A Multi-University Internet-Based (H.323) Graduate Course in Turbulence, Part I: Academic Description.

Honglu Wang[1], William K. George[2], Hui Meng, Lisa Stephens[3], Elizabeth Fellendorf, and James Whitlock
State Univ. of New York at Buffalo, Buffalo, NY, USA
[1]Tel: (716)-645-2593x2322, Fax: (716)-645-3875, hw4@eng.buffalo.edu
[2]Tel:(716)-645-2593x2323,Fax:(716)-645-3875, trlbill@eng.buffalo.edu
[3] Tel: (716)-645-6347, Fax: (716)-645-7983, stephens@buffalo.edu

Mark N. Glauser [4]and Dan Dullea
Clarkson Univ., USA
[4]Tel: (315)-268-6683, glauser@clarkson.edu

Luciano Castillo[5], William Hayes and Evelyn Smith
Rensselaer Polytechnic Univ., Troy, NY, USA
[5]Tel: (518)-276-4892, castil2@rpi.edu

Sharon Hoshida and Peter Koritschan
Univ. of California at Santa Barbara, Santa Barbara, CA, USA

Ricke Casterlin and David Shurtleff
State University of New York at Binghamton, Binghamton, NY

Daniel Ewing[6]
McMaster University, Hamilton, ON, Canada
[6]Tel: (905)-525-9140x27476, Fax: (905)572-7944, ewingd@mcmaster.ca

Abstract: This paper summarizes our experiences in teaching a multi-university graduate course on the fundamentals of turbulent flow. Particular features of interest include the manner in which university faculty interacted across university boundaries, the incorporation of web-based resources and an Internet-2 (H.323) video conferencing link, and utilization of national and international research gatherings to enhance the learning experience. The course was a cooperative effort with faculty from five institutions participating. Students registered at the university of their choice. Professor George lectured live for two hours each week from the Institute for Theoretical Physics at the University of California at Santa Barbara where he was participating in the NSF funded Program on Hydrodynamic Turbulence. The host faculty participated actively in these lectures from their own institutions, and in addition conducted a local weekly lecture/recitation. The course included numerous interviews with other turbulence researchers visiting ITP, and utilized modern interactive tools including a chat room, web-based lecture notes and assignments. At the end of the course, the students from all institutions made presentations at a special session of the 1000 Islands Regional Fluids Conference, an annual meeting of fluid dynamicists from Northeastern USA and Canada universities. The lectures from California utilized a new Internet-2 (H.323) based link between Buffalo and Santa Barbara. This link was then transmitted to the other institutions using ISDN (H.320) bridge available through the State University of New York at Binghamton. The technical details of this innovative technology are described in a second paper at this conference by Stephens et al [1].

Keywords: distance learning, students and teachers mobility, applications of new communication and information technologies in teaching and learning, turbulence

1. Introduction

This paper, together with the companion paper by Stephens et al [1], describes a multi-university Internet-based (H.323) graduate course in turbulence involving five institutions. The paper by Stephens et al [1] focuses on the technical and communications issues, while this paper summarizes our experiences in planning and teaching this course.

2. Reason for the course

A graduate course on the fundamentals of turbulent flow is a key course for graduate students in the fluid and thermal sciences. The traditional way of teaching the course is that the professor uses one (or more) semesters to give classroom lectures. The content may vary, but usually includes the nature of turbulence, the fundamental equations for turbulence, an introduction to typical turbulent flows, and the different ways to approach the turbulence closure problem. Almost any introductory turbulence course will include some statistical theory as well. The degree of emphasis on each topic depends on the perspective of the particular professor and the interest of audience.

In many universities, interruptions in the scheduling of such higher level courses can occur because of staffing problems due to sabbatical leaves and illness, not enough students, etc. This can present a major problem for students who plan to finish their degree in a certain time period, and can delay beginning students who may need a particular course to help them begin their research. Problems can also occur because active research faculty wish to participate in specialty conferences, symposia and research institute programs ? and in fact permission to participate in such programs is often determined by teaching commitments. The latter was the case here, and this course was born because Professor George wanted to accept an invitation to spend the semester in a special program on turbulence at the NSF-sponsored Institute for Theoretical Physics at the University of California at Santa Barbara.

The Internet-2 (H.323) and teleconferencing technology (described in detail in Stephens et al [1]) made it possible for Professor George to teach in Buffalo, while physically present in California. But, in addition to providing a means for Professor George to both fulfill his teaching requirements AND to participate in the ITP program, the new techniques allowed us to expand the scope of the course substantially, and to change the manner of teaching. Two other universities opted to participate ? Clarkson and RPI. Several others became involved because of logistical necessities ? Santa Barbara and SUNY/Binghamton.

3. Description of the course

Figure 1 shows a conceptual communication model of the interactive instructional links among the four institutions involved in the academic program. For reference, Clarkson and RPI are approximately 200 kilometers apart, and both are about 500 kilometers from Buffalo. UCSB, on the other hand, is in California, three time zones and 5000 kilometers away. (Note that SUNY/Binghamton only acted as a bridge among the NY State institutions.)

The basic format for the course was as follows: Professor George lectured live from a studio at UCSB for two (consecutive) hours each week via an Internet-2 based link from Kerr Hall at UCSB. During these lectures, Dr. Wang (who was a visiting post-doctoral fellow at ITP/UCSB) acted as producer. For these lectures, the students sat together with their host professors in studios at their respective institutions. Students registered at the university of their choice, and all midterm examinations, homework and grading were handled locally.

A key feature of the course was the designation of a "host" professor at each site ? Professor Glauser at Clarkson, Professor Castillo at RPI, and Professor Meng at SUNY/Buffalo. Of these, only Professor Glauser had taught turbulence before. Professors Castillo and Meng were relatively new faculty, although active reseachers in

turbulence. The host faculty participated actively in these lectures from their own institutions. In addition they were responsible for a one hour weekly lecture/recitation. This was especially important in view of Professor George's lecture style and content that encouraged students to challenge many of the ideas found in texts. This approach left the host faculty in the wonderful position of simply moderating as the students debated the merits of the book versus the lecture. The emphasis throughout was teaching the student to think for himself, instead of simply accepting ideas as fact. The development of such an approach to life-long learning and critical thinking was believed by the participating faculty to be especially important in a field like turbulence where so little can be assumed to be known for sure.

Another feature of the course was that almost every lecture was preceded by an interview with a distinguished visitor to the ITP Hydrodynamic Turbulence Program. The interviews ranged from 10 to 30 minutes each, and were intended both to share the experience of these senior researchers, and to inspire students to want to learn more about turbulence. Such exposure never happens in the traditional turbulence class, at least at this scale. Although some interviewees spoke over the heads of these introductory students, others were quite skillful in making complex ideas understood. But all were able to make their subjects come alive in a manner that left the students enthused and wanting more. The host professors were key in orchestrating and eliciting questions from students, and in making these interviews interactive.

Although the course described herein focussed on the fundamentals of turbulence, an attempt was made throughout to make the students aware of the problems encountered in the more advanced topics of turbulence theory and modeling. The overall goal of the course was to provide the students with the tools necessary to continue the study of turbulence on their own, and especially to enable them to read and understand abundant literature and current developments. Again the role of the host instructors was crucial, since their understanding of their own students' interests and needs enabled them to ask questions and provide feedback which directed the discussion times.

Professor George prepared a detailed text for each lecture using LaTex and WinEdt on a PC. These were organized into Chapters and were made available to each institution via the RPI CT-Web site designated for the course. Students were also able to download the lecture notes from the web-side before each lecture, and on them make their own annotations. Because these notes were being created as the course progressed, there was often a great deal of concern as whether a given lecture would be completed in time. All were, in spite of the nearly, 2.5 days average required to prepare them.

The identical text from the notes was then turned into a set of presentation notes for each lecture, again using LaTex, but with much larger fonts. The result was similar to Microsoft a Power Point or SliTex presentation. As Professor George lectured, these notes were projected from UCSB using his laptop computer and Ghostview. The cursor , magnification and pagination feature of Ghostview made it preferable to the other alternative. Because of the occasional communications breakdowns and the intermittent quality, the host faculty found it desirable to also project the same notes locally using either Ghostview (.ps) or Acrobat Reader (.pdf). This dual projection both insured that students could always read the text, and provided a backup when communications broke down entirely. On one occasion a lecture was delivered by Professor Glauser when the sound was lost from UCSB; and on another, Professor Castillo performed the same role. One of the most amazing features of the course was how smoothly these transitions could be made with one professor lecturing from another's notes, mostly without preparation.

Discussion questions and guidance were provided weekly by Professor George to the host professors, usually after a lecture and in consultation with them. These included suggestions for weekly homework problems, additional reading materials, and most importantly, particular points to be emphasized to reinforce the lecture concepts or to prepare for new ones. This shared responsibility was helpful to the younger faculty members. On the other hand, their openness in admitting the concepts which they themselves found challenging was helpful in tailoring these sessions (and the lectures as well) to facilitate the learning process for all.

One common mid-term take home exam was given in traditional way. For the final exam, the students from all institutions made presentations at a special session of the 1000 Islands Regional Fluids Conference, an annual meeting of fluid dynamicists from Northeastern USA and Canada universities. Details about this meeting can be obtained from Professor Ewing (http://www.mech.mcmaster.ca/~ewingd/1000_islands). This annual meeting provided a unique opportunity for the students to meet each other, the other instructors, and to meet at least a portion

of the turbulence research community. It also provided an opportunity to assess student reaction to the course, their perceptions about the technology, and to solicit their suggestions as to how it might be improved. Some of the details of this assessment are included in the accompanying paper by Stephens et al [1]. For the most part, the comments were positive. The students appreciated the intense effort expended on their behalf, and the unique nature of the experience. The fact that the technology was new and that they were pioneers in a sense, probably did much to make the technical problems tolerable.

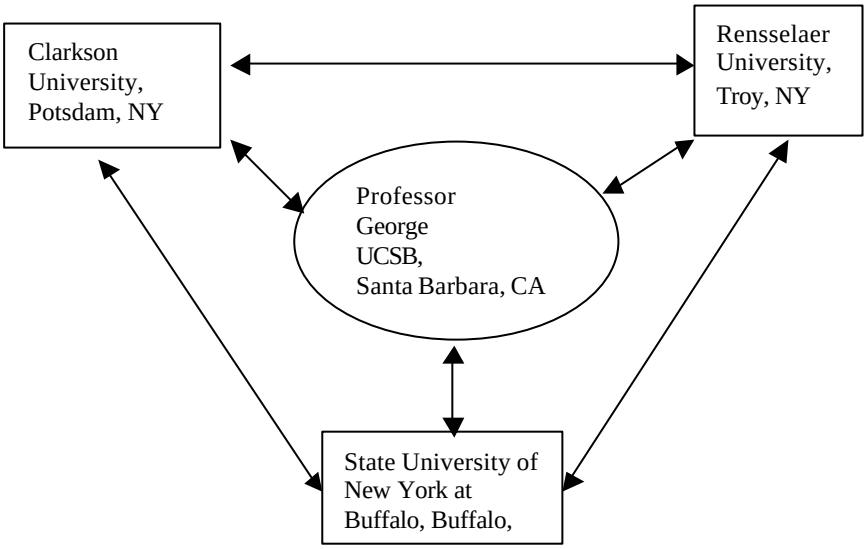

Fig. 1. Schematic showing conceptual communication model.

4. **Advantages and Disadvantages**

There are certainly a few disadvantages to such a combined effort. Among them are:

?? The local instructor certainly has less control, and efforts to move independently can have an adverse ripple effect.
?? Of necessity, much of the course must be created on the fly, especially since no one has any experience with such an effort.
?? Things go wrong ? for a variety of reasons, some technical, some because ideas do not work out as planned. When this happens the leader must not lose sight of the overall objectives, and must have the ability to assure others that this is the case.
?? Technology can complicate things, even when it works. Therefore special effort must be expended to ensure that the course objectives and content remain the focus.
?? One faculty member has to do a great deal more work than for a normal course. On the other hand, for the others it is probably less.

In spite of these, there are tremendous advantages, some not obvious. Our short list includes:

?? The collaboration can be inspirational to both older and younger faculty alike. The older faculty found themselves with new energy and new ideas. The younger faculty found themselves empowered with wisdom and vicarious experience far beyond their own.
?? The students received an exposure to ideas far beyond the scope of a normal course. Many of the top researchers in the area are now familiar faces to them. This both inspired them and should facilitate their entry into the technical arena.
?? The faculty and students established relationships that will probably for many of them continue throughout their careers. The incorporation of the course with the 1000-Islands Fluids Conference was especially helpful in this regard.

Finally, the ideas tried in the course would seem to present several possibilities for the future. They include:

?? High quality graduate courses can be offered to students in universities where they might not otherwise be available.
?? The technology should be able with modest improvements to create learning opportunities for students anywhere in the world**.**
?? Faculty should be able to teach effectively from anywhere in the world to anywhere else. This will present tremendous opportunities for them, and interesting challenges for their administrators.

5. Summary and Conclusions

As in any pioneering effort, the greatest challenge was to make things work once the course had begun. Some of the problems we encountered were expected (like coordination), others were not (like some of the technical difficulties). The abundance of goodwill among the principals and between the academic and technical teams made our effort successful. Remarkably, every single participant is both willing to do it again, and even enthusiastic about the possibility.

6. Acknowledgement

We gratefully acknowledge the contributions of the graduate students at SUNY/Buffalo, Clarkson and RPI. Without their goodwill and patience we could not have succeeded to the extent we did. Even more, their enthusiastic participation, their suggestions and questions (often by email), and most of all their burning curiosity made the effort worthwhile.

[1] Lisa Stephens et al, "A Multi-University Internet-Based (H.323) Graduate Course in Turbulence, Part II: Technical Details", ICEE 2000, Taipei, Taiwan, August, 2000.