

Development of An Extended-Classroom IT Infrastructure for Engineering Instruction

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Abstract – To provide the same classroom experiential learning for local and remote students, the BAE department at UGA has developed an "extended classroom" facility whereas all involved (teachers - local or remote; students - local or remote) can hear, see and otherwise interact with each other. Furthermore, in real time, all local and remote participants can annotate their personal versions of classroom activities being recorded into searchable multimedia files that they can take home to review and modify. This report documents engineering instructional needs from the departmental, faculty and student viewpoints and describes the integration of the software "NetSupport Manager" and "Silicon Chalk" in the delivery of a Machine Vision course and a Java Programming course. This report also describes the adaptation of our video-conferencing equipment into this system so that symmetry is achieved between local and remote sites allowing easy switching between originating teaching sites during any given class session.

Keywords: Extended Classroom; Remote Control; Information Technologies.

INTRODUCTION

Several reports from the National Research Council ([Pritchard, 10] and [Hilton, 5]) advocated the adoption of Information Technology to improve student learning at the high school and university levels, but [Hilton, 5] also acknowledged that "Information Technology (IT) is changing at a breathtaking pace, making it virtually impossible to accurately predict its future impact on teaching and learning in undergraduate science, mathematics, engineering, and technology education". [Raschke, 11] predicted that the University, as we know it, would be "deconstructed" in the near future as learning shifts from a teacher-initiated orientation to a more active role from the student. [Johnstone, 6] wondered if all higher education institutions are "really ready for laptop high school grads" who are now used to sitting in wireless classrooms and working on whatever they think is critical. [Cuthell, 2]'s study in the UK indicated that students who used ICT as an integral part of their work were developing into autonomous continual learners. However on the other side of the coin, [Wankat & Oreovicz, 16] reported that almost 25 percent of first-year engineering students study less than 10 hours per week outside of class, with only 12 percent saying that they spend more than 25 hours on school work, showing rather clearly that students are not yet ready to be responsible for their own education. [Prince, 9] reviewed the most relevant research literature on "active learning" and suggested that students can retain more content when brief activities are interspersed in the lecture, and that instructors should promote collaborative and cooperative environments. [Ellis, 3] found that "Animation" fostered a greater degree of learning in Boolean algebra, while [McKenna & Agogino, 8] showed that using a representationally-rich learning environment with 2 components, 1 web based and 1 with hands-on Lego activities, can enhance students' mechanical reasoning and understanding of simple machines concepts. In his work on learners motivation, [Kytyle, 7] proposed 10 elements for better learning, but acknowledged that it is both artful and difficult to find the right mix of elements so that students can become the active learners we want them to be.

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BAE Engineering Instructional Needs and Constraints

Belonging to an "Ag" college, the BAE department at UGA is consequently spread out over 3 campuses: Athens, Griffin and Tifton, and most BAE students reside in Athens. Currently, our department has no asynchronous on-line courses, as the preferred mode of content delivery to students is still the live classroom lecture format. Thus over the past 3 years, the BAE department had been engaged in developing and adopting pervasive learning technologies with the goal of engaging our students into an active learning mode inside and outside the classroom. One of the thrusts for our department curriculum is to enhance the experiential learning aspects for our engineering students during class lectures by performing equipment demonstrations that will serve as brief activities to help students remember content as [Prince, 9] had recommended. However it is usually difficult or sometimes impossible to bring in "equipment" from the "lab" into the "lecture hall" due to equipment size or its location off building or campus. Some courses such as Simulation and Computer Programming further require students to remember elaborate software operation procedures that compete for their attention away from the actual technical or scientific concepts being delivered. In other words, present-day engineering students also require modern multimedia annotation tools that allow the recording of the flow of complex computer activities along with the instructor verbal explanations.

About half of the BAE teaching faculty uses PowerPoint slides regularly as the information delivery tool, while the other half finds the standard chalkboard adequate for their needs. At present, about 2 temporary instructors and 6 regular faculty members (among a total faculty of 27) had investigated and used, at varying levels, the area of technology-enabled teaching (TET), because the tenure process at UGA (and elsewhere) is still penalizing innovative non-tenured faculty for activities in this area ([Starrett, 14]). In the area of using information and communication technologies (ICT) in instruction (in the broadest sense of the word) we can organize our faculty in 4 ICT skill levels:

1. Videoconferencing users: using ICT to keep in communication with other campus faculty or graduate students doing thesis work away from the main campus.
2. Local TET users: interested in teaching interactively to local Athens students, mostly because the subject matters require intensive computer usage such as Circuit Analysis, Sensors and Transducers, Finite Elements Analysis, Computer Programming, Machine Vision and Modeling & Simulation.
3. Remote Instructors: needing ICT and TET to allow them to teach from remote sites into the main campus where the BAE students are located (at the present time). Presently these subject matters are in the Environmental Engineering and Systems Engineering areas.
4. Multi-site Instructors: definitely needing advanced ICT and TET in order to manage 1 local classroom and 1 or 2 remote classrooms at the same time. At present, this group is not yet constituted, but recent budget realities are requiring the formation of such infrastructure for the near future. Here, system symmetry is very important as we should be able to switch originating teaching sites easily and smoothly from any BAE site during any given class session.

From the departmental administration point of view, there is a present need to involve BAE faculty from remote sites to teach students on the main campus, and in the near future for any faculty from any site to teach into any other site as needed. There is also a need for instructors to have viable ways (beyond the usual course evaluation surveys) to assess pace and comprehension levels of students for their continuing teaching improvement.

At present, our students are nowhere near ready for a full-blown student-centered problem-based learning approach, thus the author's goal was not to design a solution that would be too far from the possible adoption reach of the majority of the faculty and students. The adopted solution would then be "teacher-centered" with some elements of "interaction" and "collaboration" between teacher/student and student/student, and also definitely "live-lecture" based due to the preference of the majority of BAE faculty. The designed system should accommodate the 4 groups of faculty described above which will always exist, although specific faculty members may be moving from one level to another more sophisticated level in the future. The specific objectives of this report were:

1. Describe the design, implementation and recent revision of an ICT architecture suitable for teaching interactively local and remote students simultaneously. This work was partially reported in [Thai, 15].
2. Report on the performance and student usage of the multimedia annotation tool Silicon Chalk.

DESCRIPTION OF BAE DISTANCE EDUCATION SYSTEM

A heuristic approach was used for this project ([Rowe, 12]). From the previous descriptions, for now and in the foreseeable future, BAE students are taught and will be taught from **classrooms** located at any site in Georgia and using mainly the **live-lecture format**. As the **4 ICT/TET skill levels** described earlier for BAE faculty will always exist, a "good" solution must take this characteristic into account, meaning that it must allow for the **existence of these 4 levels at all times** and that each skill level **when mastered can be used as the foundation** to advance to the next level (an Applied Behavioral Analysis approach, see [Gillani, 4]).

Keeping these characteristics in mind, the following Distance Education system was designed (personally, I prefer to call it a Distance Teaching system):

1. To minimize long-distance TCP/IP traffic as much as possible, we used the TORM (Totally Ordered Reliable Multicast) protocol proposed by [Shi et al., 13] and described in Figure 1 when applied to our situation at UGA. It first consisted of a Wide Area Network (WAN) connecting only the Teacher Stations located at each classroom on each of the 3 BAE campuses and permitting 2 **independent data streams**, one used for **videoconferencing** and the other used for **course content delivery**. The video conferencing component was served by using simple appliances to satisfy ICT skill level 1 (Tandberg 880 and 6000 units). The remote course content delivery component was enabled by the software NetSupport Control (part of the NetSupport Manager Suite V. 8.6 from NetSupport Inc.) to be used by Remote Instructors requiring ICT skill level 3 (see [Thai, 15] for more details about the NetSupport Manager (NSM) Suite).

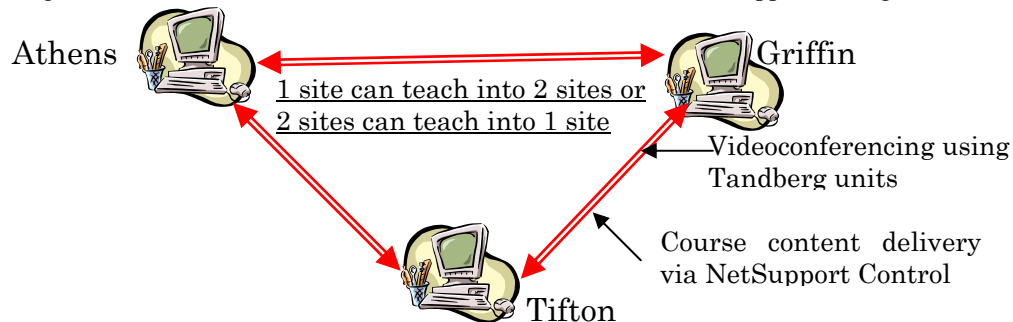


Figure 1. WAN linking only Teacher Stations from each campus.

2. For local TET users (ICT skill level 2) who wanted to teach only local students in an interactive manner, the ICT structure shown in Figure 2 was designed around an **isolated** local area network (LAN) operating at **1Gbps**. Interactive course content delivery was enabled using NetSupport Tutor and Silicon Chalk.

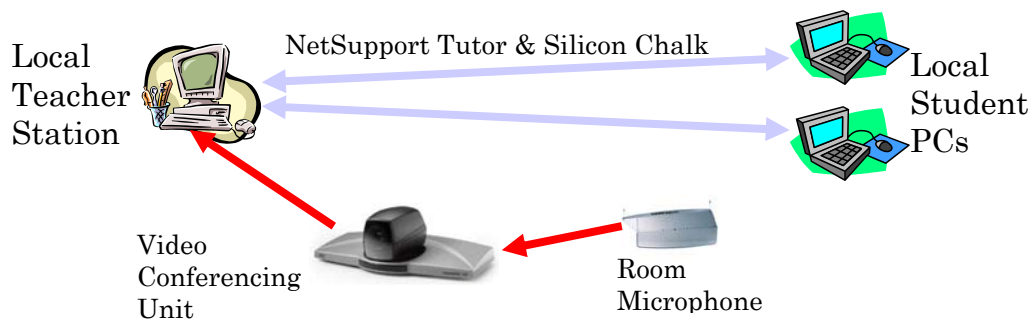


Figure 2. LAN linking local Teacher Station and Student PCs at each campus classroom.

NetSupport Tutor (part of the NetSupport Manager software suite) allowed the Teacher Station to interact with local student PCs as an individual student or as a group. Some of its features are listed below:

- The teacher can "Share-Watch-Control" each student PC on a one-on-one basis. This is used for quick response to student difficulties without having to run around from one student station to another.
- The teacher can "Show" his or her PC desktop or application to all or selected student PCs, and can "invite" 1 selected student to interact with the PC application being shown, via the student own keyboard and mouse. This is essentially an electronic version of the old chalkboard and can be used for in-class communal projects. It can also be used to transfer the remote control of lab equipment from the teacher station to a selected student.
- The teacher can "Exhibit" a selected student work to the rest of the class or organize the class into sub-groups with assigned group leaders.
- The teacher can automatically scan unobtrusively each student PC to ascertain the student progress during tests. The teacher can also Lock/Unlock access to selected PCs, and can control the execution of "approved" PC applications and Web URLs on each student PC.
- Facilities for File Transfer, Distribution and Retrieval are also available.

The local videoconferencing unit (Tandberg 880) is used in conjunction with the software Silicon Chalk to facilitate a multimedia annotation delivery system that is used by the local teacher and students during any given class session to capture and annotate course contents and instructor verbal explanations. Physically, the room microphone is connected to the Tandberg 880 as an audio input with auto gain enabled, i.e. local teacher and students verbal interactions can be captured into the 880. Next, the audio output from the 880 happens to contain both the local and far-end audio streams (from a typical videoconferencing session) and thus is fed into the microphone input of the sound card on the Teacher Station (see Figure 2). Silicon Chalk then digitizes this audio stream on the Teacher Station into its own multimedia stream containing other course materials, and broadcast this multimedia stream to the student PCs for their personal versions of the lecture notes. Of course, when one teaches only local students there is no far-end audio stream which only comes into play when one is doing remote or multi-site teaching (ICT skill levels 3 and 4). [Coatta, 1] narrated the flow of different learning activities in a typical day for a student using Silicon Chalk (SC) from in-class notes taking, to working cooperatively with fellow students on a common web-based project, to updating one's own personal notes and so on. Once the instructor started SC (V.3) with the tools he or she wanted to broadcast to the students, the instructor just minimized SC and started to use normally whatever Windows applications needed to deliver the course content as SC could be set to record, in the background, only the "top Windows application". A typical student screen is shown in Figure 3,

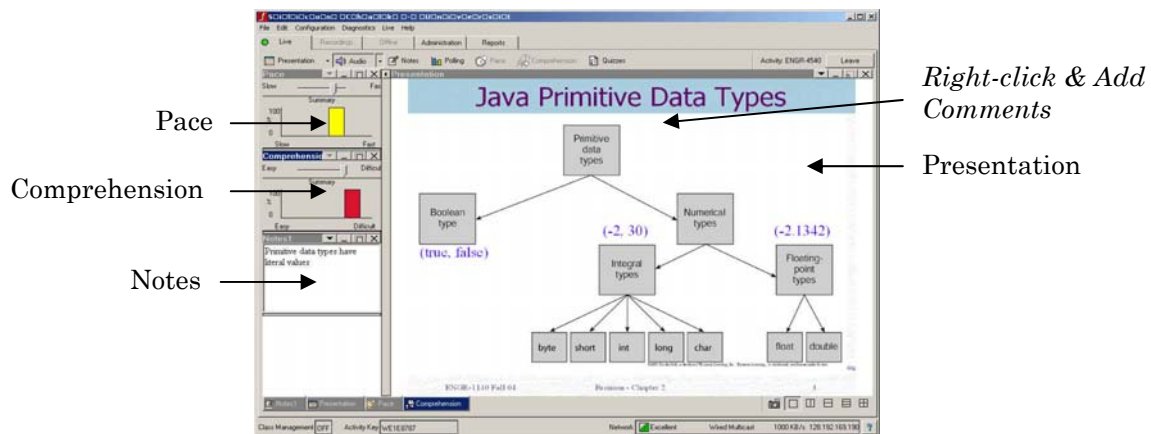


Figure 3. Typical Silicon Chalk window on student PC during class.

showing that the Pace, Comprehension and Notes tools were enabled (on the left vertical frame) and that the main Presentation window (a PowerPoint slide) was being broadcasted from the Teacher Station (on the right). Students used the Pace and Comprehension tools to provide live feedback about their own Pace and Comprehension levels (using the "slider"), while the teacher received a histogram-like summary graphical display on his or her station. Students can add Comments into particular spots/objects on any given Presentation slide or add Notes in the Notepad-looking tool during the lecture period. These comments and notes were time-indexed so that the user could just search for and go directly to a specific comment or note at review time after class. Figure 4 shows the same slide at review time for the student, with the standard Play, Pause, and Fast-Forward buttons. Students could add further notes and comments to the recording as they wished.

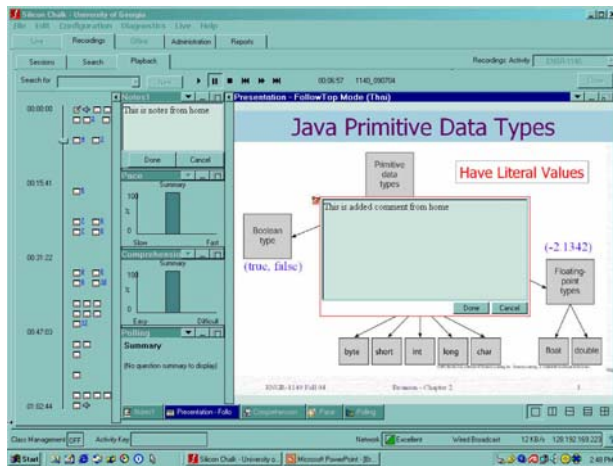


Figure 4. Typical Silicon Chalk window on student PC during review at home.

- For Remote Instructors (ICT skill level 3), let's say to teach from Tifton to Athens, the ICT structure shown in Figure 5 would be used. A daisy-chain control scheme via NetSupport Control was chosen to minimize long-distance TCP/IP traffic between Tifton and Athens, and to improve the overall system performance by actually running all the Windows applications needed for class from the Athens Teacher Station, so essentially the Tifton Teacher just needed to remotely control the Athens Teacher Station keyboard and mouse. If handwritten notes were needed, a Tablet PC was used to send its Windows Desktop to Athens

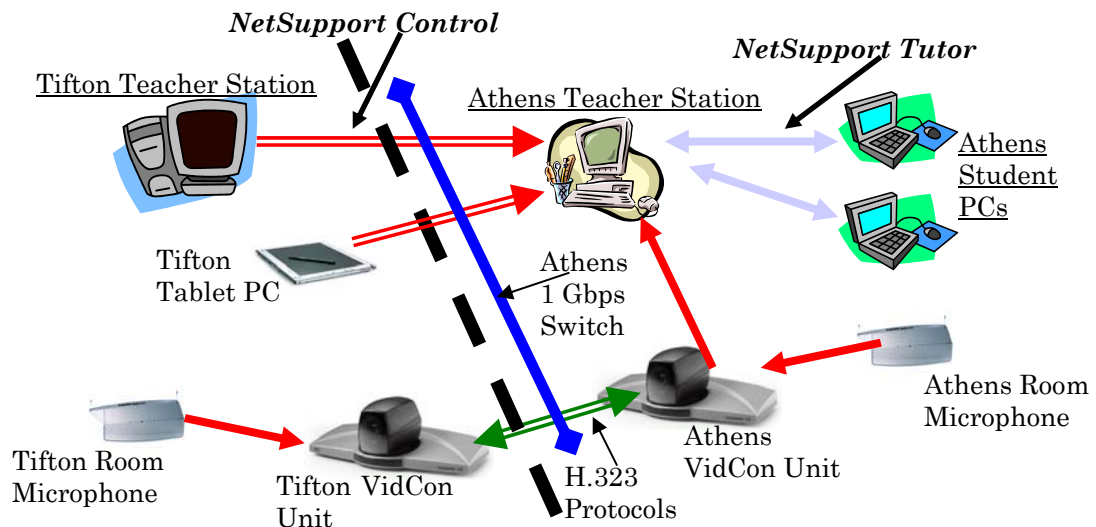


Figure 5. ICT architecture for Remote Teaching from Tifton to Athens.

via NetSupport Control. Typically, once the Tifton Teacher got control of the Athens Teacher Station, he or she can just use it as if they were physically in Athens starting NetSupport Tutor, Silicon Chalk and other Windows applications, as they are needed. The Athens Gbps switch was used to handle the local intense TCP/IP traffic without "leaking" it back into the long-distance TCP/IP traffic to Tifton. The Tifton Teacher verbal explanations were sent via the video conferencing units as a far-end audio stream that would be blended to the local Athens classroom audio stream and finally fed into the microphone input of the Athens Teacher Station sound card, and thus would be recorded by Silicon Chalk into the lecture multimedia notes. If the Tifton instructor needed to interact with a selected Athens student PC, he or she would just use NetSupport Tutor, running off the Athens Teacher Station, to perform this task because the instructor already had full control of the Athens Teacher Station via NetSupport Control. In other words, a Remote Instructor would be better prepared to have the experience of teaching interactively at the local level first.

4. For Multi-site Instructors (ICT skill level 4), let's say to teach from Athens to Tifton at the same time, the ICT structure shown in Figure 6 would be used, which was a combination of the architectures used for local and remote instruction (see previous Figures 2 and 5). Figure 6 also shows how PCs controlling Spectrometry and Machine Vision equipment from a nearby Machine Vision laboratory can be brought interactively into the classrooms (via Netsupport Tutor), therefore into the multimedia class notes for live

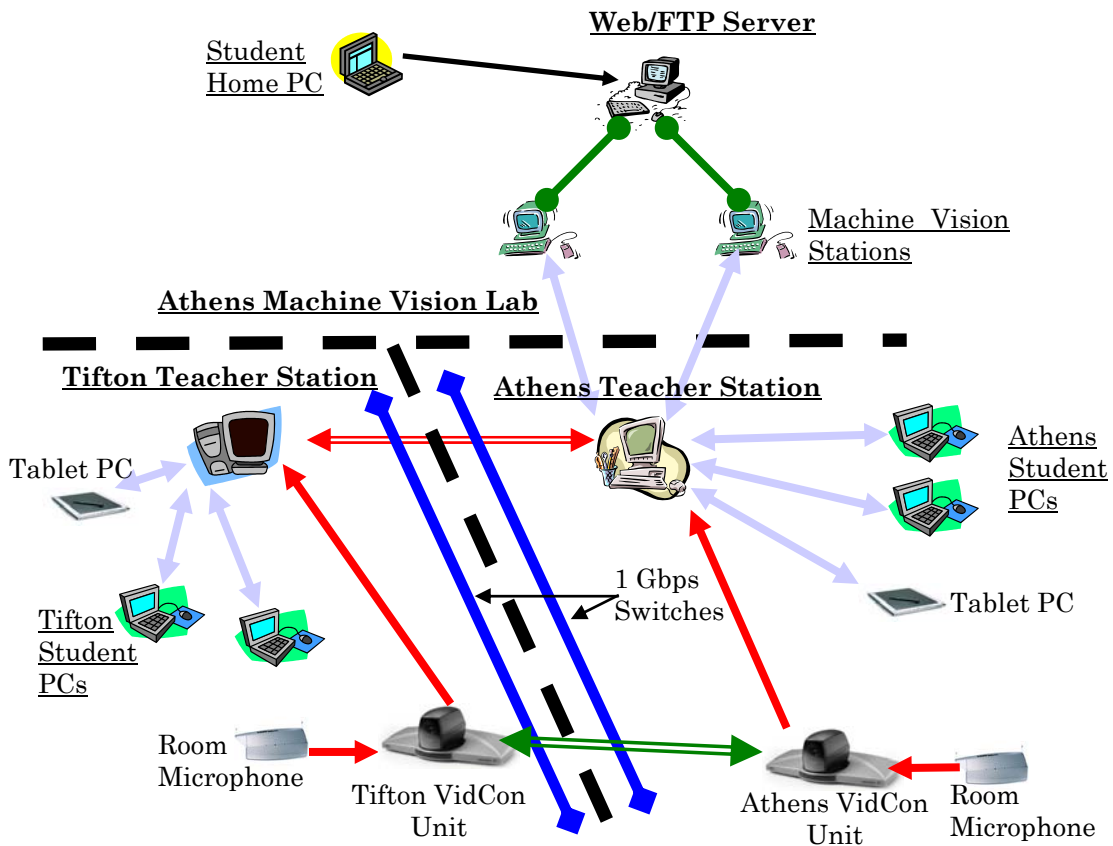


Figure 6. ICT architecture for Multi-site Teaching from Athens and Tifton.

demonstration of equipment usage. With this ICT scheme, verbal interactions between both sites are blended into mixed audio streams at each site and fed into the respective PC sound cards for each Teacher Station, in other words there would be no difference in the audio experiences (live and recorded) for students wherever they may be. A typical class session would begin by starting Silicon Chalk **independently** on both sites in the minimized mode, and using NetSupport Control, the **current teaching**

site would send its Top Windows Desktop to the other site, then would proceed to teach normally as if there were only local students, although the remote students also received the same course materials and verbal explanations at the same time (strictly speaking, with a small time delay). Each student at each site would still have the opportunity to work on their own personal Silicon Chalk notes as described in the previous Section 2. If there were a need to switch the current teaching site from site A to site B, it would be a simple task of first for site A to stop sending its Windows desktop to B and also to relinquish its control of B, then site B using its own NetSupport Control software starts to control site A and subsequently sends its Windows desktop to site A and finally proceeds to teach normally. Please note that there was no need to change anything to the layout and progress of Silicon Chalk. This feature illustrates the importance of the symmetry characteristic in the design of our DE system and the minimization of long-distance TCP/IP traffic into a single stream of the course content packets between the respective Teacher Stations, and not streaming multiple paths into the student PCs directly, thus wasting network bandwidth.

USE AND PERFORMANCE OF BAE DISTANCE EDUCATION SYSTEM

Software costs were as follows:

- NSM Tutor & Control Suite costs \$70 per PC with university discounts (a one-time purchase if one does not need yearly updates).
- Silicon Chalk costs \$40 per PC for an Annual Lab License, allowing free student software usage at home for 1 year. For additional years, students need to pay \$10 per year, on their own, in order to continue reviewing old notes or take another class at BAE that happens to be taught in the Silicon Chalk Lab.
- Other hardware and software were existing resources for the BAE department.

Since Fall 04, we had been using the above system (integrating NetSupport Manager and Silicon Chalk) for teaching Java Programming to local Athens students only. A preliminary survey shows the following results from 13 student responses (i.e. from half of the class):

- 10 out of 13 used SC in class & at home (2-3 times a week).
- 12 out of 13 found the use of technology in class helpful.
- 10 out of 13 found the use of technology in class NOT difficult.
- 11 out of 13 found the use of technology in class NOT a nuisance.

Personally, the author has reviewed the SC recordings for this course and had found them indispensable in refining his content delivery flow and techniques, a task that was not possible to do before the adoption of Silicon Chalk.

We had recently checked that the ICT infrastructure described in Figure 6 to be viable and operational with several short hourly tests within the UGA Athens network and we are planning for some short tests between Tifton, Griffin and Athens in the near future to test the Quality of Service between our 3 sites.

CONCLUSIONS

This report has shown that an ICT infrastructure for an extended-classroom model can be built using current affordable technologies. This infrastructure can greatly enhance the “active” instruction of engineering subjects within the classical lecture format by allowing the instructor to bring in seamlessly interactive activities that reinforce engineering concepts and help students retain course contents. It has a “symmetry” feature that helps remove the perceived “quality and equality” barriers between local and remote classrooms for both instructors and students from those sites involved. Finally, this infrastructure will also help our BAE department to adjust and perhaps expand in the inevitable world of “doing more for less” of U.S. higher education.

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