MANAGING INTERNATIONAL ACADEMIC DESIGN COLLABORATION

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Abstract --- *A successful experiment in international collaboration in aircraft design education has been conducted by the aeronautical and aerospace engineering departments at Virginia Tech and Loughborough University for several years. This paper discusses some of the lessons learned in that experiment related to the management of both the collaboration and the international student design teams. An emphasis is placed on the need for good communication among both participating faculty and students as well as on the necessity of both interpersonal "soft" skills and management skills in building the design teams. Suggestions are made for others who may wish to develop their own international collaboration experiments in engineering design education.*

Index Terms -- Aerospace engineering, design, international collaboration, teaming.

Introduction

For the past five years Aerospace and Aeronautical Engineering faculty at Virginia Tech [VT] in the US and at Loughborough University [LU] in the UK have been conducting a program of international aircraft design education with students working together during the entire academic year on a common design project [1]-[3]. Virginia Tech has also attempted similar experiments with Kasetsart University in Thailand, and with Ecole des Mines de Nante and ENSICA in France. These experiments have differed in scope and emphasis, both to take advantage of the strengths of the participating institutions and to build on past experience. One outcome of the program has been the development of designs that have won several awards in national and international aircraft design competitions sponsored by NASA and the AIAA.

The first three VT international design collaborations were essentially an international sharing of design related ideas by students and faculty without forming an international team. At Ecole Des Mines the VT students presented their design concept to the French students and sought their suggestions for the project during a week of work together. In Toulouse, the VT students conducted an on-site case study of a design developed by ENSICA students the previous year and obtained ideas for their own related design project. In the first year of collaboration between LU and VT teams at each university worked separately on very similar projects, sharing their results through an exchange of visits. This was the first time that this experiment had generated enough interest in the European partner to lead to visits by students from both universities to their international partner institution.

The second year of LU/VT cooperation brought an initial attempt at creating an international team with students from both universities working together on a single project. This VT/LU collaboration is now entering its fifth year and its fourth year of working with international teams.

A similar attempt at design team collaboration between students and faculty at VT and Kasetsart University in Bangkok, Thailand has not progressed as far and has only involved a small number of students over two years of experiments. Travel expense, communication difficulty over a twelve-hour time difference, and academic year schedules that are six months out of phase have made this a more challenging collaboration.

One of the key factors in the success of the LU/VT program has been a similarity of academic objectives in the design courses of the two institutions. It is necessary that those teaching the two or more design courses involved in any international collaboration have similar course objectives and use similar methods of assessment of student success.

Contrary to popular belief, the common use of the English language is not the reason that the VT/LU collaboration has worked better than the other programs. In both France and Thailand the students and faculty involved in the program spoke English well enough to work together. Pairing students from certain parts of the UK and the US can result in as much of a language impasse as one will find anywhere in the world.

Conducting a successful international collaboration in design education requires common interests and goals but

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also needed are effective management procedures and "soft skills". It necessitates, for example, the development of student assessment criteria that will meet the requirements of two universities operating under different academic systems. Also required is the establishment of a program timeline which will allow teaming among students who are on different academic calendars. Student and faculty communications are extremely important.

Once the involved faculty have eliminated the above mentioned problems in project and course timelines, course objectives, and assessment criteria, the major remaining challenges are those inherent in working with any student team project. Student teams are, of necessity, composed of people with a broad range of communication, management, and interpersonal skills and the inevitable shortcomings in these capabilities inevitably impacts the team's performance of their assigned task. With international teams, such problems can become much more challenging than they would be with a team of students who have a common educational and cultural experience. Those who work with international teams must be prepared to deal with the resulting difficulties and to attempt to preclude them wherever possible.

Project and Team Management

There are two levels of management for any international design collaboration, the management of the collaboration itself and the development of the team structure for student management. The former has proved, in most cases, far simpler than the latter.

The management of the collaboration is largely dependent on the willingness of design faculty at the cooperating universities to work together and to modify their traditional design course. It is essential to have common goals, to stress team rather than individual student work, and to accommodate the needed timeline to the course schedules of both universities. This requires flexibility on the part of participating faculty. This has proved possible for the VT/LU program and each year's experience has brought new insights into ways to better coordinate the two design courses involved in the program.

Collaboration management also requires planning and conducting an exchange of visits and arranging needed financial support. This requires the effective use of resources at the departmental, college, and university levels and a good working relationship with personnel at those levels with access to funding from "foundations" and similar sources. Most US universities now place increased emphasis on "internationalization" of a university education and the help needed to arrange design collaboration may not be hard to find.

In some parts of the world establishing this type of collaboration requires formal documentation of agreements and exchanges of paperwork between the upper administrative levels of the involved universities. In other countries and universities everything can be handled quite informally, building on initial contacts at the faculty level.

Management of an international team is perhaps the most challenging aspect of a student design collaboration. Design is usually a team process and most engineering students have had little or no training in team management skills. Most design faculty do not have the luxury of selecting specific students for their teams, although the constraints on number of students in a special international program may allow some selectivity. In any student design team conflicting personalities and a diversity of work ethics are inevitable and the students must be prepared to work out problems among themselves. Such conflicts can be accentuated with an international team and a leadership structure is needed which can solve rather than exacerbate these problems.

An international student team must have a leader at both universities and the primary task of these "co-leaders" must be the coordination of the work of the two parts of the team. An international team can easily degenerate into two competing sub-teams with separate timetables and agendas. The design faculty can help prevent this by ensuring common course goals and an emphasis on the results of the work of the team rather than on individual output. The "co-leaders" must view themselves as leaders of the entire team, not just their own part of the team. In our experience with the LU/VT collaboration it is imperative that all the students view the entire project as their own and not one with British and American parts. Without good team management it is easy for an international collaboration to become an international competition.

There are many ways to select team leaders. In industry a team can be built around an experienced manager and team leader and fashioned with the right mix of people to get the job done. In an engineering design class the faculty are faced with the task of building a team from a list of students about which little is known beyond past grades on technical courses. Letting students select their own teams is usually not a good solution since a team composed of a set of past "friends" may lack many of the communication and technical skills needed in the design process. Teams selected in order to achieve some balance of needed technical interests or even teams generated randomly are often superior to self-selected teams.

The choice of a team leader is equally difficult. It is not uncommon for a student team to realize in the middle of a project that they have selected the wrong leader. The early division of the design class into small teams for at least part of the initial academic term can help identify students with leadership skills before the larger team is formed. This allows

both students and faculty to observe the capabilities of two or three team leaders before selecting someone to head the larger group.

The early formation of a multidisciplinary team instead of one with only students from a single academic major can prepare them for work with an even more diverse international team. The inclusion of Industrial Engineering and Systems Engineering students with Aerospace Engineering students in the VT/LU team has helped give the students a head start in dealing with team diversity issues. It also ensures the involvement of some team members who have previously taken courses in team management theory.

The international team will probably need a nominal leader at each campus. These can serve as "co-leaders" or one can be selected as the overall team leader or coordinator. The biggest task of the leaders will be to keep their team members focused on the "team" objectives rather than on their own narrow goals and to insure effective communication among all team members. The team leaders need to be aware of all the inter-team communications and to anticipate any possible conflicts before they grow into team problems. Actually, the team leaders are its communication managers who set agendas for regular teleconferences and redirect the efforts of members who fail to communicate properly with the rest of the team.

Student leaders must have good interpersonal or "soft" skills. They must be able to lead by example, be well organized, and be able to motivate the team membership. The lack of any one of these skills can diminish the team's efforts. If a team does not have a member with all of these talents a division of responsibilities between two leaders can work very effectively if, and only if, those sharing the lead are able and motivated to work well together.

"Soft Skills"

Interpersonal and other "soft" skills are seldom directly addressed in current under-graduate aeronautical engineering curricula, yet all academic advisory bodies regard such knowledge as essential in a modern professional industrial working environment. It is difficult to add formal courses in these skills to an already overflowing engineering curriculum. A commonly used resolution to this dilemma is the incorporation of soft skills experience into group design projects. Many management soft skills can be combined with engineering methods that are required for design synthesis. In this way individual development, team building, communication issues, project management, and technical organization can be set within a simulated industrial context.

Professional aeronautical engineering is no longer conducted within the confines of a single plant, company, or even a single country. International integration of the design manufacturing, marketing, and support activities has brought with it the need to consider management practices to account for cultural diversities. Communication in its broadest extent becomes inter-related to the management of people as well as to the transfer of technology. The international student project work described here reflects these complications.

Some of the "soft skills" needed in both industry and international design collaboration are listed below:

Communication Issues

- Networking
- Oral presentations
- Developing phone/video/internet skills
- Writing reports
- Defining group working standards
- Understanding cultural and personality traits

Individual (Personal) Development

- Time management
- Communication (local/external)
- Identifying expectations
- Selling ideas
- Exchanging constructive criticism
- Dealing with difficult people
- Managing conflict
- Assertiveness
- Making decisions
- Giving feedback in a timely manner
- Working with others including students from other majors

Team Building

- Project Planning
- Leadership
- Motivating
- Group decision making
- Scheduling
- Managing technical skills
- Managing facilities and resources
- Delegating responsibility
- Group reporting and feedback
- Managing effective meetings
- Negotiating

Although the VT/LU student groups were similar (mostly white/middle class, mixed gender, penultimate or final graduation year, English! speaking), several cultural differences were observed. When asked to compare their preconceptions with eventual appreciation of their respective groups, they all agreed that many of their apprehensions were not realized. They found each group to be similarly hard working, intelligent, sociable, with equal academic abilities

and similar professional aspirations. Some minor contradictions were apparent relating to style of humor and approaches to problem solving. These led to some confusion about the meaning of some e-mail communications and to disagreement resulting from differences in the freer thinking American approach ("brainstorming") and the more analytical British practice.

We have noted a tendency of the British students to want to thoroughly analyze all initial suggested design concepts before attempting to converge on a single team concept. On the other hand, the American students approach the process by taking a somewhat cursory look at proposed initial concepts and converging on a single proposal through a general analysis of their "pros" and "cons". The American students also have a tendency to want to go immediately to sophisticated computer solutions to every design problem while the British students seem to prefer a more basic level analytical approach. These differences may be partly due to the educational system traditions in each country. These diverse approaches can either enhance the design process or lead to serious problems, depending on proper team and program management.

Communications

It is clear that when a design team is split across two continents, good communication is imperative to achieve the team goals. Our goal is to provide a communication infrastructure that allows the two halves of the team to communicate as efficiently as if they were collocated. In practice, it must be accepted that communication problems will result in delays and misunderstandings and that awareness of the potential problems will allow their affect to be mitigated at the earliest opportunity.

The organization of a design team largely dictates its communication needs. A team could be organized in at least three ways. The most common industrial practice is to split the project geometrically (e.g. the Airbus approach in which one sub-team is responsible for wing, another fuselage etc.). Alternatively, the project could be split functionally (e.g. one sub-team responsible for aerodynamics, one for structural analysis, etc). In our case, we are dealing with the conceptual design process where there is considerable interaction between the design disciplines and the design is subject to continuous change. The two sub-teams are organized on a symmetric basis with responsibility for a given functional area split between two sites. Of the three organizational structures, this perhaps entails the most communication overhead as discussion will be taking place at the lowest design level.

In a conventional design team communication occurs on at least the following levels:

- Informal conversations between team members, essentially face to face discussion that is only loosely planned and may be opportunistic (i.e. meeting at the water cooler)
- Planned (typically weekly) team meetings, discussions around a table with paper drawings passed around and calculations available. Team members often have different goals (relating to their responsibility in the design). Often no external input.
- Formal review meeting (typically at significant milestones in the project). Well planned and prepared meeting (formal presentations with slides) with a common goal (pass the review), likely to be well documented. External input essential.

In our international teams the same levels of communication are often achieved electronically, resulting in both problems and benefits.

- Email and chat systems replace informal (verbal) conversations. This has the benefit that discussion is more formalized and the email sent and received provides a record of statements and decisions. Time zone differences can lead to significant lags in response to questions. (A question asked in UK morning may not be answered until US afternoon, which is then not read until UK morning the following day). It can also be difficult to explain graphical and numeric details easily in the constraints of text based email. Sketches and equations can be scanned as images and sent as attachments but this capability is not used as much as it could be. Email can also lead to misunderstanding since it is often used as if it were informal conversation without the users recognizing that the visual cues which accompany direct conversations are missing, sometimes making it easy to misinterpret a comment. A typical example is where one person makes a humorous statement which is interpreted as a serious proposal by the other person or sub-team.
- Telephone conferences and web sites replace the weekly team meetings. A benefit is that material must be prepared in advance and placed on the web site for it to be visible by both sub-teams. This leads to more structured and productive meetings. The content on the web site then leaves a trail of information that shows the evolution of the design. A problem with telephone conferences is that discussion can be slow and prone to misunderstanding. The content on the web site is essentially static and so it is difficult to be creative within the meeting.
- Video conferences and web sites may replace the formal review meetings (we are just beginning to

experiment with this). A live video link helps to communicate emotion and help avoid misunderstandings. Of equal importance is the ability to use a document camera so that hand drawn sketches can be seen and impromptu discussions carried out. We are currently investigating the use of Microsoft Netmeeting and 'SMART board' technology to allow a shared whiteboard and shared control of software applications. A third remote party can also use the videoconference to participate as an external reviewer, leading to higher quality reviews.

The main drawback with video conferencing techniques is the expense of the equipment and recurrent costs. The use of internet protocols (IP) reduces the recurrent costs but is barely acceptable with current transatlantic bandwidths.

In a teaching environment it is also important to remember that the faculty involved in supervision and guidance must be able to communicate efficiently and reliably. In fact when problems occur between the two sub-teams, it is imperative that the corresponding faculty communicate quickly. This allows mechanisms to be put in place that will 'short-circuit', or help to resolve, the problem. The easiest communication mechanism is often a direct telephone call to the corresponding faculty.

Finally, it important to stress the value of the initial student visit to the partner institution. This visit allows the students and faculty to develop a greater trust in the competence and reliability of their international team partners and makes the consequent communications more productive. This visit includes a mix of social and study activities, all of which contribute to healthy relationships among team members.

One might assume that students would be much more interested in social activities than study when on an international visit but our experience has shown the opposite. It is not at all uncommon for students to replace social activities placed in their schedule by faculty with work periods. Requiring some kind of presentation by the team at the end of the visit helps provide the incentive for students to maintain a focus on their project objectives.

It should be noted that when English is not the common first language of both groups of participants in international design collaborations, communication becomes a little more difficult. However, some of the misunderstandings which can result from differing conversational styles and humor within a common language no longer present problems. When working in English with others who normally communicate in another language people tend to take more care in trying to speak and write clearly in order to assure understanding. Conversation is often much more difficult than written communication as many for whom English is not a native language find that their "foreign" language study has better prepared them for written then oral exchanges.

Cultural norms can also be detrimental to communication and teamwork. In some parts of the world the social custom discourages the frank exchange of views, and group conformity is valued above creativity. In such circumstances both communication and effective teamwork can become a challenge. Otherwise simple meetings can become exercises in international diplomacy and informal communication via email can become quite difficult. Placing American students and faculty, who are not hesitant in critiquing each other's ideas, into a culture where a student would never dare question the word of a teacher, can lead to some very interesting team meetings.

Conclusions

International collaboration in design education can be a very rewarding experience for both the student and faculty participants but it can lead to some interesting challenges in team management and communications. Our experiences have made us more aware of the need for some introductory training in the soft skills required by the students to become effective team players. While we may not wish to use such methods to pre-select members of our groups, we may introduce some form of personality evaluation to help the team better utilize their full potential. In addition to some simple guidance on team working, presentational skills (oral and written reporting), and meeting procedures, we may add specific advice to the team leaders on managing and creating an effective team.

As the communication processes expand with the use of web and video links, it will become essential to impose standards on the use of data and the development of the design detail (e.g. a formalized decision making process).

We enthusiastically recommend that other universities conduct similar experiments in international collaboration. Programs such as this can often be much more beneficial to many students than more traditional "study abroad" activities. The broad-based academic programs mandated in American universities often are not very compatible with the more focused curricula of European or other institutions, and the student wishing to pursue a semester or study "abroad" may find it impossible to match the course requirements at his or her own school. The result is that many students sacrifice a semester or even a year of work to take advantage of international study. However, almost all engineering programs have an extensive design component and collaboration in design education can offer an important international experience to many students who would not otherwise take advantage of foreign study.

Making this type of experience even more valuable is the fact that it is excellent preparation for a career in today's

international engineering marketplace. This is especially true in the aerospace industry where multinational companies and consortia are the rule rather than the exception. We are confident that programs such as this will help prepare our engineering graduates for careers and for full citizenship in a truly international twenty-first century.

References

1. Marchman, J. F., "Multinational, Multidisciplinary, Vertically Integrated Team Experience in Aircraft Design", Intl. Joul. of Engineering Education, Vol 14, No. 5, 1998.

2. Jenkinson, L. R., Marchman, J. F., Page, G. J., "International Teaming in Aircraft Design Education", AIAA Paper 99WAC-25, Oct. 1999.

3. Jenkinson, L. R., Page, G. J., Marchman, J. F., "A model for International Teaming in Aircraft Design Education", Aircraft Design, Vol 3, No. 4, Dec. 2000.