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# **AC 2011-1056: WORK IN PROGRESS: DISTANCE TEACHING OF THERMODYNAMICS WITH ADOBE CONNECT AND DEDICATED ENGINEERING SOFTWARE**

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## **Work in Progress: Distance teaching of Thermodynamics with Adobe Connect and Dedicated Engineering Software.**

### **Abstract.**

A considerable number of schools nationwide are currently offering undergraduate engineering and engineering technology programs via *distance-learning*. Unlike other “narrative” academic programs, however, engineering programs still present pedagogical challenges in distance education especially in subjects that require mathematical derivation, sample problem-solution, property evaluation and laboratory practice. Several technologies are currently available for distance education, such as: TV broadcasting, web-based instruction, video-streaming, video-conferencing, etc. Nevertheless, distance teaching of subjects such as, Fluid Mechanics, Thermodynamics, Heat Transfer and other recognizable subjects in the field of Mechanical Engineering and Technology proves to be a didactically-involved and effortful task. An innovative and simple teaching method to impart synchronous instruction in Thermodynamics to local and distance students has been implemented by the author, and it is discussed in this paper. The method combines the use of the internet via Adobe Connect and dedicated software to evaluate properties in Thermodynamics and solve illustrative problems. The method is simple and allows the instructor to quickly solve illustration problems during the lecture in spite of mathematical complications that may be involved. Specific examples of the technique are discussed, and the requirements to implement the method are disclosed. It is shown that such technique allows the instructor to be totally mobile, and deliver his/her lectures and illustrative problems in Thermodynamics live from any classroom or lab in the U.S. provided that an internet connection is available.

### **Introduction.**

Distance Programs have become the preferred method for a considerable number of students seeking to complete degree programs from Institutions of higher learning within the U.S. and abroad. Initially, distance education was particularly appealing to adult non-traditional students interested on completing their higher-level education or sharpening their knowledge and skills (continuing education). More recently, however, distance education has become more and more attractive to traditional students due to its convenience, versatility, and affordability.

Distance learning is indeed increasing access to education and training opportunities worldwide and organizations such as the United States Distance Learning Association are strong advocates and networking centers to understand and learn better about distance education.

Many academic Institutions in the U.S. have been extremely successful in developing distance programs that capitalize on the educational opportunities sought by students, together with the existing technologies to broadcast instruction via television or *on line*. One of the best examples is the University of Phoenix, a for-profit educational institution that provides distance learning to more than 200 sites nation and worldwide, and confers associate’s, bachelor’s, master’s and doctoral degrees in a wide range of academic programs. Enrollment at the University of Phoenix

is near half a million students which clearly shows the trend and preference in higher level education among students.

Distance education has and continues to be pursued and offered by many Institutions of higher learning in the U.S. It is beyond the objective of this paper to enumerate all these institutions. However, it is safe to say that the implementation of distance education in current times is becoming a common objective among a considerably number of Schools as a viable means to attract and secure student enrollment into their academic programs.

Implementing distance education, however, is not a task without challenge. The level of challenge depends on the type of program or course of instruction to be imparted. Programs such as Criminal Justice, Business, Accounting, Law, Nursing, and Education and others in the narrative disciplines, have been the choice of many institutions to initiate their distance learning programs, while engineering and engineering technology programs continue to be a challenge and distance enrollments are well behind as compared to the programs mentioned above.

In particular, the implementation of distance learning in traditional engineering fields such as Mechanical, Civil and Electrical Engineering and Engineering Technology still faces educational complexities inherent to their practical nature and requirements of hands-on activity in laboratories. Nevertheless, continuous efforts are made to offer degree programs in engineering, very often, by combining *distance lecturing* with practice courses where students are still required hands-on activity in the lab. There are also efforts to replace actual activity in the lab with “virtual” labs. The effectiveness of these “virtual” labs for “practical” training in engineering is still under study and it has been matter of controversy and discussion in educational circles, but the efforts to implement distance learning in engineering have not stopped and they are a *work in progress*.

### **Old Dominion University in Distance Learning.**

Old Dominion University of Norfolk VA (ODU) is recognized as a pioneer institution in distance education and telecommunication since the mid 1980's. “Teletechnet”, is a satellite broadcasting system implemented and used by ODU since the early 1990's to deliver courses and degree programs to a network of distance locations not only within the continental U.S. but also to US Navy ships and submarines deployed around the globe. At present, ODU delivers distance education using technologies beyond satellite TV transmission. Newly available computer-based and Internet technologies have been implemented and are extensively used to provide educational access to students worldwide.

ODU offers a wide variety of programs and educational opportunities to distance students, including technical undergraduate major and minor programs in engineering and engineering technology such as, Electrical, Civil, Mechanical, Nuclear, and Motorsports engineering technology.

Engineering instruction frequently presents some pedagogical challenges in distance learning, especially in subjects that require mathematical derivation, sample problem-solution, property

evaluation and laboratory practice. For instance, lecture-based courses of mechanical engineering and mechanical engineering technology, such as: Mechanics (Statics, Dynamics, and Fluid Mechanics), Thermodynamics, Heat Transfer, and other recognizable subjects in mechanical engineering are still a laborious task for distance teaching and learning especially if they are to be delivered live and simultaneously to distance students and students in a local classroom.

Fortunately, advances in internet communication and versatility of computer software and hardware can now be adapted not only to lecture distance students in such subjects, but also to encourage and facilitate their active participation during the lecture.

An innovative method that combines live lecturing using the internet via Adobe Connect in conjunction with dedicated software to solve equations and evaluate properties in Thermodynamics and Heat Transfer has been implemented at Old Dominion University for synchronous teaching of local and distance students. Detailed characteristics of the method, and the advantages found over other available techniques to deliver the course are explained in this paper. The method is simple to use and allows the instructor to quickly solve illustration problems using the computer while broadcasting the lecture, in spite of complications that may be involved in writing equations while explaining solutions to problems or conveying concepts. Some examples will be used to illustrate the simplicity and suitability of the method for teaching Thermodynamics and Heat Transfer courses, both frequently considered by engineering students as “challenging” subjects.

### **Simultaneous live lecturing of local and distance students.**

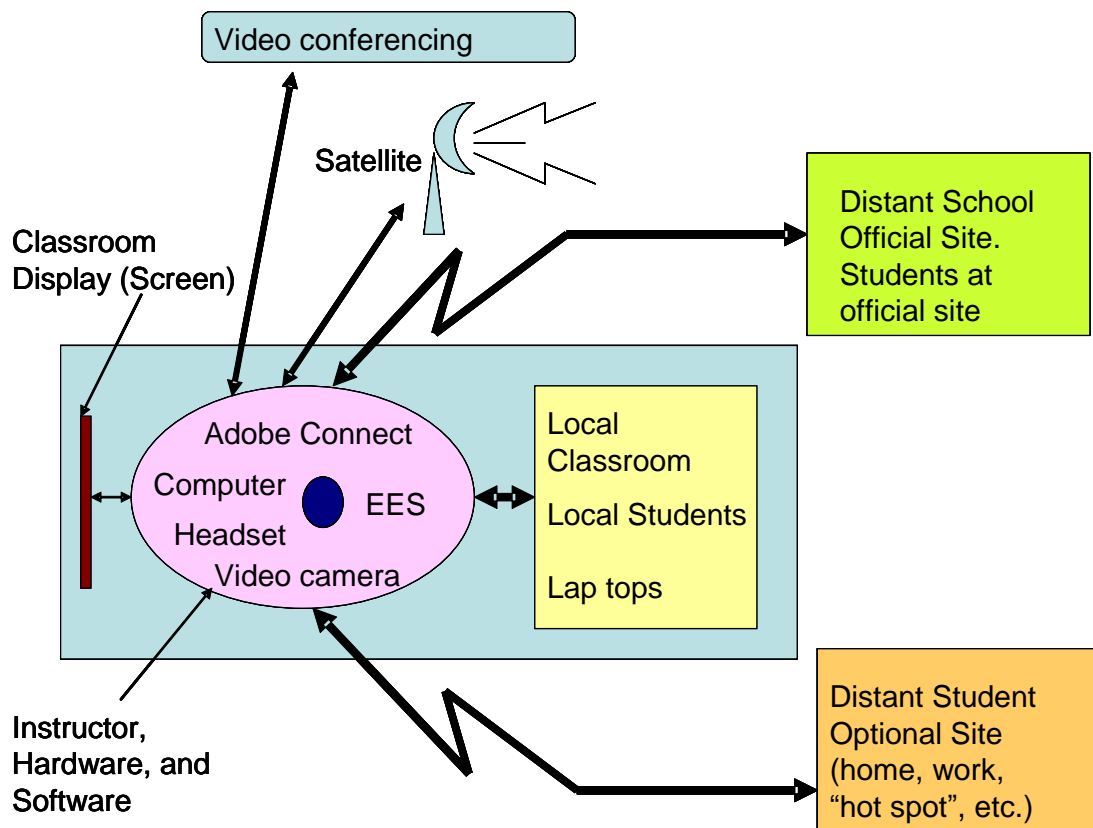
Television broadcasting of lectures is a relatively simple way to deliver descriptive lectures to local and distance students. As expected, however, watching TV lectures discourages the active participation of students in the learning process, particularly in engineering subjects where problem-solving practice is crucial to learn the applications of principles and concepts.

Up until the development and commercialization of HDTV sets, the picture quality on the TV screen had also been an issue. The clarity and readability of the material presented by the instructor was always a common concern. Fortunately, the quality of the picture is no longer a problem due to impressive advances in screen resolution. Furthermore, the quality and clarity of handouts and lecture presentation have greatly improved with the widespread use of word processors or presentation software such as the highly popular Power Point viewgraphs. Nevertheless, the passiveness of students inherent to the simple TV screen watching continues to be an important educational challenge.

In Thermodynamics and Heat Transfer courses, particularly, problem-solving through application of concepts and principles assures effective learning. As every instructor of these subjects knows, by only watching the lecturer to solve problems during class is not enough for students to comprehend and retain concepts and principles. Their active participation and practice are indispensable in the learning process. Unlike other narrative subjects where the teaching stresses on “impressing” and “entertaining” the audience, engineering technical subjects

like Thermodynamics, are better learned by doing, participating and making use of the foundation of math and science learned in basic subjects such as algebra, calculus and physics.

The method discussed below, is an educational approach designed to improve the instruction of engineering students taking Thermodynamics and Heat Transfer. The method promotes extensive use of the computer and encourages the active participation of students. The method is highly versatile and can be used to teach and communicate with local and distance students simultaneously. It is a synchronous and hybrid delivery of instruction that uses the internet and dedicated software for lecturing and problem-solution illustration. The method is also mobile, and it can be used in any classroom or laboratory with internet access even when the room lacks dedicated (and often expensive) equipment for distance instruction. Figure 1 shows a schematic diagram of the main elements involved in the method.



**Figure 1.-** Schematic diagram for Thermodynamics and Heat Transfer lecture simulcasts

In this figure, the instructor (represented by the blue dot) uses a computer and a small headset (microphone and speaker) in order to deliver lectures and interact live with local and distance students simultaneously. A video camera attached to the computer is optional. Students receive

the lecture on their computers which in most cases have a built-in microphone and speakers. Communication is achieved via Adobe Connect, a versatile web conferencing software tool provided by the School and supported by most internet browsers. Adobe Connect is used in conjunction with dedicated software for descriptive explanation of themes inherent to the subject matter, and problem solving. Problem solving is presented using the software EES, a dedicated equation solver for subjects of Thermodynamics and Heat Transfer.

The figure also shows the Satellite and Videoconferencing systems. These systems, however, are less versatile than the Adobe Connect-EES system. Satellite TV communication and Videoconferencing require more specialized and often costly hardware, and a dedicated room, as compared to a simple computer laptop and a small headset required for the Adobe Connect-EES system.

The author has utilized both, Satellite TV Communication and Videoconferencing for delivering distance lectures from ODU's main campus. Both systems are quite effective when broadcasting to sites that possess the required and compatible reception hardware, room space, and technician support. In contrast, the Adobe Connect-EES is simple, easy to use and accessible from any place where internet service is available. The system can also be used simultaneously with Satellite and Videoconferencing transmission. The level of training needed is minimal and only a short period of time is needed for students and instructors to become familiar with it. Typically, students will be ready to use the system within a few minutes of the first lecture provided that they have their computers at hand.

The Adobe Connect-EES method can be used to deliver instruction simultaneously via the web in the local classroom, at a dedicated distance site (Official Site), and/or any other site that may be convenient for the distant student (Optional Site). In any option, students will be able to participate live and actively during the lecture. The figure depicts the options, elements, and instructional capability of the method.

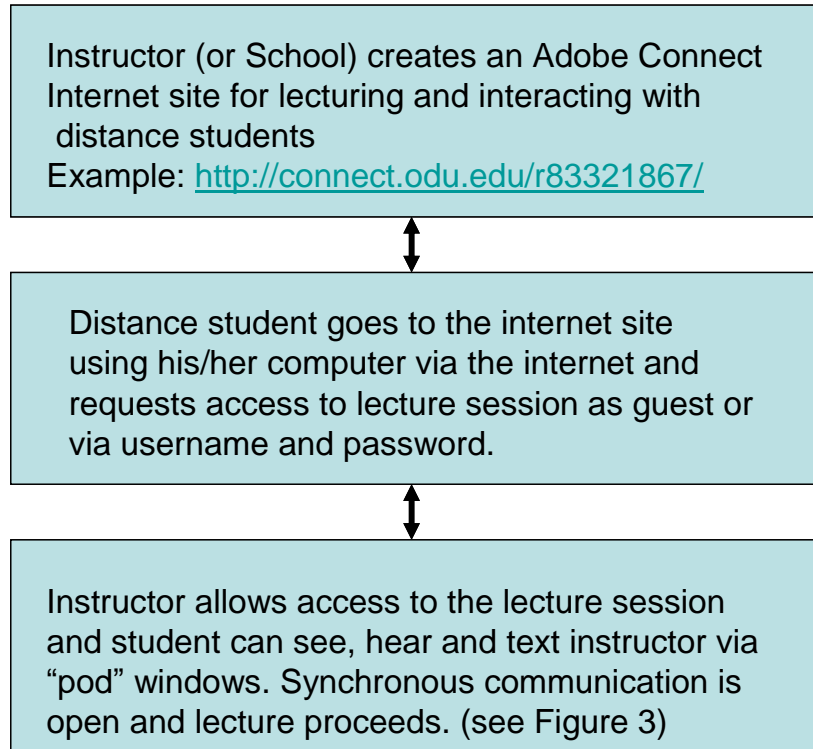
### **Adobe Connect, a versatile lecturing tool**

Adobe connect is a web-based tool that allows instructor and students to interact synchronously using video, audio and text simultaneously. "Webinar" is currently used as a short term to describe this interactive method to receive and provide presentations, lectures, seminars, or workshops via the internet.

Students are able to access a *lecture session* through a dedicated web address that has been created by the instructor or institution offering the course. Access can be controlled directly by the instructor who may request a username and password, a special code, or simply allow free student access to the sessions as guests.

A short time before a scheduled lecture begins, the Instructor opens the session and distance students are invited to join the session using their computer browser. Students request and confirm access following the instructions shown on the screen. The website address needs to be

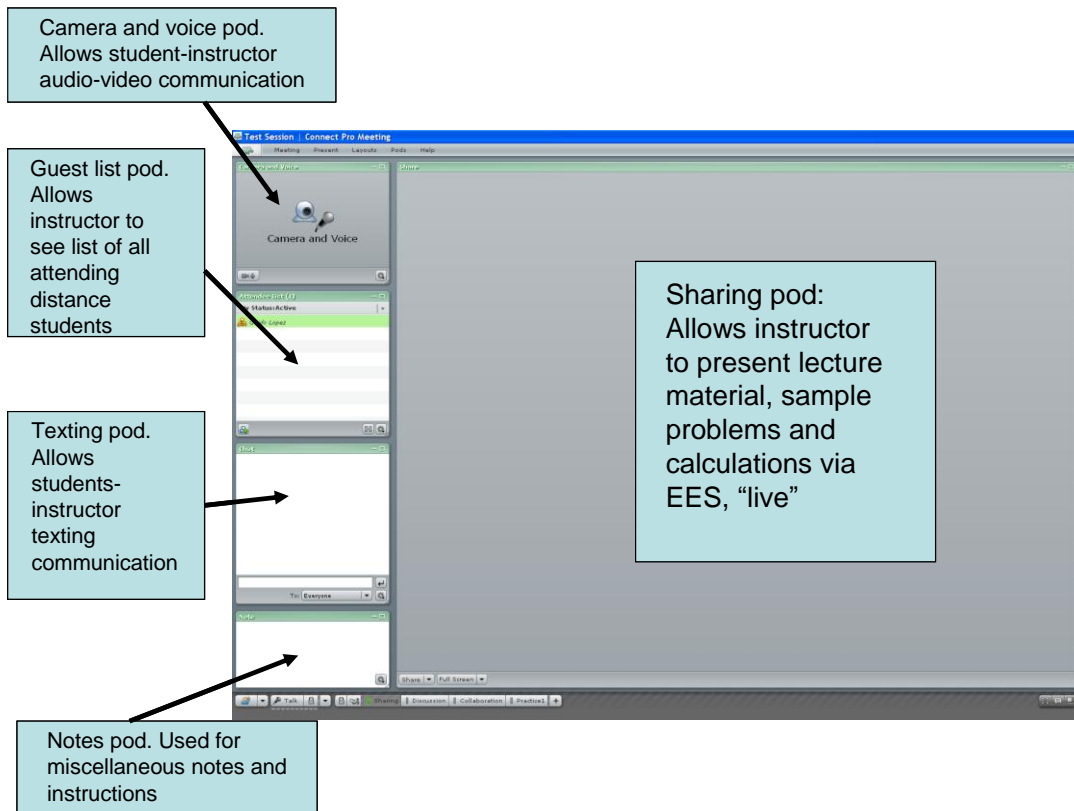
set up by the instructor with due anticipation before classes start (at the beginning of the semester). Figure 2 describes the procedure schematically.



**Figure 2.-** General scheme to set up Adobe Connect student access to lecture instruction

Once access has been granted to the student, he/she will see on the screen of the computer a system of “pods” for synchronous communication. An example of such screen view is provided in Figure 3. This is the default display of Adobe Connect and proves to be convenient for teaching Thermodynamics and Heat Transfer.

Adobe Connect can be considered an intermediary tool for instruction in Thermodynamics and Heat Transfer. It facilitates direct audio and video communication with students and the use of the software EES which is the tool to solve problems, show figures, plots, diagrams, etc. that are a regular part of the explanation and illustration during class. The work is shown in the “Sharing pod” of Adobe Connect



**Figure 3.** Default screen display of Adobe Connect

While the instructor writes formulas, numbers, draws figures, etc. the student sees them on the sharing pod while simultaneously listens to the voice of the instructor who broadcasts the explanation using the headset microphone. Although solutions to problems could be printed and distributed ahead of time to students in a computer file, this discourages student active participation. Thus, the intention of this method is to mimic a traditional live lecture, where the instructor writes words and equations, or draws figures on a blackboard while he/she explains the subject matter and requests the participation of all students.

The Adobe Connect-EES method facilitates this type of live explanation of topics and solution to problems, and effectively encourages the participation of students. In the author's teaching of Thermodynamics and Heat Transfer, in particular, students are required to work together with the instructor to understand and solve illustration problems cooperatively. Thus, students work with the EES software during class while receiving the explanation of the subject matter.

Students are encouraged to ask questions or provide answers to issues found during the application of principles via problem-solving. The work they do in EES constitutes their class notes and they may share the work "live" with the rest of the class if so desired or requested by the instructor during the lecture. The instructor is capable to grant any student the capability to share their work through Adobe Connect as needed.



Every procedure is seen on the “share pod” of Adobe Connect and students are able to follow the instructor’s explanation and learn about the procedures to solve problems. EES, loaded in the student’s computer, on the other hand is used to verify solution procedures, perform calculations and obtain answers during the session. Once the solution to a problem has been achieved, the work done can be saved for future review and further practice at home.

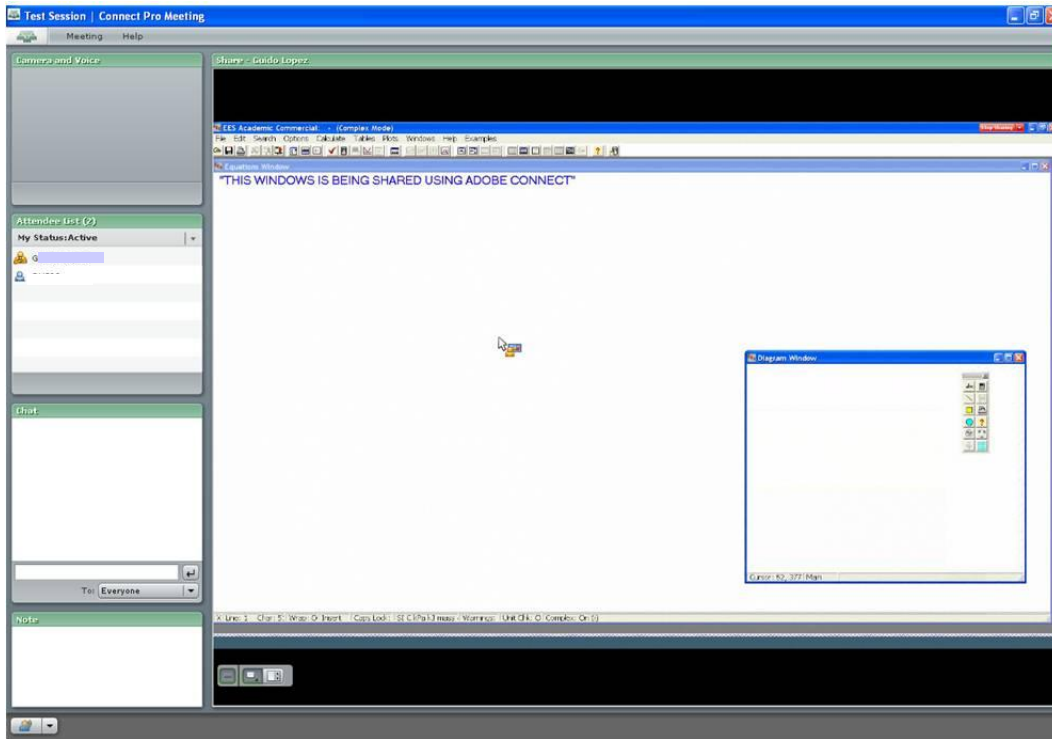
## **EES, a versatile computer tool for teaching Thermodynamics and Heat Transfer**

EES stands for Engineering Equation Solver. It is dedicated software particularly designed to solve problems in areas of Thermo Fluids such as Thermodynamics and Heat Transfer. The software is highly versatile and easy to use. One important and extremely useful feature of EES is its availability of thermo physical properties for a wide variety of substances, both in the International System of Units and the English System of units. This has, in fact, made the use of printed “tables of properties” obsolete. Calculations using EES are easy to carry and fast, and its use is not limited to Thermodynamics and Heat Transfer. The author has used EES successfully in the teaching of other subjects of Engineering and basic Science, including Physics, Chemistry, Mechanics, Stress Analysis, Optics and Electricity.

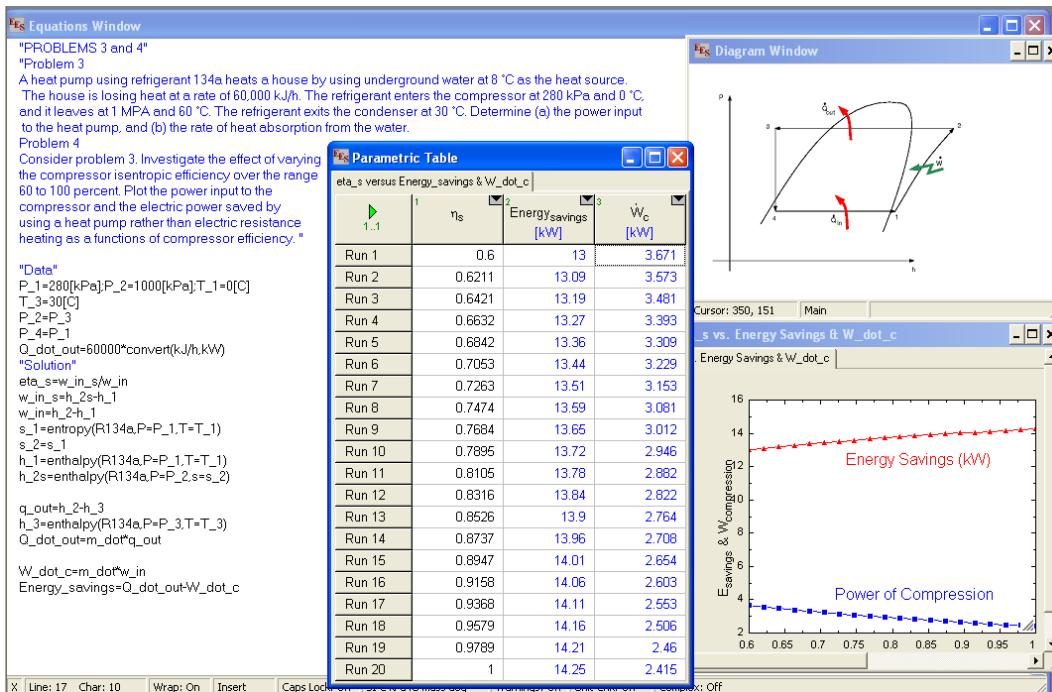
For the purpose of this paper, EES can be considered a tool that combines a traditional display used to write words and/or equations during a lecture (similar to a blackboard, whiteboard, or a piece of paper), and a calculator which is commonly used in engineering to perform numerical calculations in order to obtain answers to problems of academic or practical character. Obviously, EES is substantially more than that, but in the context of engineering education using computers, EES is indeed a tool to improve pedagogy and facilitate a more efficient delivery of instruction to local and distance students taking Thermodynamics and Heat Transfer.

Figure 4, shows a blank display of EES as seen by students via Adobe Connect. The figure shows EES ready to be used for writing words, displaying figures or imputing equations and developing solutions to problems. EES uses a traditional *windows* and menus format found in other software packages of common use. The *Equations Window* could be considered as the main portal for educational purposes. This window is extensively used to develop and present procedure algorithms to solve problems. Once the procedure has been developed, the answers are presented in a *Solutions Window*. The *Diagram Window* can be used to construct diagrams and show illustration figures.

Figure 5, shows the use of EES to solve a typical illustration problem of Heat Transfer. The algorithm makes use of principles imparted during the lecture and algebraic procedure that students are assumed to master at this level. The procedure is developed with close participation of all students who are required to follow its development in their own computers and confirm the correctness of the steps and the answers.



**Figure 4.** EES blank display ready to be used for instruction and shared through Adobe Connect



**Figure 5.** Illustrative problem developed in EES with close participation of local and distance students and shared via Adobe Connect.

## **System mobility and general procedure for lecture delivery.**

The Adobe Connect-EES method is noticeably mobile. The instructor only needs to carry his/her lap top computer and a small headset to the classroom where the lecture is to be delivered. The system can be used very comfortably from virtually any room where internet access is available. Wireless access to the internet adds versatility to the method. Also, a wireless headset is preferable for comfort and mobility in the classroom. A video camera is optional, and the author has found that the quality of the instruction and interaction is not affected if a video camera is not utilized.

Because the communication is synchronous, distance students can pose questions at any time during the lecture by “raising their hand”, a small icon readily available in the Adobe Connect tool. Students have the choice to use audio or text to formulate their questions. A student will need a microphone connected to his/her computer to ask questions via audio. Many students prefer to use text to type their questions. The instructor hears the question in the headset (audio) or reads the question on the computer screen (text). Subsequently, the instructor addresses the question in the same way he/she would do when the question is locally raised by a student in the local room.

The following simple steps need to be completed in order to ready the system for lecture delivery and instruction using the Adobe Connect-EES method

1. Obtain an Adobe Connect web address for the class. Students are directed to use their computers and browsers to access such an address at the official time scheduled for the lecture. The following is an example of web address: <http://connect.odu.edu/r83321867/>
2. Distribute and Install EES in all computers (Instructor's and Student's). The software is to be used to develop solutions to problems proposed as exercise, homework or test. Every student is required to bring his/her lap top to class with EES installed.
3. Viewgraphs may also be prepared as additional aid to explain subjects during the lecture. Power Point presentations, for example, can also be shown in Adobe Connect during the lecture, as needed.
4. Although the method assumes internet accessibility, it is advisable to check whether the assigned classroom has access to internet (wired, wireless or both) with due anticipation.

Once these preliminary steps are completed prior the initiation of classes, a simple routine as explained below can be followed for every scheduled lecture.

1.- A few minutes before the lecture starts, the instructor access Adobe Connect from inside the local classroom, checks the proper connection and functioning of the headset, and opens the web session inviting students to request access. Instructor knows that students are requesting access by looking at small windows popping on the screen of his/her computer with the student names. Instructor grants permission to access the session.

2.- The lecture starts at the scheduled time and the instructor starts the explanation of the subject using teaching aids such as viewgraphs shared through Adobe Connect. The instructor speaks normally through the headset while local and distance student will be able to listen to the explanation and simultaneously watch the material shared on Adobe Connect.

3.- When it is time to solve illustrative problems, Students are asked to run EES and work together with the instructor in the development of solutions. The instructor presents such development in EES shared via Adobe Connect, while students follow and take notes of the explanation using EES directly installed in their computers. Students can save the work in their computers for future review and study at home.

4. Students are encouraged to ask questions while solutions to problems are under development. Similarly, the instructor may choose to direct a question to a local or distance student using audio or texting.

5. Near the end of the scheduled period of class, the Instructor announces the closing of the Adobe Connect session. The session is wrapped up and Adobe Connect is closed.

## **Conclusion**

The use of computer hardware and software is transforming instructional pedagogy and opening educational opportunities to students well beyond the traditional lecture in a local classroom. The rapid advances in communication technology and the power of the internet make possible to deliver education to distance students even in challenging programs of study such as engineering.

Distance education in engineering has its peculiar challenges due to the *applied* character of engineering. While “narrative” courses are relatively easy to deliver via distance learning, the mathematical character of engineering subjects requires a more refined and elaborated approach. This has slowed down the spread of distance engineering programs offered by schools. In contrast, the offering of distance education in more narrative programs of study such as Business Administration, Law, Counseling, Home Land Security, etc, have increased dramatically.

Nevertheless, continuous efforts are made to find suitable didactic methods to provide distance education in engineering. The writing of equations and formulas and the solution of illustrative problems to convey concepts and principles is a common characteristic in the teaching of engineering subjects such as Thermodynamics and Heat Transfer.

A method of instruction that combines the use of Adobe Connect, a tool for web-based communication and EES, a powerful software that simplifies the writing of equations and problem solving in Thermodynamics and Heat Transfer has been found suitable for delivering distance instruction of those subjects. The method can be used to deliver instruction live to local and distant students simultaneously. The method is versatile, easy to use, and it requires minimum hardware consisting of a computer (preferably a lap top) and a small headset.

Using the Adobe Connect-EES method, instruction can be delivered from and to any place or room with internet access. It has received a great deal of acceptance among the author's distance students at Old Dominion University, and the method proves to be successful for imparting instruction in Thermodynamics and Heat Transfer. It promotes active student participation and facilitates effective communication between instructor and distance students. Students require only a minimum level of training to familiarize with the method.

Further refinements to the method are under way. Because ODU possesses well-equipped Satellite TV communication and Videoconferencing systems, the Adobe Connect-EES method can also be used in conjunction with those technologies in order to enhance the access to distance education. This process is currently under way and it is to be tested in engineering laboratory instruction in a very near future.

## References

1. Cengel, Y, Ghajar, A. "Heat and Mass transfer: Fundamentals and Applications. 4<sup>th</sup> Ed. McGraw Hill. 210.
2. Cengel, Y, Boles, M. "Thermodynamics and Engineering Approach" 7<sup>th</sup> Ed. McGraw Hill. 2011.
3. Means, Barbara .et. al. "Evaluation of Evidence-Based Practices in Online Learning. A Meta-Analysis and Review of Online Learning Studies" Center for Technology and Learning. U.S. Department of Education. September 2010.
4. Scheines, R.G. et al. "Replacing lecture with web-based course materials" Journal of Educational Computing Research 2005.
5. WestEd and Edvance Research. "Evaluating on line learning: Challenges and strategies for success". U.S Department of Education. 2008.
6. Adobe Connect User Manual.
7. Engineering Equation Solver (EES) user manual.