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

William R. Heffner
Lehigh University

Himanshu Jain
Lehigh University

Steve W. Martin
Iowa State University, swmartin@iastate.edu

Kathleen Richardson
Clemson University

Eric Skaar
Clemson University

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Abstract
As engineering becomes more and more specialized, both the faculty resources and number of interested students become limited. Consequently, very frequently highly specialized graduate courses are not offered, especially in disciplines like Materials with small faculty and enrollment. NSF’s International Materials Institute for New Functionality in Glass (IMI-NFG) has successfully addressed this problem by successfully introducing the concept of multi-institution team teaching (MITT). It brings together via internet both the expert professors and students from many universities. By pooling the talent of various instructors, the courses become technically stronger and students learn advanced topics that would be available otherwise. As an example, a recent MITT course included instructors from 10 US institutions, and students from many more US and international universities.

Software such as ‘Adobe Connect’ is used for the live delivery of lectures, wherein students can see the instructor and Power Point slides as in a normal classroom. The students may ask questions any time during the lecture, and the instructor would respond immediately. They register and pay tuition at their home institution, so that no exchange of funds is involved between universities. Survey results support that a majority of the enrolled students liked the format and delivery of the course, and more than 75% students felt that multiple instructors, who “taught information of their expertise”, made the course stronger. In conclusion, the concept of MITT has been successfully demonstrated for teaching highly specialized graduate courses.

Disciplines
Engineering Education

Comments
he state course of study. Conversely, we also provide the content knowledge in this area. develop the activity to a point where it can larger than we had anticipated. This may ring the testing phase. We were fortunate to die school, but in testing the activity we have sol students. Outreach to other area schools and al despite a range of attempts and efforts. As a overnight trip to Lake Eufaula to work with to do detailed pre/post test evaluation of mitive evaluation for our efforts. That we underlines the importance of building strong suggests that lasting partnerships can not be regular visits to do in-class activities to build having teachers work in research labs as a

Abstract

As engineering becomes more and more specialized, both the faculty resources and number of interested students become limited. Consequently, very frequently highly specialized graduate courses are not offered, especially in disciplines like Materials with small faculty and enrollment. NSF’s International Materials Institute for New Functionality in Glass (IMI-NFG) has successfully addressed this problem by successfully introducing the concept of multi-institution team teaching (MITT). It brings together via internet both the expert professors and students from many universities. By pooling the talent of various instructors, the courses become technically stronger and students learn advanced topics that would be available otherwise. As an example, a recent MITT course included instructors from 10 US institutions, and students from many more US and international universities.

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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

William R. Heffner, Himanshu Jain, Steve Martin, Kathleen Richardson, and Eric Skaar

1 Int. Mat. Inst. for New Functionality in Glass, Lehigh University, Bethlehem, PA 18015, USA
2 Materials Science and Engineering, Iowa State University, Ames, IA 50011, USA
3 Materials Science and Engineering, Clemson University, Clemson, SC 29634, USA
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-NPG, 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, structural characterization 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 had only 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. It was particularly
helpful to students when the links to archived lectures were available within a day or two
following the lectures. 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. 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. 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 gauge 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 gauge 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
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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
lector, 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.

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

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.
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 webpage, 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.

5. Recommendations for Future 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.

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.”

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.

6. 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.

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