual lecture map, additional layout of the content or concept map and the lecture path map may be used to assist students in following the progression of the lecture. Note that in Figure 3 there are three sets of content need to be captured and compared in order to assess the success of the learning. The key issue is how to monitor the delivery of the material with respect to the prepared material and the intended objectives for the lesson as well how much of the material is learned by the students.

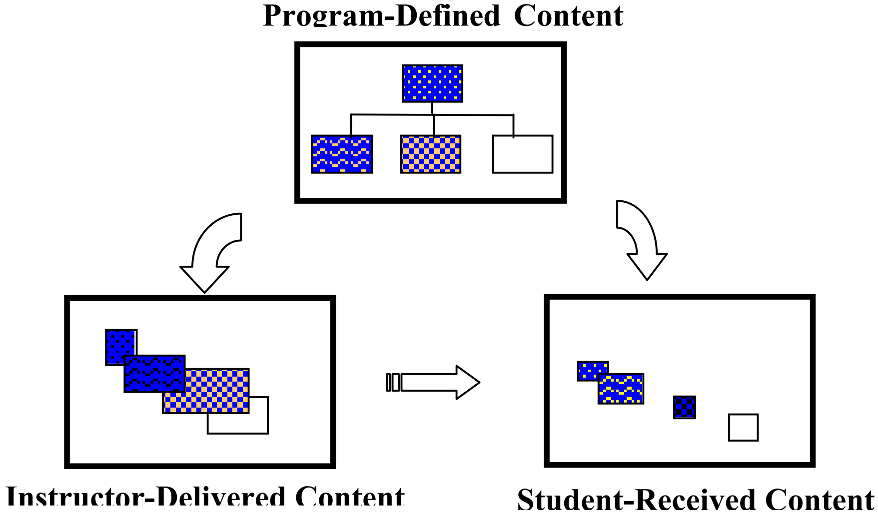

Figure 3. Content Maps at different stages of instruction and learning

For each student, both the concept map of a lecture and the lecture map can be used to augment the classroom learning experience. To actively engage them, students can participate both directly and indirectly, through a networked, student-centered learning tool, such as a note-taking system. As students perform actions during the course of instruction, both in class and as they review class instructional streams, the system collects their activities into a timed sequence. The content within the instructional streams provides the context. Student evaluation on each content area will provide the final link between instruction and student performance. By unobtrusively recording these activities as timed, synchronized events, a data trail can be created that links final outcomes to specific student and instructor activities. This rich collection of activity data can be mined to gain a better understanding of when and how learning occurs and what can be done to improve it.

3. Creating and incorporating assessment

This section will further discuss when and how technology could provide integrated assessment activities in the educational process.

As we have discussed, learning and instructional processes are complex and involve many inherently, though not necessarily explicitly linked steps, beginning with program development and culminating with student knowledge acquisition. By better understanding this very complex process we will be able to improve instruction and learning. Assessment provides an accurate perception of the current state of the program, courses and learning, and thereby facilitates incremental and timely improvement. Assessment practices range widely and may cover a variety of specific aspects: content identification, communication, timing, intended delivery versus actual delivery. Assessment hooks can and should be integrated throughout the instruction and learning process. It is our belief that assessment activities incorporated at each stage, program, instruction, and learning based upon captured, connected events can be far more effective than the typical practice of assessing all stages at the end of each academic year based upon hazy recollection and anecdotal encounters.

Educational assessment has multiple, distinct uses in instructional improvement including: school and student accountability for academic achievement, feedback for teachers to revise teaching, and for administrators to allocate resources, and stimulus for students to receive a deeper understanding[7]. Despite the multiple stakeholders in the educational assessment, there are essentially three (interrelated) simple questions that need to be addressed: did students learn; did teacher instruct; and did program provide well-defined objectives and necessary resources for both teachers and students to succeed?

The rest of this section will discuss different areas where technology can improve assessment and consequently student achievement.

3.1 Connecting program objectives to student learning

Ideally, an explicit connection can be made from program goals and course offerings through class sessions and instruction to student achievement and learning. A fairly typical program will have defined objectives and a curriculum consisting of courses that a student must take to satisfy the program requirements and, it is thought, the program objectives. Each offered course instructor will hopefully deliver the content that satisfies the course's allocated portion of the program requirements and program objectives. And finally, the students taking that course from that instructor will, again hopefully, learn and retain the material that supports the program objectives covered by that course. So there should be an unbroken chain from program objectives to student learning, as shown in Figure 1. But does this really happen? This is where assessment comes in.

It is here that we see the first example of where the gap in intent and realization can be measured. However, this can only be accomplished if at each step we have: Documented the intent, measured the realization, and made the connection between the two. For example, a program may have as an objective for the students to be able to communicate in a variety of media. One course in the program could be 'Introduction to Web-Development.' The intent is for the course to teach students how to communicate in a multi-media web environment. Perhaps, however, the instructor interprets this course to be a survey course on web development that others have done and shows the students web pages, but never shows them how to make a web page. In this case there was a disconnect between intent and realization, from program objectives to course instruction. Say, on the other hand, the instructor presented html syntax, javascript and how to use various graphic image programs. However, when the students complete the course the best they are able to manage is a blank web page that produces an error message in every browser. In this case there was also a disconnect between intent and realization. This time, though, it was between instructor intent and student achievement. If assessment is only applied at the end of the term, or worse at the end of the program, both of these cases look the same in that the students cannot communicate in a variety of media. To apply a targeted solution to this problem we need assessment that pinpoints the breakdown. In other words, the assessment needs to be

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integrated throughout the process, assessing how well the program connects objectives to content to learning and achievement.

3.2 Immediate feedback

Another area where technology can and should insert assessment into the educational process is by facilitating immediate feedback. Without timely feedback connecting student learning to instructor evaluation, neither the instructor, nor the students nor the program administrators have the power to affect change or to correct problems. Consider typical feedback from student to instructor. Students evaluate a course with a course survey, completed at the end of the term. They fill out this survey with the knowledge that their comments will not be read until after grades have been posted and so will not affect their grade. It is thought that this will promote student candor. Unfortunately, this also removes the motivation for the students to provide meaningful feedback. So, not only is the instructor prevented from affecting changes to course based upon the feedback, but also the feedback has questionable validity. As Reid[2] notes, "…it is vital that students can provide feedback wherever they are receiving instruction, in a fashion that is seamless with their learning environment." Ovando[8] adds, "…researchers are conceiving of teacher evaluation as a mechanism for improving teaching and learning." Further, "…teacher evaluations 'must analyze teaching on the basis of what students are learning as well as effectively integrate the teacher evaluation and staff development processes with school improvement…'"

Also consider the case for students. Generally the feedback they receive is intermittent and only after major course milestones, such as a midterm or final exam. According to Brien and Eastmond[9] in Cognitive Science and Instruction, "During instructional activities, the competencies taught must be reinforced each time they are adequately used by the learner."

Research that focuses on getting more out of the classroom experience indicates that student needs and viewpoints have to be taken into consideration when course material is given in technology-based classrooms[10]. Therefore, it is important for the instructor to know if and when the students are making learning progress so that proactive adjustments can be made. A technologically based system will allow instructors to demonstrate they have provided the content and provide a feedback system for students to demonstrate that they have received it.

Lastly, feedback to the program can take the form of departmental assessment reports, student complaints, instructor dissatisfaction with student performance or prerequisite knowledge and skills. Again, much of this feedback is provided informally, without adequate documentation and well after the events that prompted the feedback. However, by providing formal, documented, supported feedback as it occurs, program directors can act proactively and effectively, correcting problems iteratively and tracking their effects incrementally.

It is during the contact time in a classroom that the instructor can exert the greatest impact on student learning. In fact, a study from the University of Tennessee found that teacher effectiveness was the dominating factor affecting student academic gain[9]. Thus, it is important to assess learning in the classroom and let instructors take timely measures and make any necessary remedial changes, to work more collaboratively with the students. By integrating

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technologically-based feedback into the educational process, immediate or timely feedback can be given to students as they learn, to instructors as they instruct, and to program directors as they make proper policy and provide adequate resources when they are needed.

3.3 Timed, synchronized activities

Most importantly, technology can assist assessment by bringing in the time dimension into the solution space. Assessment tools can help line up or synchronize learning events (successes and failures) into a timed sequence. The event must be placed into context. It is not always enough to know that an event has occurred in order to take corrective action, we must also know when the event occurred and what actions preceded the event. Further, to correct or replicate the event we must know the string of events that took place before the event in question.

As a summary, we have presented both the importance and the benefits of assessment in educational programs in the last sections. In the section that follows we will discuss our internet-based educational tool and specifically how it provides a foundation for integrated assessment.

4. The assessment tool - CaSA

For assessment, we propose an automated, Internet-based, activity collection system that will capture student classroom activity, sequence this activity into event trails, associate these trails to learning units and connect these events to learning outcome assessment with respective to program objectives. The assessment system is based on the CaSA (Classroom and Student Achievement assessment) framework[11] that we have developed in house to integrate other existing systems that provide adaptive learning and intelligent FAQ[12], stream storage and playback services (from the UC Stream Media Group[13]), and a multimedia stream marking and note taking system[14]. However, these systems are currently still in modular form and have not been completely integrated yet for assessment purposes.

4.1 CaSA Framework

Briefly, CaSA is a flexible framework to augment the classroom experience by coordinating and synchronizing instructional streams, matching class plans to student class experience, and presenting instruction in a variety of media forms to promote self-directed learning. It consists of and coordinate three major components: a Preparation component, a Real-Time Stream component, and a Review Component. These components are organized by whether their functionality supports the e-classroom primarily prior to, during, or after classroom instruction.

Towards that end, the system is implemented as a Java-based 3-tier client-server model. The underlying software has been written using a layered approach to maximize reuse and interoperability. Open source tools and standards are used for portability: XML is used as the format for data representation of the content material, Java is used as the programming language, JAXP is used for XML processing, JMF is used for multimedia data processing, MySQL is the database and Apache/Tomcat is used as the hosting web server. Figure 4 demonstrates a full communication cycle through the front-end client layer to the backend database layer and back.

The associated CaSA Java classes used in these layers are StudentPresentation, CaSAClient, CaSARMIClient, CaSARMIServer, CaSAServer, and DBComm.

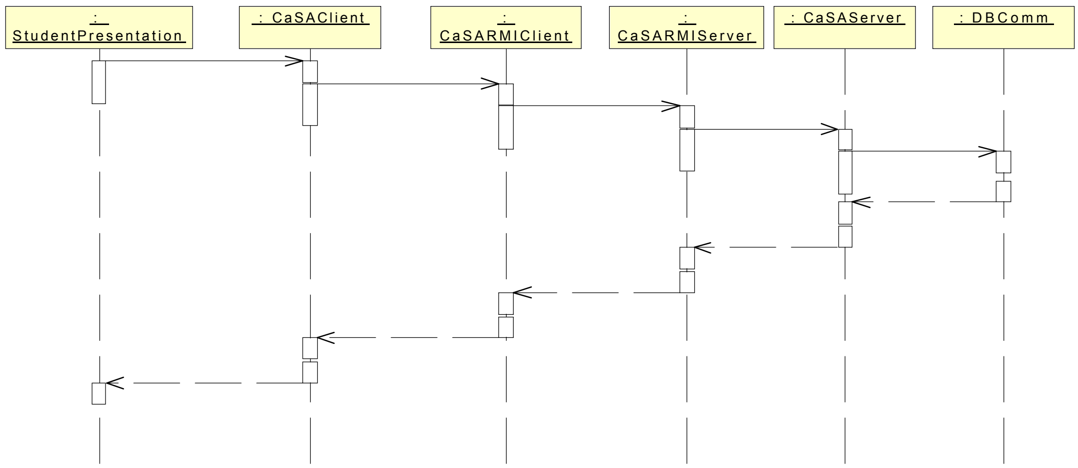


Figure 4: CaSA System Layered Communication Overview

One of the goals of this system is to provide benefits to the instructor without putting a large preparation load on the instructor. The intent is to give an instructor an easy point of entry—minimal effort for maximum benefit. For example, by entering a course session outline into CaSA prior to a class session, the instructor will be able to publish the topics to students at the start of class, set their expectations for the class session, enable topic marking, stream synchronization and assessment stream data capture. All of this can be received by entering the topic outline, generally created during class preparation, into the CaSA system.

The most important modules of the CaSA framework are now complete. Additional functionality, including learning object support (Learning Object Metadata Working Group 2002)[15], will be extended in the future.

4.2 Note-taking system

As shown earlier in Section 1 and Figure 1, lesson plan can be represented in a well-structured and organized format. Once the lesson material is represented in XML-based format file (Figure 5 shows a very simplistic case), it can be easily exchanged with the DOM (document object model) and translated with XSLT and XSL (XML stylesheet) into as many different page formatting formats as needed for publishing on the Web[16, 17]. Figure 6 shows the display of the sample lecture note in DOM format.

Instructor’s Lecture:

…
Main Focus
Concept Definition
General Explanation
Derivation
Key Term
…

```
<!—edited with XML Spy v3.5 (http://www.xmlspy.com) by Zhuo Wang (Univ. of Cincinnati) →
<?xml-stylesheet type="text/xsl" href="ShowNotes.xsl"?>
<Lecture category="Lecture">
        <H1 category="MainFocus">
          <H2 category="ConceptDefinition" >Here is the definition of thread… </H2>
          <H2 category="GeneralExplanation">Here is the general explanation…</H2>
          <H2 category="Derivation " comment=" " feedback=" " doctype=" ">
                 Here is the    derivation…</H2>
          <H2 category="KeyTerm" comment=" " feedback=" " doctype="movie"
        docfile="keyterm.mov">Here is the key term…</H2>
        </H1>
</Lecture>
```

Figure 5 A sample lecture content in XML format

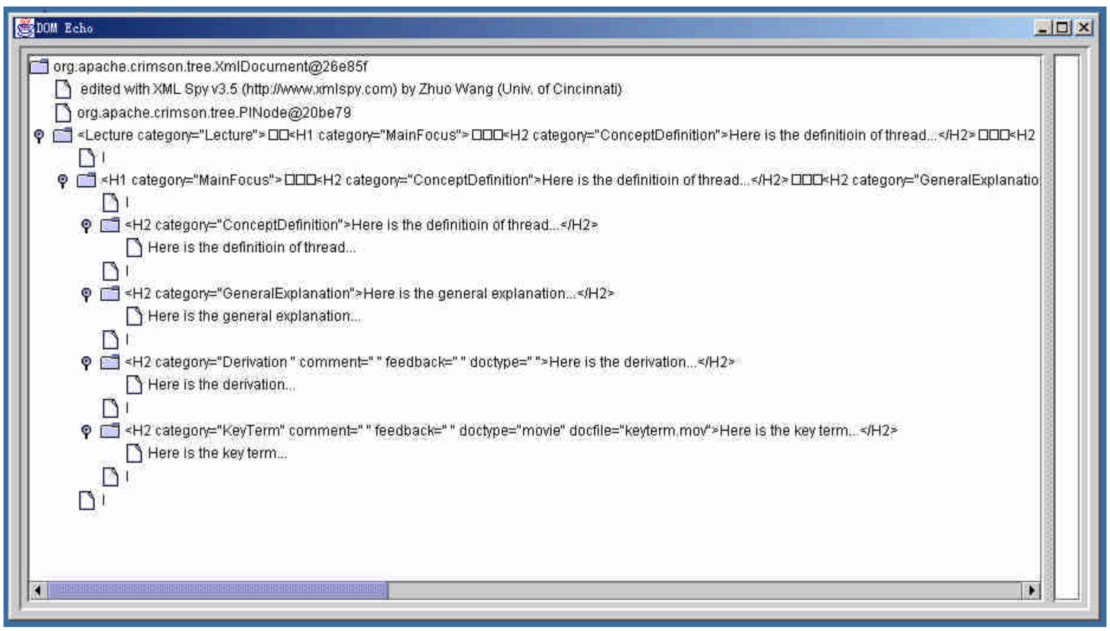


Figure 6 Lesson content in DOM format and displayed in directory tree-like hierarchy

Figure 7 shows an example of a panel for student to take notes on the right panes while viewing and marking on the lesson outline provided by the instructor on the left pane. Figure 8 shows an example of post-classroom review, when the student views the playback of an instructional stream of multimedia content, based on the student personalized note marking of ‘interesting’ during class when the instructional stream was presented. With the capability of setting marker on the video stream, only a marked section of the video is replayed during review. It is important to note that the entire lecture can be captured as a video stream and indexed for later access through streaming media over the Internet[13].

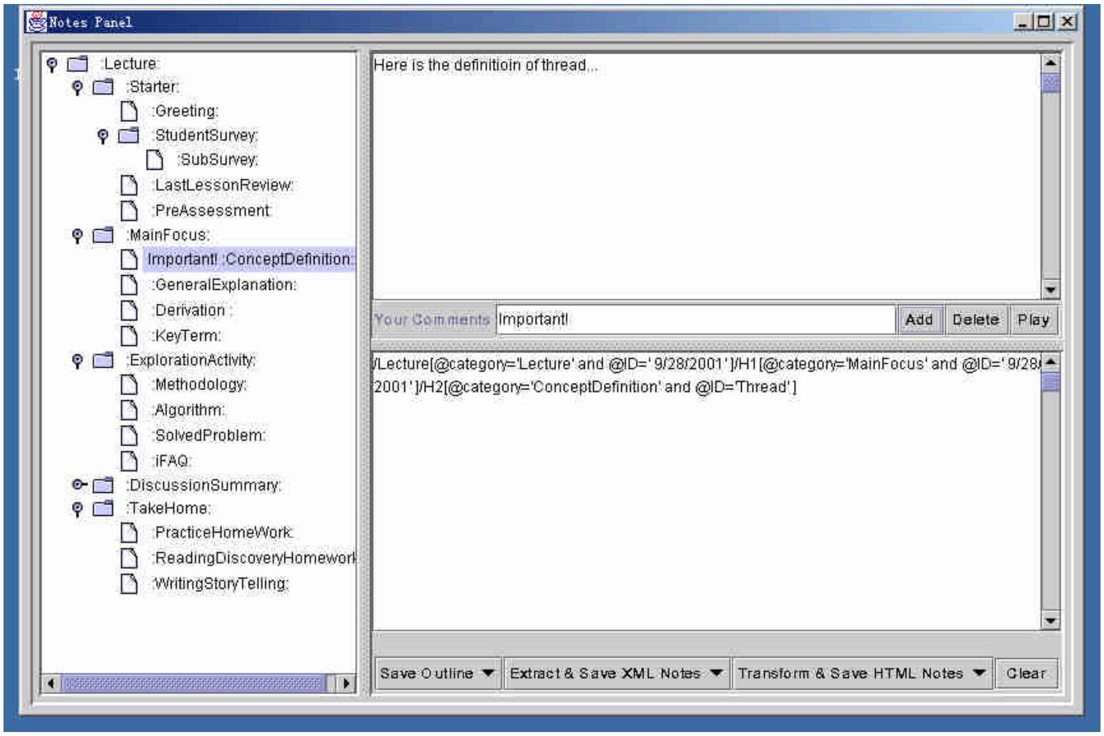


Figure 7. A sample panel for student to take notes and view lecture outline.

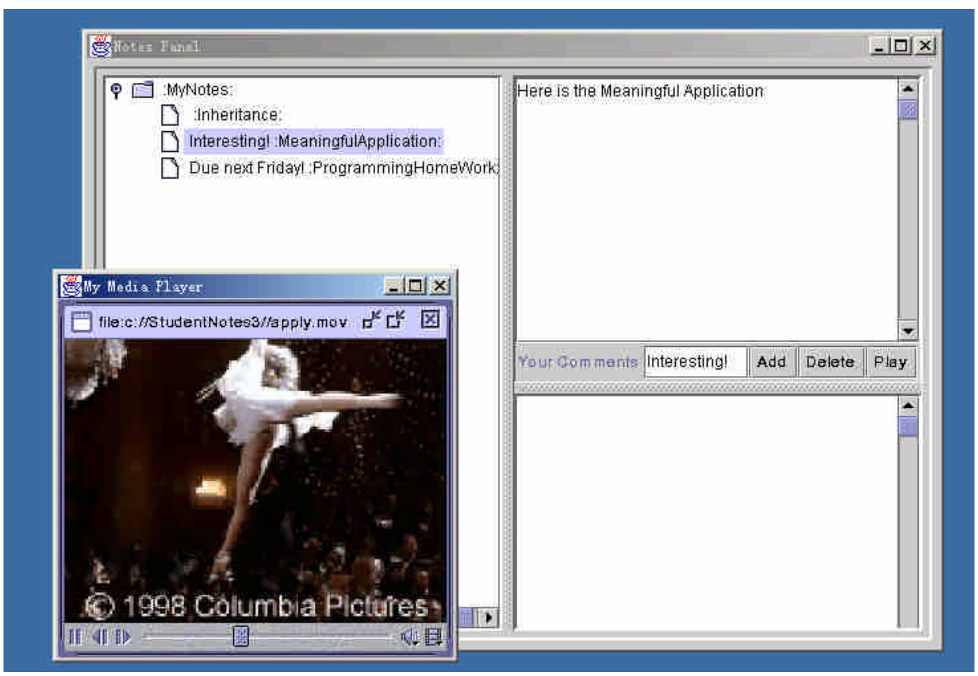


Figure 8. A sample popup window for stream playback based on the student's notes.

4.3 Assessment tool

The assessment can only be done properly when considering the timed sequence of interactive activities between the teacher and students. The student's input to the note taking system will be time-stamped and recorded. For instance, in Figure 9, the student's perception of what time a given concept is introduced or understood can be inputted and recorded. This temporal information is very critical in later analysis of assessment.

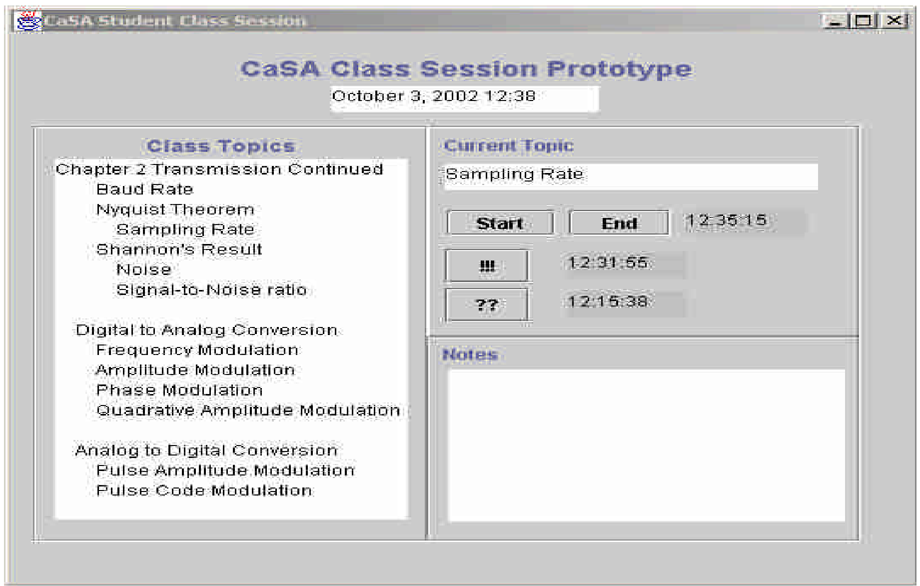
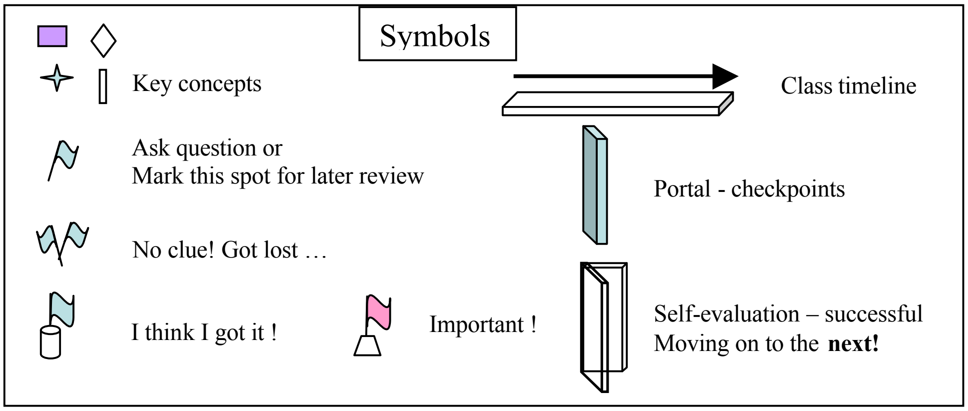
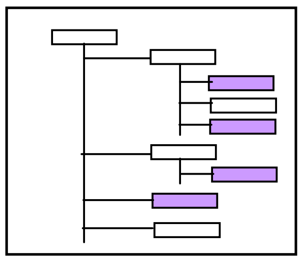


Figure 9. A sample panel for inputting annotations on learning

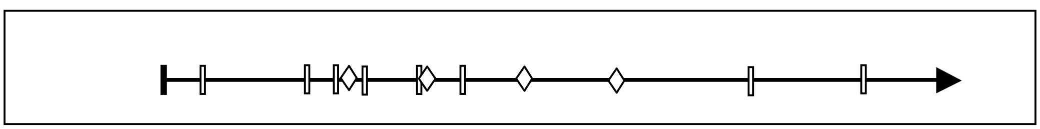
With this brief description of the CaSA system, we are now ready to explain when and how assessment can be incorporated into the learning environment. Figure 10 presents four different components for illustrating when and where the educational assessment can take place. Program objectives and the course content that are reflected on the syllabus can be detailed in the concept maps for the course (Figure 10 (a)). The teacher organizes the material into modules based on the concept maps, identifies (and highlights) the minimal set based on the relevance of the material (Figure 10(b)), and prepares a set of evaluation test questions after the key concepts are presented. Then, as the teacher goes through the material, the actual material covered or delivered during classroom presentation is shown as modules markers along with the respective evaluation tests and checkpoints (Figure 10(c)). Students take notes of the lecture and each student's learning path is generated as in (Figure 10(d)).

What is taught versus what is scheduled by the program can be assessed as shown in Figure 3 and by comparing data presented in Figures 10(a), 10(b), and 10(c). Student's progress can be evaluated through the students' actions, either collectively or individually, as exemplified in Figure 10(d).

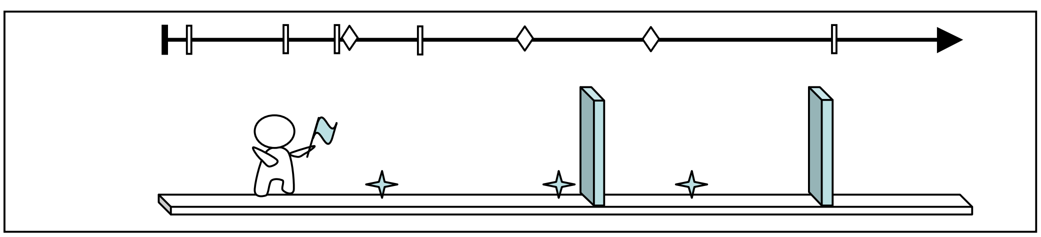




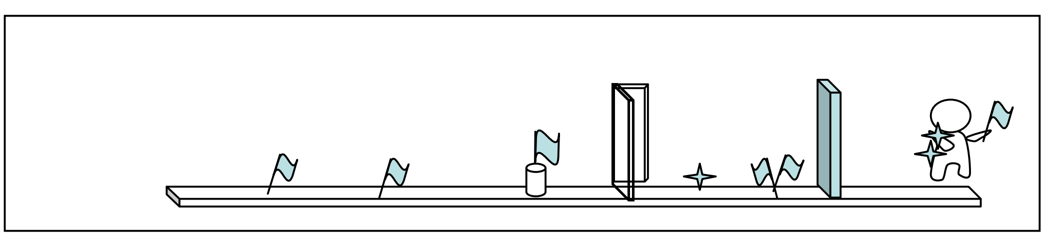
(a) Course concept map



(b) Planned lecture map (based on course concept map)



(c) Actual lecture map (based on planned lecture map)
& Student learning map



(d) Student in-classroom learning path

Figure 10. Highlights of the instruction and learning process

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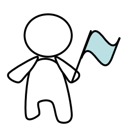
The assessment can be done quantitatively by the students' performance evaluation and the general patterns of learning can be obtained by using the information gathered from all four maps. For instance, by the end of the class, the example illustration in Figure 10(d) (along with other students' map) shows that in general, students did well at the first part of the lecture and a majority of the students (like the one shown in 10(d)) then got lost. Checking the lecture map, we might deduce that few important concepts were not covered very thoroughly. Further analysis of the detailed lecture map (in Figure 2) might indicate that too much time was spent covering non-essential topics and less time was spent on important topic. Also, as shown in Figure 2, there was no time for practice nor was there opportunity to emphasize the key concepts required to complete the whole picture of the subject. Instructor can use this information to plan for the next lecture by reintroducing the key concepts covered in the latter part of the previous lecture and more exploratory activities can be planned. At the meantime, teacher can schedule additional reading assignment as homework to partially remedy the situation.

4.4 Sample GUI for students

To further illustrate how students can easily engage in classroom through their own computers, this section provides a sample graphical user interface (GUI) to students to self evaluate the understanding of the material delivered during the presentation and later during the post-classroom review. By voluntarily using this tool, useful information of learning are collected, analyzed, and feedback to teacher and program. The following presents the `Help/Instructions` given to the students on the client machine.

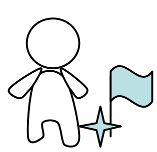
`Help/Instructions`

The human figure represents you, the student. There are various options for you to personalize your character (hair-color, clothing, etc).



Hi. My name is ____________

The star symbol represents a key concept. If you think you understand the concept (50% or better), pick up the star. If not, mark the location using the flag as a place to revisit for later studying.



FLAG MARKING STAR:
Revisit later

STAR PICKED UP:
Concept grabbed

Each class is a journey of learning, represented by a time line on which you move left to right. Doors represent the portals from one section of the lesson to another related (or possibly unrelated) section. Doors also represent checkpoints—a few questions will be asked to check your understanding. Stars and doors are placed according to the pace of the professor's lecture.

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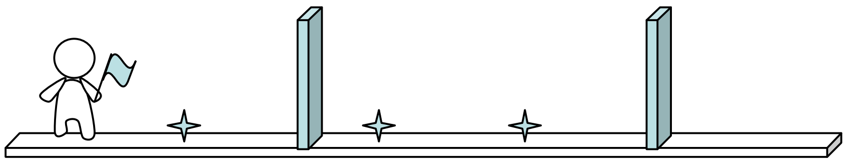
CLASS: Computer Science 205	INSTRUCTOR: Dr. P.C. Macintosh
DATE: September 14, 2002 10:00 – 10:50 am	



You will be notified when you reach a star or door. Questions on both the subject matter and self evaluation of your understanding of the material will be posed. To improve the effectiveness of teaching (and your learning) it is important for you to answer them honestly—*your answer/performance has no effect on your grade*. After you have submitted your answers, a box will appear revealing your answer (in bold), the correct answer (in larger font), as well as the percentages of students who chose each answer for each problem. For example:

(Sample) Question 1:

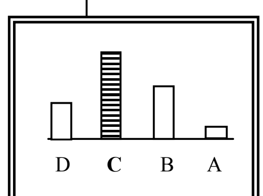
You are traveling to Columbus, which is 150 miles away. If you are driving at 60 mph, how long will it take you to reach your destination?

- ○ A) 3 hours
- ● B) 2.5 hours
- ○ C) 1.5 hours
- ○ D) Don't know

```
(A) 15.3%
(B) 63.5%
(C) 17.1%
(D)  4.1%
```

So far, we've been talking about [key concept].
How well do you think you understand the concept?

- ○ A) Well 75% and up
- ○ B) Pretty well 50-75%
- ● C) So-so 26-50%
- ○ D) I'm lost 25% or less



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5. Conclusion

An Internet-based assessment tool for the educational programs that are incorporating the latest computer technology into their classrooms is presented in this paper. The assessment tool is timed, integrated, and connected. Because the 'product' of an educational system is the successful student performance and educational accountability requires that teachers create successful student performance, an effective means that can ensure success at all points along the production continuum is needed. We contend that this is only possible with real-time data collection and timed assessment in a clearly defined context with respect to the objectives. With immediate data feedback, teachers can make timely decisions that positively affect the students with whom they work. In addition to the connectedness provided by the technology, the system addresses the time dimension of the teaching and learning relationship. Thus, the activities of the learning environment stakeholders can be timed, synchronized, and integrated. This rich collection of activity data can be mined to gain a better understanding of when and how learning occurs and what can be done to improve it.

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