AC 2009-2429: MULTI-INSTITUTION TEAM TEACHING (MITT): A NOVEL APPROACH TO HIGHLY SPECIALIZED GRADUATE EDUCATION

William Heffner, Lehigh University

Bill Heffner is the associate director of the International Materials Institute for Glass at Lehigh University where he has been since 2004. In this position he facilitates research exchanges promoting new functionality for glass and is developing an e-based glass learning curriculum for the glass research community as well as developing hands on experiments for the young science enthusiasts.Prior to this current role, for 25 years he was with AT&T Bell Laboratories and Agere Systems as a distinguished member of technical staff. Bill has taught courses on lasers and optoelectronic device physics at Penn State University and created an optoelectronics training curriculum for Agere employees. He received an MS in Chemical Physics from Indiana University and a PhD in Physics from Stevens Institute of Technology. He has 16 publications and 6 patents on optical devices.

Himanshu Jain, Lehigh University

Himanshu Jain is currently the T.L. Diamond Distinguished Chair in Engineering and Applied Science, a Professor of Materials Science and Engineering, and Director of NSF's International Materials Institute for New Functionality in Glass at Lehigh University. Previously, he conducted research at Argonne and Brookhaven National Laboratories for several years on various glasses. His current research is focused on functionality in glass through fundamentals. He is a recipient of the Otto Schott Research international prize, Zachariasen international award for outstanding contribution to glass research, Doan award by his Department's senior s for the most influential teacher, a Fulbright Fellowship for lecturing and research at Cambridge and Aberdeen in UK, and a Humboldt Fellowship for research in Germany. An editor of 8 books, and author of 2 U.S. patents and over 250 research articles, Jain is a Fellow of the American Ceramic Society.

Steve Martin, Iowa State University

Steve W. Martin earned his B.S. degree in Chemistry from Capital University and his Ph.D. in Physical Chemistry from Purdue University. He joined the Faculty of the Department of Materials Science and Engineering at Iowa State University in 1986, where currently he holds the rank of University Professor. He has published more than 160 refereed journal articles and presented more than 200 invited and contributed talks in the broad area of glass science and engineering. He has mentored more than 20 Ph.D., 15 M.S. and more than 70 undergraduates in his research group. He is a fellow of the American Ceramic Society, as well as the winner of the George W. Morey Award in Glass from the Glass and Optical Materials Division of the American Ceramic Society and a number of teaching, service and research awards from Iowa State University.

Kathleen Richardson, Clemson University

Kathleen A. Richardson is the Director and Professor of the School of Materials Science and Engineering at Clemson University. She holds her Ph.D. in Ceramics, her M.Sc. in Glass Science, and her B.S. in Ceramic Engineering all from Alfred University. She has more than 90 publications in refereed archival journals in the broad areas of optical, nano-, thin film, glassy and amorphous materials. She has served as a visiting professor at a number of international universities and has served as the manager of a large glass and optical materials research and development center for a multi-national glass company.

Eric Skaar, Clemson University

Eric C. Skaar holds B.S. and Ph.D. degrees in Ceramic and Materials Engineering from Alfred University and Massachusetts Institute of Technology, respectively. Dr. Skaar has over 20 years of experience in the Ceramic and Materials Engineering field, including 16 years in his current position as a faculty member of the Gilbert C. Robinson Department of Materials Science and Engineering at Clemson University. He has served for two years as a staff scientist at Gould Inc. and two years as a senior experimental ceramist at General Motors Corporation.

Multi-Institute Team Teaching (MITT): A Novel Approach to Highly Specialized Graduate Education

Summary

As engineering becomes more and more specialized, academic institutions often have fewer specialists to teach specific topic areas. This situation can potentially compromise the student's ability to obtain a comprehensive education. Often as a result, highly specialized graduate courses cannot be offered due to the small enrollment of students. The problem is particularly exacerbated in disciplines like Materials Science and Engineering, which exist at many universities as a necessary component of engineering education, but usually as one of the smallest departments. In any given term, there are too few students who sign up for specialized courses, and it is difficult for the Administration to approve courses that have fewer than half a dozen students. As most universities pursue hiring new faculty in emerging fashionable areas, the education of conventional, but critical, subjects suffers or altogether disappears.

NSF's International Materials Institute for New Functionality in Glass (IMI-NFG) has successfully addressed this problem by initiating the concept of multi-institution team teaching (MITT). The first course of this kind, 'Experimental Methods for Glass Structure' was offered in Spring 2007. Six professors from as many institutions (Clemson, Lehigh, Iowa State, Michigan, Alfred and Coe College) taught 3 to 5 lectures in their respective area of expertise. Another course, 'Physical Properties of Glass', was offered in Fall 2008 by a team of nine professors with students coming from many more institutions spanning continental US and Brazil. Students attended the class from these and a few other universities. By pooling the talent of various instructors, the course not only became technically stronger, but formed a course option that no individual university would have been able to offer due to low, individual institution student numbers. Course evaluation indicated that the majority of students liked the format and delivery of the course. More than 75% students felt that the course was made stronger by having multiple instructors who "taught information of their expertise".

Adobe Connect software was used for the live delivery of lectures over the Internet such that students could see the instructor and Power Point slides all the time as in a normal classroom. The students could ask questions any time during the lecture by typing in a box on their computer screen, and the instructor could respond immediately. A benefit of the Adobe platform is that the course lectures are easily archived and thus become available for viewing in the future. Students registered and paid tuition at their respective home university, so that no exchange of funds was involved. Whereas the homework and assignments were given and corrected by the lecturing instructor, the local instructor coordinated the course and assigned grades to students according to the norms of his or her institution. The final examination for the first course consisted of joint projects completed via collaboration among students from different institutions. The results of the project were presented at a national conference on glass where the students met with their classmates for the first time.

In summary, the concept of MITT has been successfully demonstrated for teaching highly specialized graduate courses. Technology and infrastructure exist to communicate and

disseminate information. The students like the diversity of subject material, top experts as instructors, and the fact that the course encourages team interaction and building a network of colleagues across multiple universities, some being international.

1. Background

Glass science and engineering has been taught as a discipline of engineering for centuries, although only at very few universities. With increasing interest in more modern amorphous materials, many universities in the US hired faculty to teach glass in the late 20th century, while the traditional centers of glass education diversified into other materials. So even though the total number of professors at US universities, who are active in glass research may not have decreased over the years, most of such universities have just one token faculty member in glass science. This person typically teaches just one glass course, which ends up being an introduction to the whole field. Even when the lone professor of glass offers an advanced course, there are too few students in any given term, who sign up for such a specialized course, and it is difficult for the Administration to approve courses that have fewer than half a dozen students. The result is a larger number of students exposed to glassy materials, but with relatively shallow, cursory knowledge that does not prepare them to become a professional glass scientist or engineer.

NSF's International Materials Institute for New Functionality in Glass (IMI-NFG) undertook the challenge to correct this gradually but certainly deteriorating situation. It proposed to combine the resources of various educational institutions to share courses, by making use of remote teaching via satellite, Internet or a combination thereof. This approach has been tested successfully for the delivery of special education in rural areas[1,2] and nursing education[3], but not engineering education. So it began as a novel attempt on transferring specialized science and engineering knowledge to aspiring students rather than just through the traditional courses of lectures taught by one instructor in one classroom. To some degree, this basic idea was successfully tried at Lehigh University by a group called the Materials Pennsylvania Coalition (MatPAC), a network of six Pennsylvania-based universities with exceptional collective strength in advanced materials research and education. The MatPAC, comprised of Carnegie-Mellon University, Drexel University, Lehigh University, Penn State University, the University of Pennsylvania, and the University of Pittsburgh, had developed an educational model for multi-institutional sharing of courses via Internet2 to promote the field of advanced materials. In this case, a well established course taught by one professor is made available to students at all the member schools. As a result, each university is enabled to take advantage of the diverse expertise in materials education across the state. Two of the authors, under the sponsorship of IMI-NFG, proposed to explore the feasibility of cooperative teaching by glass professors at various US universities.

A course was then designed and offered in the Spring 2007 semester, followed by another course in Fall 2008. The student feedback indicated that the project was very successful. It was felt that the Multi-Institute Team Teaching (MITT) model could be a solution to the teaching of highly specialized advanced topics from many other fields of science and engineering where the enrollment or faculty expertise is too limited at any one institution. We hope that this report of our experiment on cooperative teaching and learning will help others to apply it in their areas of engineering as well.

2. Course Organization

The two cooperative MITT courses were intended to be second-level courses in glass on an advanced senior or elementary graduate level. They were organized to first review the material which would be covered in an introductory glass course. The review segment was covered in the first week of the semester. The remaining segments of the courses covered material new to the students and were taught by experts in their respective fields. Each segment emphasized a particular technique for structural characterization for the first course or an associated property of glass for the second course, using examples of the correlation between structure and properties of glass.

In the planning discussions among the instructors, formation and structure of glass was decided as the focus for the first cooperative course. This topic area was deemed to be fundamental and focused, building on the basics of glass science that each of the six institutions taught to their undergraduate cohort within an Introduction to Glass Science course. Thus the target student audience for the course was aimed at senior undergraduates who had taken this Introductory course, or first year graduate students who only had limited exposure to glass and glass formation processes. It was determined in a post course evaluation that this defined "starting point" level was suitable to most students taking the course.

There were several logistics problems related to scheduling and matching of calendars, not to mention the challenge of getting the course's approval from the Administrations of the participating universities. There was much excitement about the teaching of this course, which helped in resolving all the problems and overcoming initial hurdles. As a result, each institution allowed the course to be offered as an experimental course with the appropriate institutional identification number, with the local professor being responsible for its execution. There were no financial transactions involved in this teaching experiment. The classes were taught over the Internet as lectures, with the help of powerful software, Macromedia Breeze (2007) and Adobe Connect (2008). It allowed each student to see the lecturer in one small window on computer screen, whereas the much larger second window showed PowerPoint slides (see Fig. 1 and Section 3). The students could ask questions any time during the lecture by typing in yet another window.

The first course was taught by six instructors from six different institutions spread across as many states in the East and Midwest. It was taught live with active communication between the instructor and students. The class met twice a week from 5:00 to 6:30 pm EST on Mondays and Wednesdays, making it convenient for graduate students to attend in two different time zones. In addition to the six universities represented by the instructors, the course was also taken by the students from Penn State University. The day-to-day operation of the course was managed from Clemson University. The lectures were also archived at Lehigh University at the IMI-NFG web site for distribution to the wider worldwide glass community. The recordings of the lectures were made available to the students for later viewing at their convenience and pace. Altogether 56 students and postdocs signed up for the course, out of which 28 took it for credit.

Each instructor tested the students on his or her part of the course via homework assignments, quizzes, or take home exams. A multi-institution team-based project was structured for the course's final examination. For this purpose, the students were divided into nine teams, each consisting of three or four students from different institutions, so that they had to collaborate over the internet and use other means of long distance communication. Each team was asked to analyze a different topic or issue of the structure of glass. The specific assignment was for the students to develop an experimental research proposal to solve specified glass science and/or technology problems. They were asked to prepare and present to the instructors and the rest of the class for review a short poster summary such as shown in Fig. 2. The posters were electronically submitted to the course web page, and graded by each instructor separately. The students then presented their posters at the Spring meeting of the Glass and Optical Materials Division of the American Ceramic Society (Fig. 3). There they met with most of their classmates for the first time and presented their proposal to a broader group of glass and materials professionals. By working with colleagues from another university and without physical face-to-face meetings, the students experienced how to collaborate with peers in an international Internet environment. Aside from some initial student resistance, the team project concept worked well, and by the end the students appeared to appreciate the experience. The grades on all the assignments and the final poster were made available to students and instructors via the course web page maintained on Clemson University's Blackboard course web page system. The final grades for the semester were then assigned by the local instructor according to the norms of his or her university.

Encouraged by the success of the first MITT course, the core faculty decided to offer another course, 'Physical Properties of Glass'. In fact, there was such enthusiasm within the glass community that the second course was taught by nine glass faculty from as many institutions. We also expanded its delivery outside the United States with a very eager group of students from Brazil. Significantly, it turned out that one of the instructors, who happened to be on sabbatical leave in The Netherlands, delivered her lectures from there. This gave us an opportunity to test the international aspects of this course offering modality. The level of the targeted audience and the organization of this second MITT course were along the lines of the first course with one difference: each instructor gave a relatively more elaborate homework, almost like a take-home exam on the topic of his/her part of the course. Consequently, there was no final exam, and the course grade was based on nine take-home assignments.

3. Distance Learning Mode and Technology

Throughout the ages, teaching has gone from the apprentice style to the lecture style to now the distance lecture style. Each of these styles has advantages and disadvantages. Perhaps the most in-depth learning takes place under the apprentice style of teaching, but it is restricted to very few students in a single geographic location. The lecture style accommodates larger numbers of students, but they must still be in a single geographic location, the same location as the lecturer. Depending on the size of the lecture, more or less dialog can take place. Larger lectures accommodate fewer dialogs; nevertheless the lecturer can gage his or her effectiveness by general feedback from the audience. Distance presentations allow material to be taught to a large number of students in many different geographic areas. They can be synchronous where everyone attends the presentation at a single time or asynchronous (such as on-demand lectures) where the student can view the presentation at her / his convenience. The problem occurs with feedback from the students to the lecturer. Generally, the lecturer cannot see or hear the audience, and therefore cannot gage his or her effectiveness by general reaction or body language. In the case of asynchronous learning the lecturer has no real time clue at all.

Even though distance teaching eliminates much of the general feedback from the students, it nevertheless offers some advantages that make it very attractive for some situations. For example, in our case, we are interested in a topic which is rather specialized, and would not attract the numbers of students as would a class on a topic such as statics or dynamics. In this case, in cash strapped universities, the opportunity for teaching such a topic would be limited at best. By utilizing the distance techniques available today, such a class can be taught simultaneously on several campuses throughout the world by the top experts in the field. The students can be exposed to techniques, results and nuances generally not available from a local lecturer. Moreover, the expert can deliver his or her lecture from anywhere (s)he happens to be and the students can attend the lecture from any place convenient to them. The flexibility of distance lecturing opens up wide vistas of opportunity for education. Furthermore, from the university administration perspective, the effective faculty "cost" for one's effort in these courses is reduced significantly by the participation of external instructors.

In our cooperative glass courses, we utilized the synchronous approach, which required some scheduling compromises due to the time zones we covered. All of our students and most of our lecturers were in the western hemisphere, and as such we did not have anyone attending class at 2 AM or some other such inconvenient time.

Our lectures were hosted by the Clemson University servers and broadcast out over the internet. The only equipment required for the students was a personal computer equipped with a fast internet connection, modern browser and sound. Similarly, the instructors only required the student configuration with the addition of a microphone and camera. With modern laptop computers and high speed internet connections readily available, this mode allowed both lecturers and students to attend class while traveling, and indeed this occurred on several occasions. Additionally, each lecture was recorded, and those who missed the lecture were able to view it asynchronously.

In some universities the internet feed was projected in the classroom, and the students attended the lectures as a class with their local instructor, rather than individually. This paradigm works well, and students seem to like it. One distinct advantage in this case is that the local instructor can field some questions and refer others to the expert lecturer as well as expand upon the lecture material.

The servers hosting the class were running the Adobe Connect® software. A screen shot of a distance lecture is shown in Fig. 1. The main features of a lecture are: a motion picture of the lecturer, the class attendance, the chat box and the presentation area. Within the presentation area, the lecturer has a pointer and can, if desired, annotate slides using whiteboard electronic tools. Questions and feedback from the students are given in the chat box, and appear in real time to the instructor and the class participants. This particular feature is the main real time feedback the instructor gets from the class. However, we have found, in this era of instant messaging and texting that students do not hesitate to use the chat box to ask questions or give other feedback. It is actually a rather good method of getting feedback.

The final feature of our software is the motion picture of the lecturer. This particular feature has some advantages and some disadvantages. The main advantage to seeing the lecturer in real time is that the student wants to know or get some idea of the person who is talking to him or her. Additionally, the "talking head" distracts attention from any hesitations which always accompany a lecture. The disadvantage to this feature comes from the fact that a lot of data has to be transmitted for the motion. If internet conditions are particularly busy, this data can interfere with the audio or other data being sent over the internet. We found that in some cases we needed to freeze the motion for an acceptable lecture.

In general, our experience with these distance MITT courses has been favorable, with the advantages outweighing the disadvantages. We certainly intend to continue this form of course delivery.

3.1. A Challenge for MITT

Although technology has developed far enough to enable the transmission and reception of lectures remotely, there can be non-technical challenges in its implementation. Here we cite one hurdle and describe briefly how it was resolved. Since the first course was delivered smoothly from the 'control room' at Clemson University, which utilized Macromedia Breeze and Blackboard software systems, we decided to make no changes in this respect for the second course. Soon we realized that the delivery platform was upgraded to Adobe Connect® software. This modification was rather small as the faculty readily adapted to this change. However, we faced an unexpected challenge. The Blackboard system could not be used across the partner institutions, thus placing restriction on the distribution of course material, assignments, grades etc. Fortunately we had implemented the alternative access to course materials through the website of the sponsor, International Materials Institute for New Functionality in Glass (IMI-NFG). As the course continued, the Glass Properties webpage at IMI-NFG (www.lehigh.edu/imi) became the resource that the students could access for all the relevant information – including syllabus, lecture schedules, slides, homework, due date and even homework solutions. We ensured that all slides were available prior to the class. Once implemented, the manual collection and distribution of grades by the IMI-NFG staff served the purpose, and the host instructors could add these grades to their own Blackboard type systems.

The Adobe Connect was under the control of the Clemson organizer. It allowed remote transmission and reception of lectures from all institutions. So, there was no problem for anyone with access to internet to participate in the MITT course from anywhere in the world.

4. Student Evaluation

The course instructors were highly sensitive to the impact of the new course delivery method to student learning outcomes. Of the six institutions participating in the first course in 2007, most of the Universities had at least some synchronous and asynchronous web-based course offerings. Thus from the beginning we included student feedback on all aspects of the course including

delivery method issues and course content quality and clarity. A student questionnaire was prepared at the end of each course to acquire their feedback and collect information for future improvements. The questions were prepared by Lehigh and Clemson University organizers. The on-line survey tool, Survey Monkey, was used to provide the survey and collect anonymous response from the students. A copy of the on-line survey questions used by the students for the most recent course is available on the IMI-NFG website at:
http://www.lehigh.edu/imi/docs_GP/SurveyResultsShare.pdf

According to the survey taken after our first course, a three-fourths strong majority felt that the course was made stronger by bringing in multiple instructors, each teaching within his or her area of expertise. However, the feeling towards on-line format was mixed: 60% indicated that they liked the on-line format of the course. With regard to the level of course, 50% indicated that the course content was at the right level. There appeared to be somewhat of a mismatch between the level of lectures and students' background. It seemed that although we had succeeded in bringing the experts into the classrooms of multiple universities, there was a need to establish among the instructors a uniform level of expectations with regard to the students' background. Indeed the discrepancy was generally within the second course, for which we had more time to plan and a larger faculty pool. For this latter course, we took a more traditional lecture approach, and put extra effort on class organization and making material available to the students in a timely manner. Improved results from this latest course are described next in some detail.

The survey link for the Glass Properties course was sent to all students in the class (37), who submitted homework assignments, but did not include the "auditing" students, postdocs or faculty. Eighteen (49%) students responded, of which sixteen took the course for grade and the remaining two indicated their participation was not for grade. The survey was anonymous.

Overall two thirds of the students rated the course as good to excellent. A great majority (82%) of respondents found the level of the course just right, with one student finding the material too easy and one student finding it too hard. Most of the students (88%) found it beneficial to have multiple instructors, supporting one of our primary hypotheses. Also they found the Adobe Connect software interface to be a satisfactory vehicle for the delivery of this course. Only one student indicated disagreement with the Adobe Connect as a suitable learning format. Audio and video quality was fine for most (89%) students with 11% students finding it unsatisfactory, probably due to the issues of limited bandwidth.

Web page management for the course documents via IMI-NFG web site, including class lecture notes and associated materials, was considered satisfactory. Most students indicated that the webpage approach worked as well as or better than the conventional course management software such as Blackboard. Part of the success of our web page distribution solution appears to have been the prompt posting of all new lecture material, as confirmed by 94% respondents. The overwhelming majority of students (89%) found it useful to have the lecture slides available before the class and all students (100%) found it useful to have the archived videos of the lectures available to review again after the class. In fact, 61% indicated they would likely use the archived video lectures again in the future, after the course.

The students appreciated the opportunity to meet and learn from multiple faculty members from across the country. Two additional items that received multiple positive comments include: (i) the posting of slides ahead of class and (ii) having recorded lecture videos available shortly after each lecture for review.

Despite some room for future improvement, the student feedback suggests that the Glass Properties Course was an effective learning opportunity with a much higher student satisfaction than for our initial course. Thanks to the archiving, this course remains available for future use by all students.

4.1. Recommendations for Improvement

From student comments two issues are identified for future improvement: a) the discussion and feedback on homework, b) some students had trouble with the streaming technology, presumably due to limited local bandwidth.

4.1.1. Homework Issues

By far the primary weakness of the course was identified with the homework. This was confirmed with a response of only 41% finding the homework useful and appropriate as well as many comments indicating complaints about the homework. The students' primary concerns were about the appropriateness of the assignments (some too difficult, too much time spent on looking up data and not always supporting the topics of the lecture) as well as too little opportunity for discussion and feedback from the instructors on the homework assignments. The latter also included concerns about: timely feedback on homework grades, availability of solutions, only getting graded assignments returned by less than half the instructors, and insufficient opportunity to discuss the homework assignments after their completion. Clearly, this is one aspect that should be addressed in future courses. One solution to this problem could be a greater engagement of the local faculty in all homework assignments, so that they can serve as recitation instructor for additional clarification and comment when needed by the students. The schedule should include a block of time for students to discuss issues with their local instructor or the distance lecturer after they have had some time to digest the material. As one student comment summarized, "Asking questions at the end of the lecture didn't work so well."

4.1.2. Bandwidth and Audio/Video Quality Issues

Internet data bandwidth was an issue for some of the students attending the course. We could see it during the lectures – some locations were experiencing trouble with delayed or intermittent audio while most other locations could hear the transmissions fine. Although most students did not seem to have any complaints on the audio/video quality and bandwidth, we received comments from two (out of 18) students about this issue. One student made an excellent suggestion that the IT department at the university should be made aware of such courses in advance, so that it can provide some priority service connections for the course. The students experiencing difficulties with bandwidth were not always aware that the problems were from their local systems; nevertheless, this was a frustration for some.

5. Concluding Remarks

It is not uncommon for an engineering faculty member to find that one of his or her courses cannot be offered due to insufficient student enrolment even though the subject is of high technological relevance. This appeared to be a pervasive problem in the field of our interest, namely glass science and engineering, due to its small size and the spread of experts at numerous institutions. We attempted to overcome this problem by introducing the concept of multi-institute team teaching (MITT). It combined advanced distance learning technology with unprecedented cooperation among faculty from several universities to share the teaching as well as their students. Our most recent course was taught live by professors from nine universities (Alfred, Arizona, California-Davis, Coe College, Florida, Iowa State, Lehigh, Michigan, and Missouri Sci. Tech.) and attended by over forty students, postdocs and faculty from many universities spanning five time zones across the continental United States and Brazil. Our experiment has demonstrated that logistics and course organization can be worked out to give students quality educational experience. Finally, for the success of MITT, it was important to start the planning significantly earlier than the usual course, to schedule an acceptable lecture time across multiple universities prior to registration, to rehearse the technology ahead of the lecture, and be open to innovation. In future, we plan to expand the concept of MITT gradually to overseas institutions from different regions of the globe.

Bibliography

1. J. Grisham-Brown, J.A. Knoll, B.C. Collins, 'Multi-university collaboration via distance learning to train rural special education teachers and related services personnel', J. Spec. Educ. Technol. 13 (1998) 110.
2. L.W. Olivet, T.C. Jones, 'Collaborative teaching: a strategy for interactive telecourses', Nurse Educ. 22 (1997) 6.
3. B.C. Collins, M.L. Hemmeter, J.W. Schuster, 'Using team teaching to deliver coursework via distance learning technology', Teach. Educ. Spec. Educ. 19 (1996) 49.

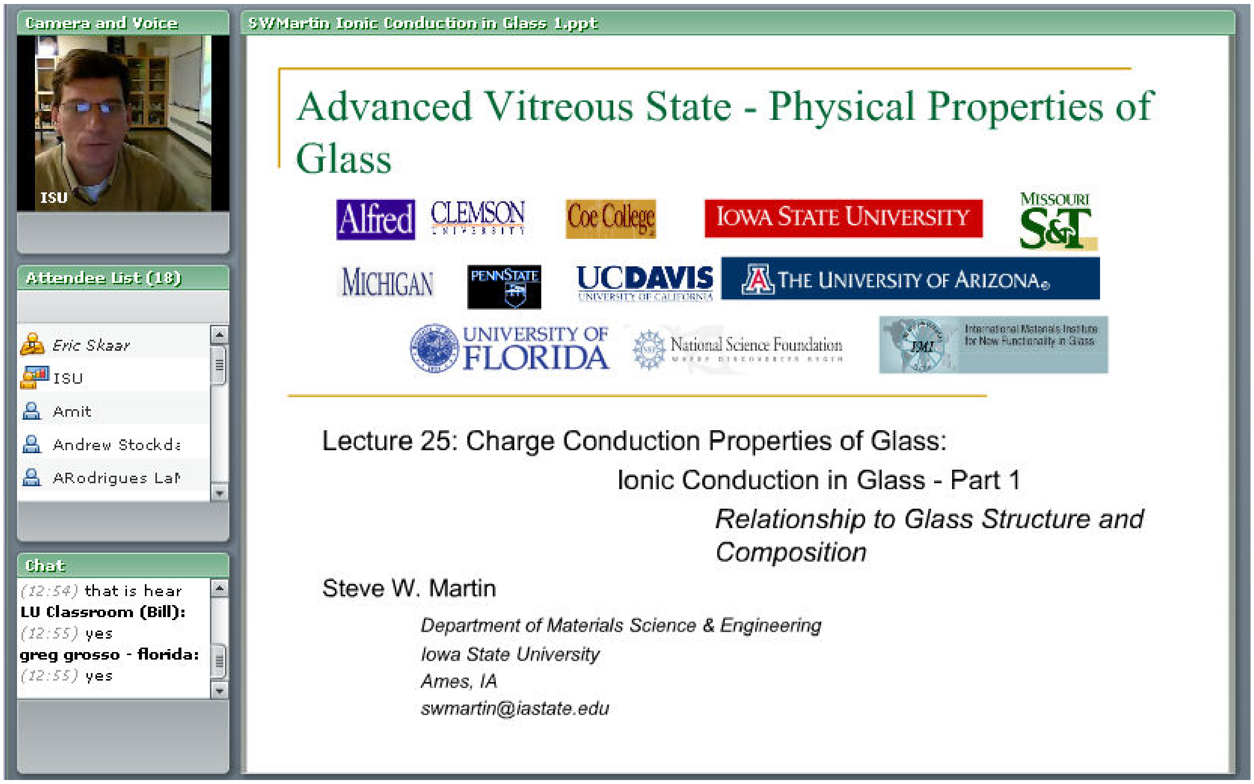

Figure 1. Screenshot of the cooperative glass course showing picture of lecturer, attendee list, chat area and presentation slide.

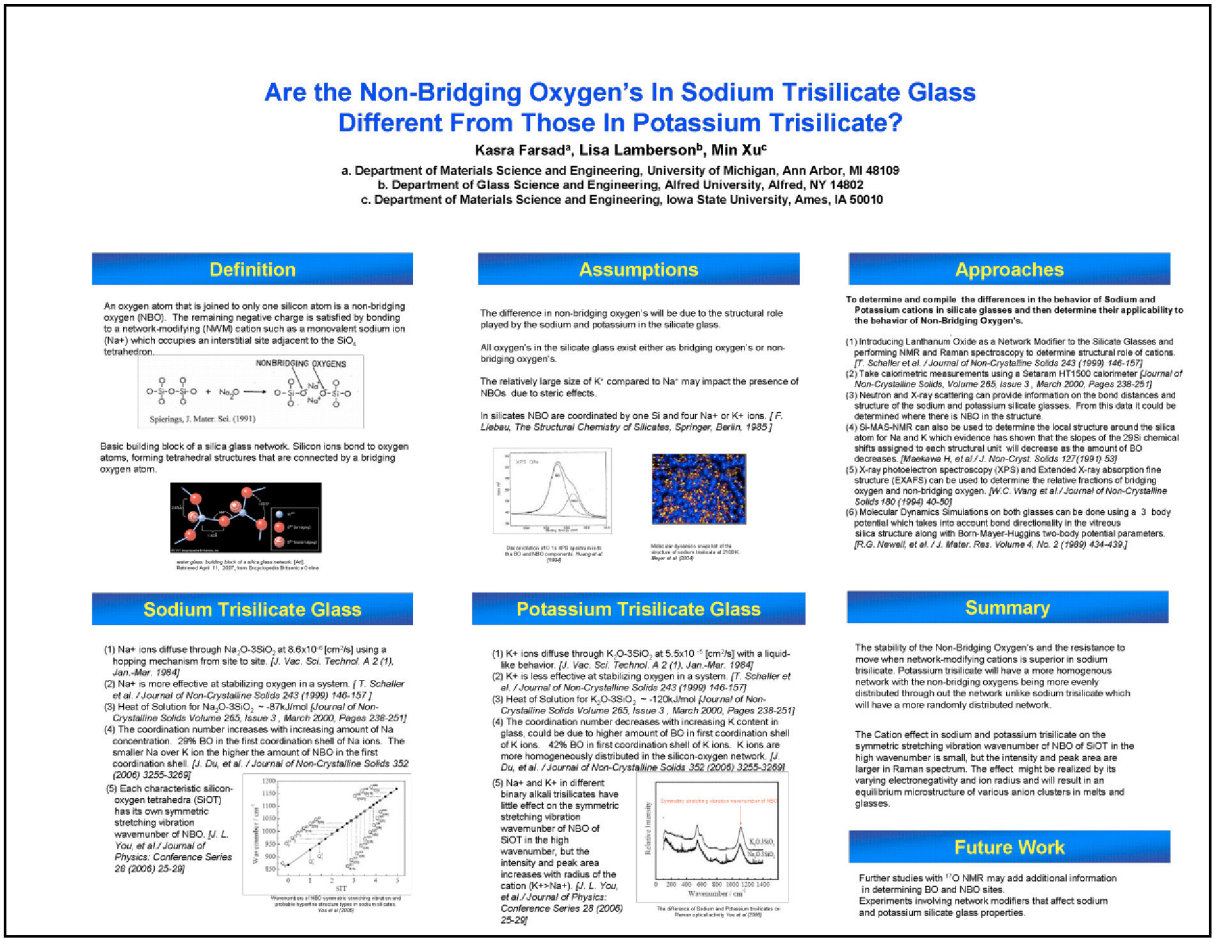

Figure 2. An example of poster prepared as final exam by a team of three students from three different institutions.

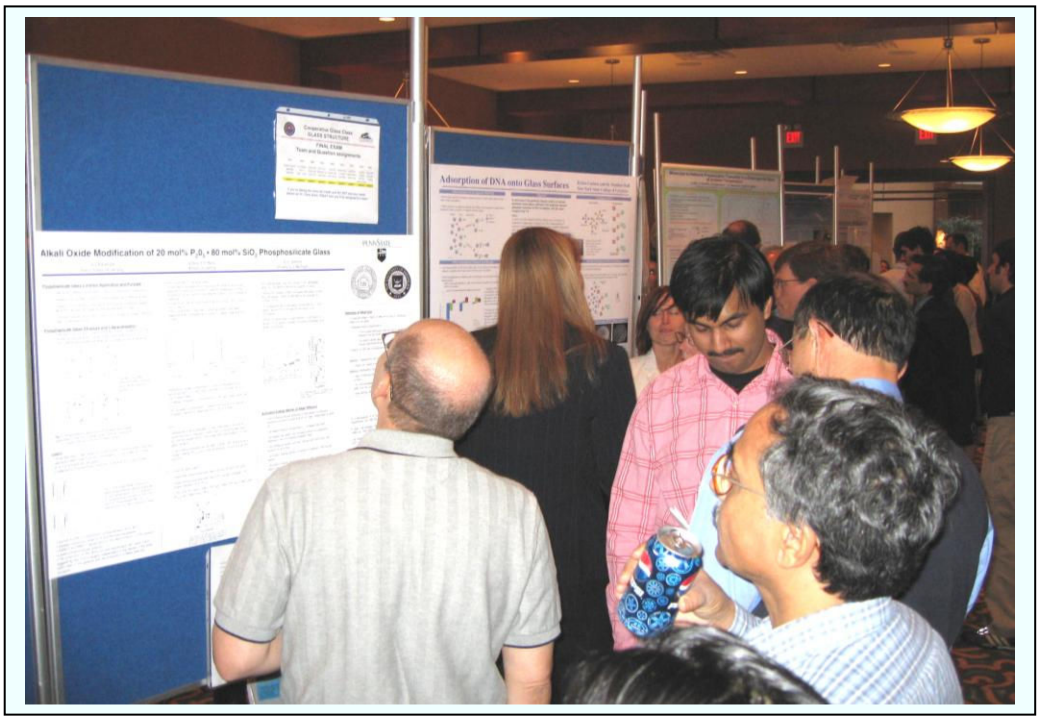

Figure 3. Students presented their ‘final exam’ poster at the annual meeting of the American Ceramic Society, and received feedback from broad spectrum of professional colleagues.