AC 2007-1822: MULTINATIONAL DESIGN: KEYS TO INCORPORATING MULTINATIONAL DESIGN

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Abstract

Design methods and approaches have been developed throughout the past century. These methods draw on the characteristics that design teams are able to communicate quickly and effectively. Use of sketches, descriptions, and 3D models further aid the clarification of designs. This paper explores how traditional methods should be applied for global design and the similarities and differences. It also shows the importance of global design training for future engineers and explores a current Senior Design example.

Introduction

Graduating engineers are beginning to see more collaboration with offshore factories than they have before. In the past, most American engineers designed and manufactured exclusively in the US. Today with the inexpensive cost of labor, manufacturing is going overseas. This is not necessarily a good or bad thing, but our future engineers need to have the skills required to thrive in such an environment. As technology advances and communication improves, engineering design occurs around the clock. In essence the world is becoming flat.

Educators must teach current engineering students the skills necessary for global collaboration. There are many intricacies that can only be worked out through experience and Senior Design (Capstone projects) are ideal for practicing the skills demanded by the global market. The real problem of global design comes when the members of the team are not in the same country or speak the same language. How can current design methods that depend so much on clear easy communication be used effectively with global teams? Design methods have only begun to be used on the Global scale. In the past it has been too difficult for teams located around the world to communicate quickly and effectively.

Due to advances in technology this is rapidly changing and will only get easier and faster. Therefore, future engineers need to be well acquainted with technological solutions to current global design problems. Partners for Advancement of Collaborative Engineering (PACE) is sponsoring an initiative to design a Formula One style race car. Northwestern University, University of Texas at El Paso, College for Creative Studies, Brigham Young University, Art Center College of Design, and Prairie View A&M University along with fourteen schools from around the world are participating in this project.

In order to accomplish the challenge given and described more fully in the next section certain applications are being used to accommodate the free flow of concepts and designs. Each school on this project is responsible for a component or assembly that will go into the vehicle. Each team will complete all the analysis and engineering design to make their component work. There were minimal initial constraints, so all of these 20
schools began working to come up with concepts that would still allow the creation and innovation of other team designs.

Imagine being able to incorporate background, training, and cultures from around the world in such a way that ideas flow freely and effectively. Feats like the Great Wall of China, placing a man on the moon, and the vast knowledge base of India are brought into one room. There is no limit to the designs that could be produced.

**Background**

PACE had the idea to create a project that would prepare students and faculty for the global markets. In order to prepare students, the project involves real-world engineering and collaboration experience with 20 schools speaking 7 different languages from around the world. A picture of the locations of the schools participating is shown in Figure 1. Table 1 shows the complete list of all the participating schools.

**Figure 1:** Shows the location of the participating schools on the world map.

<table>
<thead>
<tr>
<th>University</th>
<th>Country</th>
<th>Department</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monash University</td>
<td>Australia</td>
<td>ID and ME</td>
</tr>
<tr>
<td>University of Sao Paulo</td>
<td>Brazil</td>
<td>ME</td>
</tr>
<tr>
<td>University of British Columbia</td>
<td>Canada</td>
<td>ME</td>
</tr>
<tr>
<td>University of Toronto</td>
<td>Canada</td>
<td>ME</td>
</tr>
<tr>
<td>Queen’s University</td>
<td>Canada</td>
<td>ME</td>
</tr>
<tr>
<td>Shanghai Jiao Tong University</td>
<td>China</td>
<td>ME</td>
</tr>
<tr>
<td>Aachen University</td>
<td>Germany</td>
<td>ME</td>
</tr>
</tbody>
</table>

**Table 1:** List of all the universities participating throughout the world.
<table>
<thead>
<tr>
<th>Institution</th>
<th>Country</th>
<th>Degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peoples Education Society Institute of Technology</td>
<td>India</td>
<td>ME</td>
</tr>
<tr>
<td>Instituto Politecnico Nacional</td>
<td>Mexico</td>
<td>ME</td>
</tr>
<tr>
<td>ITESM – Toluca</td>
<td>Mexico</td>
<td>ME</td>
</tr>
<tr>
<td>Universidad Iberoamericana</td>
<td>Mexico</td>
<td>ME</td>
</tr>
<tr>
<td>Hongik University</td>
<td>South Korea</td>
<td>ID and ME</td>
</tr>
<tr>
<td>Sungkyunkwan University</td>
<td>South Korea</td>
<td>ME and MFG</td>
</tr>
<tr>
<td>University West</td>
<td>Sweden</td>
<td>ME</td>
</tr>
<tr>
<td>Art Center College of Design</td>
<td>United States</td>
<td>ID</td>
</tr>
<tr>
<td>Brigham Young University</td>
<td>United States</td>
<td>ME</td>
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<tr>
<td>College for Creative Studies</td>
<td>United States</td>
<td>ID</td>
</tr>
<tr>
<td>Northwestern University</td>
<td>United States</td>
<td>ME</td>
</tr>
<tr>
<td>Prairie View A&amp;M University</td>
<td>United States</td>
<td>ME</td>
</tr>
<tr>
<td>University of Texas at El Paso</td>
<td>United States</td>
<td>ME</td>
</tr>
</tbody>
</table>

The overall process outlined for this project is to first create a detailed design of all components that will be purchased or fabricated. Analysis is then done on the components and structures for safety and performance of the vehicle. Then all the components and materials purchased will be fabricated, built, manufactured, and/or assembled. The fully assembled vehicle will then undergo chassis and drivetrain testing.

Because this project is done on the global level it is important to have the tools to communicate with all the team members around the world. In order to do this the equipment and software has been set up before the project began. Some of these tools are video conferencing, email, application sharing, and phone conferencing. The team will also use TeamCenter Community and TeamCenter Engineering, with a myriad of other engineering software applications.

At the beginning of project the chassis was defined with a wheelbase of about 2600mm, track width of about 1600mm, and 650kg overall weight. It was also to have an open-wheeled architecture, similar to a Formula One race car. The chassis included an inboard mounted shock absorber set actuated by a push-rod design. The material for the frame could be made of any material.

The drivetrain is made of a mid-engine, GM Ecotec, mounted longitudinally. It is to be turbocharged and supercharged to 400-500hp. The supercharger needed to be declutched at high engine speeds. The transaxle would be a Hewland NLT sequential transaxle with a limited slip differential.

It addition, four bodies will be designed to fit on the chassis. The bodies will be four unique designs that will all attach to the same points on the frame. The bodies will be manufactured at the end of one project year using a 5-axis mill then laid up with fiberglass. The different bodies also have interchangeable wings for high and low down-force applications.
A few of the software packages that will be used for design and analysis are NX4, HyperMesh, Optistruct, LS-DYNA, Fluent, Nastran, ADAMS Car, and skype. And the project is planned to span a three year time period with new teams picking up where the old teams left off at the beginning of each school year.

**Keys to Design – Current Method in Senior Design**

Early in Senior Design projects a team is given the project goal. The first month or so is used discussing how to proceed and possible solutions. Everyone on the team needs to be able to share ideas without restraints. They need access to everyone’s concepts: all models, sketches, and pertaining information. In early design, engineers use sketches, whiteboards, pictures, prototypes, CAD, and lists of ideas to communicate possible designs. It has been shown that the more concepts generated early in design the better the end product. Starting designs early on allows various techniques like SCAMPER, TRIZ, and 625 to be practiced by young engineers further enhancing the quality and quantity of designs. Sketching has been an important way for designers to show what they are thinking. Goel also argues that sketching is important to capture the ambiguity inherent in design. Yang showed that generating many concepts is important, but the concepts must occur in the early stages. It is generally understood that designs will continue to be refined throughout the design and analysis process until the actual fabrication.

**Design – Global Collaboration**

Global design teams are not able to talk freely like small teams that are located at one school. In order for the overall team to succeed the project scope must be defined before the semester begins. Each team must know what there individual responsibility is and how to share the concepts they are creating. Therefore, each person on the team should have the contact information of all of the students working on the project from around the world or at least the team leaders.

For example, in the designing of a vehicle there are multiple teams like fuel and exhaust, suspension, engine, ergonomics, frame, body, etc. Each one of these teams should have multiple ways to contact any other team member. Most often projects of this scope have interdependencies on each design that must be worked out in the design process. Clear communication early in the project allows time to refine early concepts.

Early designs need to be conveyed to all participants on a global team. Some of the tools that have aided in communicating these designs have been, Skype a Voice over Internet Protocol or VoIP, a central server with application sharing software, universal CAx tools, and video conferencing equipment.

Important to design is communicating thoughts and ideas. Verbal communication is a good way to get creativity flowing. For this reason, it is important to have some method allowing verbal communication. In today’s world it is easy and cost effective to have a
VoIP service. One service that was chosen for this project is Skype because it was free, easy to use, and could handle conference calls. It also had decent sound quality when talking to anyone in the world.

Sketching which is an important part in design becomes a difficult task when it involves viewers from around the world. One solution is a database and software that allows each team to upload latest revisions and documentation for all the other team members to access. This allows students to share what they have sketched to help inspire other member designs. The software chosen for this a Senior Design that will be discussed later in detail was TeamCenter Community. It allowed sketches, designs, and corresponding documentation to be centrally located and easily accessible. Another solution for sketching is to use TeamCenter Community to do application sharing. This allows other students to take control of another student’s computer and sketch, or model right on the screen. Everyone that has joined the application share is able to see what is being sketched and then able to give verbal feedback using VoIP.

A global design project also teaches students how to manage design time when working with a global team. This is a skill that will be needed of our future engineers. It takes at least a day to get simple responses on design aspects that would take an hour if everyone on the design team was located in the same place. Global engineers need to know how to plan their time with the mindset that the design will continue at the end of the day. Designs are literally passed on to the team that is just waking up on the other side of the world. Proper understanding of use of global time is effectively developed by participating in a global engineering environment.

A tool that helped everyone manage and coordinate time better was Google calendar. Google calendar allows design teams to schedule in their own time zone a meeting that is displayed for all the other team members in their own time zone. In the beginning stages of the project there were many discussions that were missed by teams around the world because of a time miscalculation. Often teams showed up thirty minutes late or missed the meeting completely because of a miscommunication. Google calendar was the program of choice because it was able to handle the time zone differences. Once everyone became familiar with this scheduling, the design review and application sharing became very effective. Through these methods, students were able to create effective design meetings that included all needed participants.

The last effective communication tool for global design that needs to be taught is video conferencing. The majority of the schools working on this global project have access to video conferencing devices. A few American schools used a Tandberg and were able to meet with and discuss problems and issues that teams were having face to face. It also helped motivate and encourage the students to see the progress of other teams.

All of these tools took half a semester to learn and to get all of the problems worked out. Now teams are much more effective in communicating ideas and receiving feedback. All of these students will be able to go into the work force with an understanding of how to communicate effectively on a global scale.
Project Example

During the global PACE project industrial design students created multiple designs given the design constraints early in the project. Some of the designs are shown in Figure 2. The creation of many sketches proved to be beneficial because it inspired the other teams of the vehicles potential appearance. It also gave the teams that would be restricted by the shape of the body some ideas of what possible designs would work. The frame team for example became dependant on the size and shape of the body. It was beneficial to see what kinds of shapes the frame team could be working with early on to accommodate the various designs.

Figure 2: Sketches from schools in Korea, Australia, and the U.S.

On small design teams communication is easy because all pictures and sketches are easily accessible. The individual members contributing are able to explain their ideas and clarify characteristics in their forthcoming design. As discussed when the team becomes global it is important that an infrastructure is in place to allow clear easy communication. PACE’s global project set up Teamcenter Community which allows application sharing. Application sharing aids in the communication of sketches, 3D models, and analysis. It is also important to couple application sharing with a VoIP so that ideas and figures can be discussed.

VoIP allows the designing students to speak directly with other students on the global team. The effective VoIP as mentioned earlier was Skype. Skype in addition to being a VoIP software allows the exchange of files quickly and easily during a conversation. This allowed the passing of sketches and ideas in the middle of a conversation. Also students could use application sharing software to take control of others computers and describe with a visual picture and a pointing device what they were talking about. The students equipped with application sharing software and VoIP are able to show their ideas and clarify any misunderstands (Figure 3). This form of communication proved to create similar attributes that are seen if effective design settings.
Figure 3: Picture of student collaboration with other students using Skype and Teamcenter Community during an application share.

An example of the success of these tools in design is when a Korean school needed to discuss how their seat design would fit inside the frame. The picture of the problem is shown in Figure 4. The students at the Korean school were charged with designing the rider ergonomics of the vehicle. They had designed a seat and created a 3D model. They arranged a meeting to review each others design. The Korean school had downloaded the latest design of the frame and inserted their seat to show the American school how it would fit. One of the American students spoke Korean and the Korean students who spoke English were able to have a discussion about what changes needed to the frame to incorporate the Korean designs. The application sharing and VoIP were extremely important to the success of this discussion.

Figure 4: Korean schools seat design in the American school’s frame.

During this meeting it also became apparent that everyone had to speak in very simple English to be understood. It helped significantly to have someone on each team that spoke the common language fluently. The student at the American school who spoke Korean fluently aided significantly in clarifying to the Korean school how the frame could be changed to meet their needs. Once understood the Koreans and the American students were able to move forward quickly and effectively to incorporate the discussed design changes.

This understanding would be difficult to achieve had both parties not spoken a common language because being unable to see facial expressions, hand gestures, eye contact, and body language limits their ability to communicate. This skill of communicating ideas in similar, but a slightly different way needs to be taught to our future engineers. This know-how can then enable clear concise communication and collaboration to happen
seamlessly from education to profession and particularly in the area of engineering design.

Conclusion

Design has always been an integral part of engineering. We must look forward to expanding our design skills to incorporate design methods occurring on the global level. This paper has shown how Senior Design projects can develop these skills and possible areas of improvement. It has shown that traditional methods are still applicable, but need some adaptation to be effective. Future work could be done in exploring the effects of different languages and cultures on the designs from global design teams.

Acknowledgements

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Bibliography