Teaching computer science courses in distance learning

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ABSTRACT

As the success of distance learning (DL) has driven universities to increase the courses offered online, certain challenges arise when teaching computer science (CS) courses to students who are not physically co-located and have individual learning schedules. Teaching CS courses involves high level demonstrations and interactivity between the instructor and students. For example, dropout and failure rate is high in introductory programming classes. Algorithmic thinking is a complex multi-step process. More advanced concepts are layered on top of others which should be learned previously in mathematics and other science areas. The commonly used formats of course contents and methods of communication delivered in distance learning environment such as Microsoft PowerPoint (ppt) and Word, Adobe Portable File Format (PDF), phones or emails are possible to have some level of interactivity. However, better demonstration and interactivity can be achieved by using flash technologies and animated simulations, and employing synchronous communication technology which works as the collaborative platform to allow the instructor and students to have real time application sharing. In this paper, examples of using flash videos and collaborative tools to teach online CS courses are presented. In addition, findings in terms of instructional strategies and suggestions to other educators who may face similar situations to teach online CS courses are discussed.

Key Words: Computer Science courses, Distance learning, Flash technology, instructional strategies

1. INTRODUCTION

The California Distance Learning Project (CDLP_2010) defines distance learning as follows: "Distance Learning (DL) is an instructional delivery system that connects learners with educational resources. DL provides educational access to learners not enrolled in educational institutions and can augment the learning opportunities of current students. The implementation of DL is a process that uses available resources and will evolve to incorporate emerging technologies." DL allows teaching and learning not to be restricted to the classroom or the school day. It can offer a great deal of flexibility in when, where, and how educational resources are distributed. Time and commuting cost can be saved for students that would otherwise be spent on travel back and forth to school. Learning schedule can be arranged at students' convenience to fit other aspects of students' personal and professional life. Without DL education, many students would not be able to accomplish a degree in higher education. For example, mothers choose DL because they can take their classes late at night after their children sleep. Students with disabilities and those who work full time or serve in military may find DL offers more opportunities than traditional education (Bruce, 1999). Both slow and quick learners are encouraged in DL. In its self-paced learning process, students can study at a personal speed that reduces stress and increases satisfaction. DL also helps students to gain extra computer and internet skills during the learning process. Students are judged solely by the output of their minds and intellect, without their status in life or physical characteristics being a factor. Therefore, DL can potentially eliminate all biases toward race, age, and physical disability that might occur in the classroom (Anspaugh, 2009). Academic institutions and industry corporate are also benefited from DL. The cost of training is less expensive in DL (Dibiase, 2000). Since the convenience of time and broader geographical locations of students promised in DL, advanced or specialized classes in which enrollments are low in traditional classroom setting can be offered in DL ((Threlkeld, 1991) & (Olszewski-Kubilius & Lee, 2004)). After the initial infrastructure and development costs are met, the marginal cost of serving additional students is close to zero. For example, Cisco Systems' e-learning manufacturing programs have produced savings of $1 million per quarter, producing an 80 percent increase in speed to competence (Pantazis, 2002). National Center for Education Statistics has found that enrollment in distance education at degree-granting postsecondary institutions is increasing tremendously each year. The survey reports that estimated 12.2 million students were enrolled in DL courses during 2007. Of these distance education enrollments, 77 percent were reported in online courses, 12 percent were reported in hybrid/blended online courses and 10 percent were reported in other types of distance education courses (Parsad & Lewis, 2008).

Although the advantages of DL are obvious and numerous, there are also problems. It has been rationalized that students in DL courses need to be responsible, have self-discipline and a certain amount of motivation to complete the course work (Kerka, 1996). Rintala (Rintala, 1998) went further and cautiously asserted that distance education works best for more mature, motivated, well-organized, and already accomplished learners (Cereijo, 2006). In DL's learning process there is no teacher looking over one's shoulder, therefore, discipline and time management skills are mandatory. Students should be able to set their own goals and make progress continuously through to the end of the term. Students may find it hard to have the right time to study while keeping other responsibilities for work and family. Procrastination is the main cause for students to miss the deadlines of assignments posted in the syllabus. In DL the

interaction between the instructor and the learner and socialization between students can be limited due to the physical separation. The professors and other classmates are available usually by phone, email and discussion forum, which causes students not to get immediate feedback from the question or discussion. Physical separation leads to a psychological and communication gap, a space of potential misunderstanding and delay between the inputs of the instructor and those of the learner (Moore, 1991). The opportunity for the student to make the cognitive connection within the course material may be lost because of this time delay (Mallory, 2007).

Besides those general problems associated with DL, certain challenges arise when teaching computer science (CS) courses to students who are not physically co-located and have individual learning schedules. Learning to program is a difficult task for many students even in traditional class. The dropout and failure rate is as high as 30 percent in introductory programming courses at the university level (Guzdial & Soloway, 2002). Algorithmic thinking is a compound multi-step process. Problem solving ability and background knowledge of mathematics underlying the process are essential foundations. In addition, a student must be able to use the computer and software effectively to create the program, compile it, and find the output. The program produced must be tested and any programming error must be corrected. Since in DL the instructor and students are physically separated, it creates significant barrier to teach students those basic skills to use new software or debug a program. Teaching CS courses involves high level demonstrations and interactivity between the instructor and students. The commonly used formats of course contents and methods of communication delivered in distance learning environment such as Microsoft PowerPoint (ppt) and Word, Adobe Portable File Format (PDF), phones or emails are possible to have some level of interactivity. However, better demonstration and interactivity need be achieved.

In this paper, several effective teaching strategies and tools for online CS courses are presented. Suggestions for course interface design are presented in Section 2. Visual-audio teaching lessons are discussed and presented in Section 3. Collaborative tools that allow the instructor and students to have real-time application sharing is introduced in Section 4. Other findings in terms of instructional strategies and resources are presented in Section 5.

2. COURSE DESIGN

There are commercial products of Course Management Systems (CMS) used to design and organize an online course. Examples of brand names of such products include “WebCT” and “Blackboard” (http://www.blackboard.com), and “Desire2Learn” (http://www.desire2learn.com/) etc. When the instructor designs the course, the purpose of posted materials needs to be clear to the students. Is this for syllabus policy? Is this an assignment? Is this required reading material for the course? Here authors use Blackboard® as the CMS to give suggestions on how to design and organize the course. There are 12 sections in an online CS course that the authors teach (Figure 1):

1. "Starts here": A welcome message that contains important information for student to start the class including important software information, policy on assignments, exams and discussions is posted there. The page also provides a "course site map" (Figure 2) to summarize each section and aid students in the navigation of the course.

2. "Announcements": Students can view important messages from the instructor posted this section. The link will appear automatically right after students login into the blackboard when a new message is posted.
3. "Syllabus": Students are expected to read it very carefully and should contact the instructor if they have any question. "Syllabus" is also served as a "contract" that the instructor and students must follow. A complete and clear syllabus can avoid or solve possible situations that cause grade appealing and increase students' satisfactions on the course.
4. "Faculty information": The instructor can post biography information here. By providing the instructor's education background, working experience, research interest or information of instructor's personal life, it will give students the sense that they are connecting with a real people. The page also gives users a quick way to look up names including teaching assistants, email addresses, office hours, and other contact information.
5. "Course Documents": Lecture materials and other required reading materials can be posted here. Materials should be grouped and organized into modules. For example, Figure 3 shows that the course contents are presented in weekly modules.
6. "Discussion Board": The instructor and students use discussion Board to interact by posting to the discussion board. Figure 4 shows multiple forums can be created for the purpose of social and academic interactions.
7. "Assignments": Assignment information and deadlines can be posted under this menu. In the courses the authors teach, students are required to turn in all assignments through Blackboard assignment pages by midnight of the due date. The instructor will not accept solutions via email or other media due to two reasons. The first reason is to avoid potential virus. The second one is to take advantage of Blackboard assignment page to keep the record of students' submissions and the time stamps and get all student work organized and use grade center to grade them.
8. "Exams/Quizzes": This menu contains exams and quizzes of the course. Blackboard has various types of questions that an instructor can pose in quizzes and exams.
9. "External Links": This is the location where students can find additional useful websites for the course. For example, the textbook webpage that students need to access to obtain the resources such as data files and university's library page can be listed here.
10. "Grades": This page provides students easy view of the grades and access to the instructor's comments on assessment submissions.
11. "Tech/Proctor Info": Various guidelines for University policies on technology use, Ecampus student handbook and proctored test information are listed in this menu.
12. "Course Tools": This built-in menu lists all resources and adds on available in Blackboard. For example, students can download Wimba Pronto (will be introduced later in this paper) to communicate with the instructor.

3. TEACHING LESSONS

Since the separation of the instructor and the students creates more communication difficulties, the learning materials must be designed properly to engage the learners and promote learning experiences (Ally, 2004). Studies on media research have shown that students can gain significant learning benefits from audio-visual multimedia, if it is used properly (Kozma, 2001). The ability to see an actual application usage or see and hear an instructor allows behavior modeling to be applied to abstract concepts (Skinner, 1974). The multi-media teaching lessons can be delivered in either a synchronous or asynchronous way. One model suggests 80% of a

student's time is spent on self-paced learning and remaining 20% in interactive, synchronous communications with the instructor and classmates (Danchak, Jennings, Johnson, & Scalzo, 1999). The actual number of percentages is flexible and should be adjusted according to the course learning objectives, the learner and the instructor.

3.1 Synchronous teaching lessons

In a synchronous delivery method, the teacher and the student are able to interact with each other in "real time". Innovative distance learning approaches are expanding rapidly based on emerging technologies such as in two-way video conferences, for example, students interact with "live" video of an instructor by VTEL® (http://www.vtel.com/), or use Wimba Classroom® (http://www.wimba.com) which can be integrated in Blackboard. The advantage to use synchronous method is it can ensure students understand their lessons by asking for immediate feedback, answering questions and providing group discussion.

3.2 Asynchronous teaching lessons

Comparing to a synchronous delivery method, asynchronous one is not simultaneous. The instructor in this case delivers teaching instructions via computer and internet and gets later responses from students. One of the advantages to use asynchronous method is the low cost. Educational institutions with budget constraints would like to take advantage of those synchronous delivery technologies, but cannot fully do so with limited funds. Moreover, students who take online learning usually intend to avoid hindrances such as a fixed meeting schedule, and expect distance learning being as effective as traditional classroom learning. Those constraints often force very sophisticated and expensive technologies to have less access availability to schools and students.

PC-based flash technologies such as Adobe Captivate® and Camtasia Studio® can be used to make asynchronous teaching lessons. Flash is a vector based animation program. With its built-in programming language, called ActionScript®, it can produce from simple animations to complex interactive online applications. Since introduced in 1996, flash has become a popular method for integrating video and other various web page components. Commercially available flash technologies such as Adobe Captivate® and Camtasia Studio® can easily be used by an instructor without flash programming knowledge to build flash contents in a personal computer. Tools used to view the flash such as Adobe flash player® (www.adobe.com), are downloadable free as web browser add-ons. Students can view the teaching contents without the need of additional software. Compared to regular PowerPoint presentations which can also produce animations and recorded narrations, flash files are highly compressed, requiring much smaller storage spaces. Moreover, flash has much higher quality of synchronous visual and audio integrations, user-interactivities, and is considered to be the preferred medium for Internet file sharing and teaching demonstration.

Flash can create step by step animations and corresponding narrations to make the learning materials more memorable and persuasive. The components of animations must be designed properly, in order to target the course objectives and contain the right amount of information that the audience can comprehend. During authors' several course developments with flash contents, it was found that it would be easier and time saving for instructors who have not much flash programming knowledge to design lectures in regular Microsoft Power Points format

first, then to record the onscreen presentation activities using a PC-based flash technology. During recording, vocal explanations can be added as well as pre-made layouts and animations.

Flash technologies allow instructors to edit and polish the videos. The video speed should be made appropriately to suit for the learning process; otherwise it may cause learners' increased anxieties. There is no need to have an "error-free" recording. Real-time programming, compiling and debugging can be recorded to enhance learning experiences. For example, when programming in C++, the instructor may get errors after the program is compiled. It would be helpful to demonstrate the details of the error- correction process which simulates the real time situation of how the common programming errors can be and how to debug the errors in its actual application. A typical lecture using flash technologies should be divided into sessions with appropriate time allocation to gain optimum benefits. Research has found that the maximum attention span of an adult learner is about 20 minutes (Chamberlain, 1985). Therefore, the optimal duration for each session can be less than 30 minutes. Flash videos can be published in various formats and are most convenient for non-traditional students whose learning environment is adaptive.

PC-based flash technologies enable instructors to add various advanced features to the presentation to keep learners' attention focused on the course subjects as well. These features can be interactive simulation, scenario-based training or self-evaluation. Flash technologies are also compatible with easily add-ons to convert text to an artificial human speech.

Several courses and projects have been completed by the author using PC-based flash technologies such as Adobe Captivate® and Camtasia Studio®. One of the flash videos, for example, was created in the form of a PowerPoint presentation but with more dramatic visual effects, featuring the use of flash interactivity, text-to-speech technology, and Flash-in-Flash embedding. The authors found these teaching materials are much more effective in providing students an easy learning experience in both distance and traditional classroom environments compared to ordinary PowerPoint notes. A demo can be found at: http://spectrum.troy.edu/~xhuan/csdemo.html. In an e-learning system such as Blackboard®, storage space for each course may be limited by a memory quota. The instructor would have to remind students to watch or download the flash video and then update the contents periodically.

4. OFFICE HOURS

In a traditional classroom setting, a student's performance can be immediately assessed through questions and informal testing. Recent technology makes it possible for distance learning as well. In the online CS courses the authors teach, Wimba Pronto® is used as the collaboration tool to communicate with students for real time interaction. Wimba Pronto is an academic-centric instant messaging platform designed to bring informal learning settings online. One of the main differences between Wimba Pronto and other instant messaging programs is that Wimba Pronto is synchronized with the institution's Course Management System (CMS) such as blackboard. This means that students and teachers are automatically connected with other Wimba Pronto users enrolled in the same courses. Whenever a student has a question, he/she can use Wimba pronto to collaborate and communicate with the instructor quickly and easily. The features of Wimba pronto include: Audio Calling, Video Calling, Application Sharing, Queued Chat, and Help Desks (http://www.wimba.com/products/wimba_pronto).

One of the most useful features in Wimba Pronto for CS courses is Application Sharing. For example, when students install a certain application in their computers, they may encounter

different problems due to individual settings in their computers. The paths of directories can be different. The operating systems can be different. The error messages are different. Students will feel frustrated if they get stuck at the beginning stage of the class when they cannot install the software successfully. Finding a tutor locally is not an easy task in some regions. Those problems can be helped by Wimba Pronto. The Application Sharing feature allows real-time display of any document or application on the student's or the instructor's computer. For instance, in one database class, students are required to install mySQL® and use the "source" command to import a file containing all table creation and data insertion commands. The path of the file varies in individual computers. By using Wimba Pronto, the instructor can view student's computer screen and successfully help them through the importing process (Figure 5). Wimba Pronto's group chat allows the instructor to hold online office hours and manage individual attention with a large number of users at the same time.

5. OTHER USERFUL INSTRUCTIONAL STRATEGIES

5.1 Enhance Reading Culture

Reading is a fundamental aspect of programming (Rooksby, Martin, & Rouncefield, 2006). Programming is a cognitive activity that requires the programmer to develop abstract representations of a process and express them in the form of logic structures. In the case of creating, modifying, reusing, or debugging a program, the programmer must also translate these abstract representations into completely correct code using a formal language (Wiedenbeck & Kain, 2004). A mental model which refers to the user's mental representation of the components and operating rules of the system and may vary with respect to its completeness and veridicality, have been shown to play an important role in programming (Mayer, 1981). The more complete and veridical the student's mental model is, the more useful in supporting sophisticated programming it will be (Cañas, Bajo, & Gonzalvo, 1994). What can help the student to build a good mental model of programming? The research (Littman, Pinto, Letovsky, & Soloway, 1987) shows that there is a strong relationship between using a systematic approach to acquire knowledge about the program and modifying the program successfully. Programmers who used the systematic approach to study the program and build complete plan constructed more successful modifications than programmers who used the as-needed approach to jump immediately into the codes to make modifications. Programmers who attempted the systematic strategy were able to gather knowledge about the causal interactions of the program's functional components. Programmers who used the as-needed strategy did not gather such knowledge and relationships between other parts of the codes.

The textbook conveys the amount of information necessary to enable students to go through the class. However, many online students are reluctant to read or do not spend enough time reading their textbooks. There are three reasons found by the authors account for it:
1) Busy schedule: according to statistics from the U.S. Department of Education and the University Continuing Education Association, the fastest-growing group taking college courses is the nontraditional students that are 25 and older who are working and raising families. Many Online students find it hard for them to sit down and read since they have multiple roles such as parent, spouse, employee, and student at the same time.

2) Lack of interest: Adult students return to school years after employment, homemaking and/or other activity. Studying, reading and being able to retrieve the information when needed might seem discouraging for them. Those students do not feel quite interested in reading.
3) Technology transition: for the new generation, it is common to read online. Students are more likely to read blog, wikipedia, online tutorial, and use internet to gather new information. However, there is a difference between reading online and printed material. Research in the subject of online reading suggests that reading online is less effective than reading printed material. Learners also tend to skim online materials (Carliner, 1999). Students usually do not read at the same depth when they are searching online as reading printed material. When reading a printed book, readers often stop and think or visualize about what they have just read. Reading online is quite different. Almost everything about being online is faster paced. The keywords are typed in and searched through the links. Many times the reader stops at the middle of a webpage and jumps to another link.

Based on the class experiences of the authors, reading culture can be enhanced in distance learning in the following practices by the instructor:
1) Use syllabus or course announcements to address that reading and retaining information found in academic books is one of the keys to succeed for study. Urge students to set priority for reading activity. Ask students always carry a book. Time spent waiting in line or in the car while someone is shopping or kids playing soccer can be study time.
2) Provide tips. Ask students to be an active reader. For example, in an introductory programming class, students should read example codes carefully. They should type example codes in the compiler instead of just copying and pasting it, which forces students to pay attention to syntax of the programming language. Example codes should be run and tested by students.
3) Apply instructional strategies to ask questions before, during and after students' reading in discussion forum. Encourage specific questions from students. Discussion can activate students' prior knowledge, monitor and assess the reading levels and progress of students. It can also provide opportunities for students to respond, make connections and extend comprehension.
4) Research and post useful links on textbook topics. There's a good possibility the textbook does not explain certain topics well or alternative explanations may work better. Help students find good alternative resources including internet to read.
5) Provide peer review opportunity. For example, select and post the exceptional work regularly. Group project also creates pair programming opportunity for students to work with other programmers, broadens their horizons and increases the quality of code (Williams, Wiebe, Yang, Ferzli, & Miller, 2002).

5.2 Take advantage of useful resources

Developing quality multi-media educational materials requires large amount of time from the instructor. Researching and reusing existing materials developed by other educators can help significantly to mitigate the time challenge and improve the course contents. Instructors do not have to "reinvent the wheel" for each topic. There are many useful existing resources available for teaching computer science.
1. Choose a good textbook. Most effective distance education classes should be carefully and deliberately planned by the department committee to meet the educational requirements of the

course and student learning outcomes. Choosing a good textbook is critical for the success of a distance learning course. A good textbook should match the course, the instructor and students. It should have appropriate difficulty level and readability (Lepionka, 2006). Textbooks with a variety of useful high-tech supplements and links to interesting websites are especially helpful for distance learning courses. For example, the author of C++ book "starting out with C++ from Control Structures" (ISBN: 978-0-321-54588-6) provides an series of online videos to accompany the text (http://www.aw.com/gaddis).

2. Choose a good courseware. Courseware like myitlab (http://www.myitlab.com) has open simulation of Microsoft Office 2007 that allows students to complete an activity exactly as it is taught in the textbook. Its outcomes-based training is self-paced and adaptable to each student's skill level. Students can advance to the next level if they already know the subjects in the current level. Multimedia demonstrations as hints are also available for students to watch.
3. Choose good open materials. There are many useful and high quality open source materials available on Web. For example, Virginia Tech (http://courses.cs.vt.edu/csonline/) provides multimedia course material with animations to assist learning some key Computer Science topics. CodeWitz Network (http://www.codewitz.net/) invites high education institutes to produce and evaluate illustration, animation and visualization aids. Therefore, the material bank, which helps the students to better understand and master and the teachers to better explain and illustrate the problems connected to the use of basic and advanced structures in computer programming, is enriched.

6. SUMMARY

In this paper, examples of using flash videos for online teaching materials and collaborative tools to communicate with students are presented and discussed. Findings in terms of instructional strategies to enhance students' reading skills in order to support and increase self-efficacy are suggested. Useful resources to effectively teach online CS courses are introduced.

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Figure 1. Online course menu.

Course Site Map

Before you begin the course, you need to have an idea of how to navigate through the content areas and tools, which are linked to the menu on the left side of your screen. Obviously, you have successfully made it into the first one, since you are reading this.

Site Maps	"**Site Map**"…what you are reading right now. This will navigate you through the course.
Faculty Informati	You can find more information about your instructor by checking "**Faculty Information**"
Syllabus	Read the "**Syllabus**" carefully to be sure you are entirely familiar with what is expected from you and with what you can expect in the course. If you have questions about any part of it, be sure to bring them up on the "Discussion Board," which is addressed below.
Announcements	"**Announcements**" will appear periodically when I have something that the facilitator wants to convey to the entire class. They should come up automatically when you first log on, so pay attention to your first screen. You also can check the announcements through the link to on the left of the screen. University announcements related to the online programs, by the way, may also appear on your screen after you have logged in, but before you click on the link to the course. It's a good idea to glance over that screen, as well.
Course Documents	Next you will find the "**Course Document**" button where the lecture materials are located.
Discussion Board	The "**Discussion Board**" is where we will introduce ourselves and discuss the topical assignments that I will provide to you. The Discussion Board also will provide you an opportunity to ask questions that you may have. I expect every student to participate regularly in discussions of the various topics that I assign during the course. See the syllabus for further detail.
Assignments	You will find the assignments in "**Assignments**" page. It is extremely important that you keep up with these assignments. The assignments must be turned into the "**Assignments**" page by midnight of the due date. See the syllabus for further detail.
Exams	"**Exams**" contain the middle exam and final exam in this course. See the syllabus for further detail.
Grades	There is a link called "View Grades," which will give you a running summary of the grades you have earned in the course. Grades will be posted in the Gradebook at the appropriate time as we go through the course.
External Links	This is the location where you can find additional useful websites for the course.

Figure 2. Course site map.

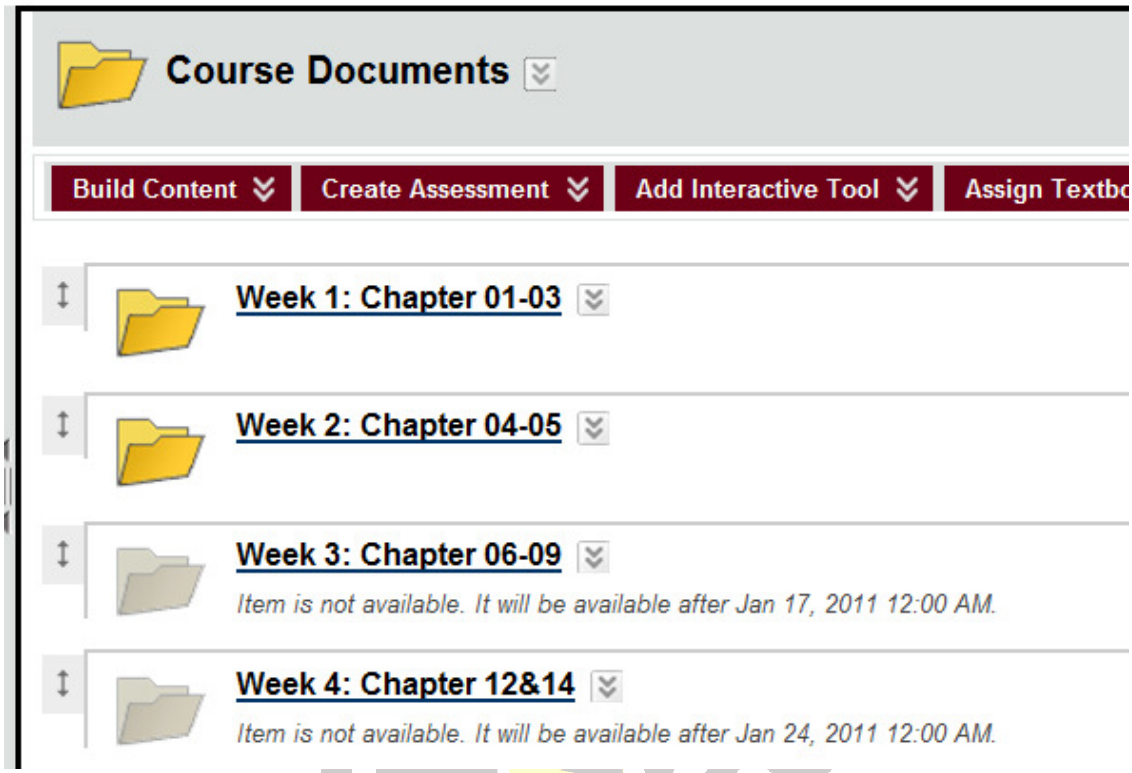

Figure 3. Course Documents in weekly modules.

Forum	Description	Total Posts	Unread Posts	Total Participants
Student Lounge	Students, please introduce yourself here, and you can socialize about topics not related to the class content. Etiquette expectations : For all online discussions and communications, as a college student you are expected to abide by the rules and regulations of the university, in addition, you are required to meet the following: 1. Be nice. Please refrain from inappropriate language and personal attacks. 2. Choose a descriptive subject. This will help other subscribers to successfully identify your topic. The instructor reserves the right to delete messages which do not follow these guidelines.	42	0	13
Ask The Instructor	You can ask questions directly to the instructor here.	5	0	4
Textbook tutorials discussion	Post the discussions about tutorials in book here.	0	0	0
Assignments discussion	You may discuss assignment questions here.	0	0	0
week 1		32	0	14
week 2		26	0	12

Figure 4. Discussion Forums.

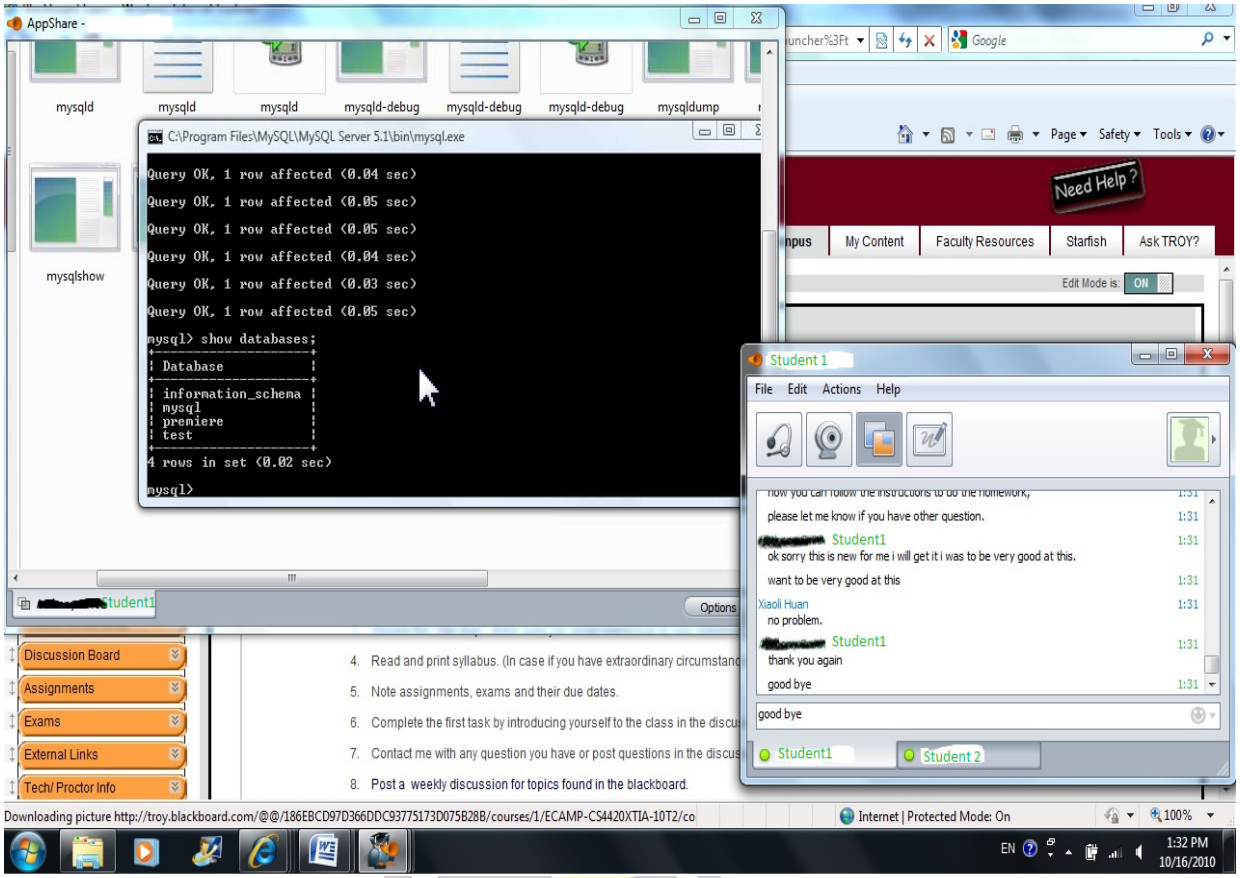

Figure 5. An example of Wimba Pronto's Application Sharing. On the left side, it is the application sharing window that shows the student's computer screen activity in the instructor's computer. On the right side, it is the Pronto's window that allows the teacher and the students to communicate.