

## The role of virtual student design teams in engineering education for the “new workplace”

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The “new workplace” for engineering is increasingly at the interface of three environments: the Virtual environment, in which designs can be created and explored, with activities that range from interaction via the Internet to 3-D visualization and immersion in alternative designs of engineered systems; the Product Realization environment, in which physical embodiments of designs can be produced and evaluated; and the Human environment, in which people work together in face-to-face and virtual teams, the latter often internationally dispersed, to design and implement products and processes. Functioning at the interface of these environments is a challenge that must be met by engineering graduates. In this paper we primarily focus on the virtual team issues as they relate to pedagogy to prepare students to function on design teams in the “new workplace” and also show how Stevens is moving to address the new paradigm.

### Introduction

Engineering is increasingly conducted at the interface of three environments: the Virtual environment, in which designs can be created and explored; the Product Realization environment, in which physical embodiments of designs can be produced and evaluated; and the Human environment, in which people work together in teams to design and implement products and processes. Functioning within these environments is a challenge that must be met by engineering graduates.

The virtual environment encompasses activities involving the manipulation of information in various forms in virtual space. These activities range from interaction via the Internet to 3-D visualization and immersion in alternative designs of engineered systems. The product realization environment encompasses the real time execution of engineering projects, products and services for example on the factory floor or the project site. The human environment encompasses all interactions, real or virtual, with all project stakeholders from teammates to users. Cutting across all three environments is

increasing awareness for the need to incorporate the process of systems thinking. Systems thinking entails the notion that every engineering project, no matter how small, is treated as a system and not as a mere collection of components.

In the realm of the virtual environment, Virtual Reality (VR) has the potential to create tremendous impact on engineering education by providing students with new insights into their studies and permitting them to explore environments that would be otherwise inaccessible. A virtual environment can represent any three-dimensional world that is either real or abstract. This includes systems like buildings, landscapes, underwater environments, spacecraft, inside an engine or the human body, etc. VR will reshape the interface between people and information technology by offering new ways for the communication of information, the visualization of processes, and the creative expression of ideas to take place. However, before that potential can be fully exploited, engineering educators must first learn not only the mechanics of VR, but also the intricacies of how best to apply this approach to engineering education. In this regard, one notes that through the use of VRML, etc., *VR tools have recently expanded significantly in scope to allow sharing of non-immersive 3D simulations across the Internet, thus enabling remote collaborations.*

While VR of itself can have a powerful impact on engineering education, a significant consideration is how to most effectively incorporate the human environment. Increasingly engineers need to adapt to a virtual teaming mode that may include others within the same organization or across organizations. Furthermore, such teaming is increasingly international and therefore multicultural. In emulating this world, one must consider educational collaboration in the virtual environment and test and refine it at the institutional level, between institutions and across national boundaries. Stevens has already begun to address this aspect with an in-depth assessment of the issues that will influence the success of virtual, international student teams in addition to some first implementations that will be described later.

The third environment that must be integrated is that of the real world, in that virtual design and collaboration only have value once a tangible output is produced. In this regard, the ability to quickly produce prototypes or other demonstration models, etc., directly from the virtual engineering tools, is very important. Ideally access to industrial

scale machine tools, etc. would also be very desirable for student teams. We will briefly describe later how Stevens has addressed this aspect of the three environments.

### **Virtual Teams and International Virtual Teams – the issues**

As previously mentioned, virtual teams including international virtual collaborations, are an ever increasing reality for many in the engineering profession. It stands to reason therefore, that as engineering educators, we need to consider ways of helping students develop the technical, organizational and interpersonal skills to be effective in the global virtual workspace. Wilczynski and Jennings<sup>1</sup> have recently spotlighted some of the issues associated with virtual student teams engaged in design. Extending this to a global perspective, Jones et al.<sup>2</sup> have been strong advocates for the use of distance learning techniques as a means to provide an international experience to engineering students, given the extremely low number of engineering students who engage in direct study or work abroad. They have pointed to a small number of engineering schools in the United States that have taken steps to introduce a virtual international experience. As we have indicated, beyond providing a more accessible means for engineering students to gain international exposure and orientation, engaging them in a virtual international team program will foster their ability to function successfully in a paradigm that is increasingly the reality of the global practice of engineering. For engineering educators this is a compelling driving force that we need to respond to.

In a recent paper<sup>3</sup> from several of the present authors, we drew upon literature from organizational psychology and behavior to elaborate on the challenges and possible solutions to providing engineering students with learning experiences that can help prepare them for the global virtual workspace. In particular we attempted to identify key

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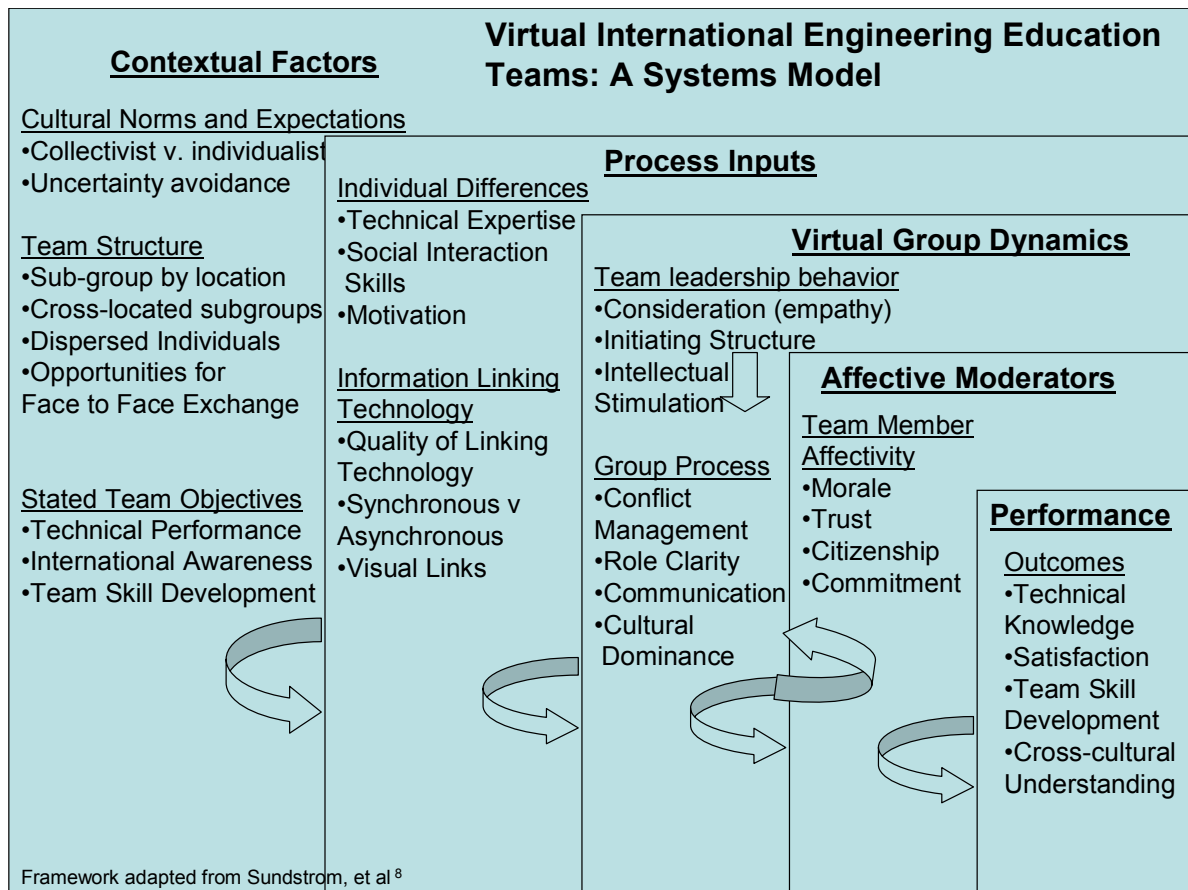
<sup>1</sup> V. Wilczynski and J. Jennings, “Creating Virtual Teams for Engineering Design”, *Int. J. Engineering Education*, Vol. 19 #2, pp. 316-327, 2003.

<sup>2</sup> (a). Jones, R., Oberst, B. (2000). “International Experience for Engineering Students through Distance Learning Techniques”, *Proceedings of the ASEE Annual Conference, St. Louis, Missouri, June 2000, Session 2360*. American Society for Engineering Education.

(b). Jones, R., Oberst, B., Siller, T., and Johnson, G., (2002). “International Exposure for Engineering Students using Distance Learning Techniques”, *Proceedings of the 2002 ASEE/SF/TUB Colloquium “Global Changes in Engineering Education”*, Berlin, Germany, Oct 1-4 2002, American Society for Engineering Education.

<sup>3</sup> K. Sheppard, P. Dominick, Z. Aronson, “Preparing Engineering Students for the New Business Paradigm of International Teamwork and Global Orientation”, *Int. J. Engineering Education*, Vol. 20, #2, 2004, to be published.

factors and issues to consider when structuring engineering design projects that involve collaborating across time, space and national boundaries. The main points are restated here and are based on an open-systems framework illustrated in Fig. 1. The basic premise of an open-systems approach is that there is a hierarchical ordering to various levels of factors that influence behavior and interaction between individuals. Each level of factors is at least to some extent shaped by the factor that precedes it in the hierarchy.



**Figure 1: A Systems Model of Key Factors Influencing the Dynamics and Performance of International Engineering Education Teams<sup>3</sup>**

Contextual Factors

*Cultural values* help to shape the kinds of behaviors that are to be expected. One of the many learning advantages of international student experiences is that they expose students to others whose values may be different from their own. On the other hand,

cultural behavior and expectations can filter information dissemination and interpretation. As a result, these differences are likely to be an important factor influencing communication, trust perceptions and overall performance among students from different countries and backgrounds.

Another dimension of cultural variability with possible implications for global virtual team interaction is uncertainty avoidance. Individuals from cultures that favor a high level of uncertainty avoidance prefer order and stability whereas those from cultures that favor low uncertainty avoidance are relatively more comfortable dealing with uncertainty and less formal structure.

*Stated team objectives* are a second set of contextual factors that are likely to have implications for how international student team members behave and perform in a virtual setting. The basic premise underlying this assertion is that behavior tends to be goal directed<sup>4</sup>.

*Project group structure* represents a third contextual factor that instructors should consider when establishing global virtual team projects. The ways in which group members are organized can have profound implications for the extent and nature of communication that occurs among them. There are at least four distinct organizational models that may be relevant for structuring international student team projects, each with their pros and cons. Establishing sub-groups by location is probably the most typical approach in both education and industry. This approach usually involves having distinct cultural groups at various locations/schools interacting with one another. For instance, students at one school might be responsible for a particular part of the design project while students at another school elsewhere in the world would handle a different part. There are many logistical advantages to this approach. However, one potential disadvantage is the possibility that the cultural values and behaviors of one sub-group will become overly dominant in terms of overall interaction across locations<sup>5</sup>. Instructors and student team members should be mindful that such a dynamic can occur and may

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<sup>4</sup> Locke, E.A. & Latham, G.P. (1990). *A theory of goal setting and task performance*, Englewood Cliffs, NJ: Prentice-Hall.

<sup>5</sup> Heimer, C. & Vince, R. (1998). "Sustainable learning and change in international virtual teams: From imperceptible behavior to rigorous practice", *Leadership & Organization Development Journal*, 19(2), pp. 83-88.

want to implement practices to prevent it. Examples could include rotating leadership for project deliverables across locations. Establishing team ground rules can also help.

Another approach is to establish sub-groups by location. In this case, members from different international locations would form project sub-teams. By promoting sub-group identity based upon project task rather than national origin this approach might help to shift a focus away from cultural distinctions and patterns. On the other hand, there may be additional logistical challenges posed by this approach.

A fourth structural arrangement is to combine virtual communication with some level of face-to face as well. One major advantage of virtual communication is that it can allow international collaborations that have some elements of face-to face interaction to continue over longer periods of time. Many practitioners acknowledge that face-face interaction can help to enhance the development and effectiveness of a team that has to function virtually for extended periods of time (e.g. Heimer & Vince<sup>5</sup>).

### Process Inputs

The two process inputs described in the model are derived from a sociotechnical systems approach to work design. The basic premise of this approach is that whenever people are brought together to perform work, a joint system is operating that consists of: a social part includes the people performing the work and the relationships that develop between them, and a technical part comprised of the tools and processes used to perform their work<sup>6</sup>. Therefore in terms of understanding virtual international student teams, key process inputs include *individual differences* amongst team members (the social part) and the *information linking technology* used to establish and sustain virtual interaction (the technology part).

In terms of technical expertise the heavy dependence on technology required to work across international time and space is likely to be impacted by students' proficiency with new information technology. Some effort on the part of instructors to both assess and/or develop student skills should probably be undertaken early on in the collaboration.

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<sup>6</sup> Cummings, T.G. & Worley, C.G. (2001). *Organization Change & Development*, South-Western College Publishing.

Along the same lines instructors should be cognizant of the fact that students may or may not come into a project with equivalent levels of engineering subject matter expertise. Here again some preliminary assessment and planning by instructors can help to ensure that students operate under relevant assumptions and share information appropriately.

There is evidence that other personality, behavioral style, and attitudinal differences as well as gender also shape how student work and learn in a virtual setting. For instance, students with certain visual learning styles and or independent behavioral styles learn better in web environments. On the other hand, aural, dependent and more passive learners may not do as well. Students with a high motivation to learn, greater self-regulating behavior, and the belief they can learn online do better<sup>7</sup>.

The second process input we consider important is the nature of *information linking technology* used within and across locations. Consistency across locations is one factor that appears to be particularly important. For instance, Jarvenpaa and Leidner<sup>8</sup> noted that it was much harder for students with inferior technology to participate consistently in an international student project. They also suggested that as a result, these students were less likely to be perceived as trustworthy.

Another technology issue, asynchronous communication, has implications for both the task and relationship aspects of team interaction. On the task management side as work becomes more complex, more precise forms of coordinated effort and related communication mechanisms are needed. As one might expect, less complex tasks are easier to manage via the asynchronous communication that typically characterizes global virtual team interaction<sup>9</sup>. On the relationship management side some have noted that asynchronous communication technology may make it harder to convey affective and behavioral aspects of communication that form a basis for interpersonal trust<sup>10</sup>.

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<sup>7</sup> Meyer, K.A. (2003). "The web's impact on student learning". *T.H.E. Journal*, May. (<http://www.thejournal.com/magazine/vault/A4401.cfm>)

<sup>8</sup> Jarvenpaa, S., & Leidner, D. (1998). "Communication and trust in global virtual teams", *Journal of Computer-mediated Communication*, 3(4).

<sup>9</sup> Bell, B.S., and Kozlowski, S.W.J., (2002). "A typology of virtual teams: Implications for leadership", *Group and Organization Management*, 27(1) pp.14-49.

<sup>10</sup> Holton (2001) "Building trust and collaboration in a virtual team", *Team Performance Management* 7(3/4), p 36.

Some planning and anticipation on the part of instructors can help to minimize potential problems associated with asynchronous communication. For example, to the extent that students will be communicating via asynchronous means, greater attention should be given to clearly structuring and defining key tasks, roles and responsibilities and deliverables. As mentioned earlier, team ground rules will also be very important and helpful. In this case, ground rules that stress communication consistency and frequency may be particularly relevant.

### Virtual Group Dynamics

Process inputs come together to create virtual team dynamics, the next level of analysis in our framework. Our focus at this level includes a consideration of *team leadership behavior* and also the nature of *team member interaction / group process*. While the fundamental principles of team leadership and behavior are likely to be more or less the same, the lack of physical proximity inherent in global virtual teams suggests that at least to some extent, these principles will have to be conveyed and applied in unique ways.

There are several ways in which instructors and facilitators of global virtual student teams can help to promote effective leadership. One way, of course would be to model some of the above behaviors in their own interactions with members of student teams. It would also help to make expectations regarding what constitutes effective leadership explicit to team members. Leadership responsibilities within the team should also be rotated across locations so that all students have opportunities to practice developing their skills.

In terms of group process, some have noted that certain dysfunctional team behaviors and attitudes (e.g. social loafing, role confusion and low levels of individual commitment) can be potentially exacerbated in a virtual context<sup>11</sup>. More recently, Montoya-Weiss<sup>12</sup> reported that asynchronous virtual communication among team members moderated the way people experienced and resolved conflicts. Some negative

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<sup>11</sup> O'Hara-Devereaux, M., & Johansen, R. (1994). *Global work: Bridging distance, culture, and time*. San Francisco, CA: Jossey-Bass Publishers.

<sup>12</sup> Montoya-Weiss, M., Massey, P., Song, M. (2001). "Getting it together: Temporal coordination and conflict management in global virtual teams", *Academy of Management* 44(6), pp.1251-1262.



less ideal forms of conflict management (avoidance, confrontation) were found to be less of a problem than in face-to face settings. The topic of cultural dominance was discussed earlier in this paper but is also worth reiterating at this point<sup>13</sup>.

### Affective Moderators

A fourth level of analysis is both an outcome of virtual group dynamics and a likely contributor to shaping it as well. In this case we are referring to general attitudes and feelings team members develop about their experiences working together. Several particular attitudes may be especially relevant. **Citizenship** refers to the extent that team members engage in behaviors that go above and beyond their formal requirements, yet promote effective team functioning<sup>14</sup>. **Commitment** is an indication of the extent to which people identify with their teams and desire to remain in them<sup>15</sup>. **Satisfaction**, is the extent to which team members “feel” gratified and fulfilled by their work<sup>16</sup>. While few of the above attitudes have been explicitly studied in a virtual team setting it is likely that they are just as relevant if not more so than in face-to-face interactions.

### Performance

It is important to hold students accountable for the technical quality of the work and for the extent to which they demonstrate (as a team and as individuals) mastery of subject matter material. At the same time however, the reasons for exposing students to work in global virtual teams goes beyond helping them to develop technical skills. Therefore, other important outcomes to consider include the extent to which students developed team skills, project management competencies and also their abilities to work with others from different cultural backgrounds. Admittedly, assessments of these outcomes are somewhat subjective but they are important. Some aspects of these “softer skill” areas lend themselves to knowledge testing but instructors may want to also

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<sup>13</sup> Heimer, C. & Vince, R. (1998). “Sustainable learning and change in international virtual teams: From imperceptible behavior to rigorous practice”, *Leadership & Organization Development Journal*, 19(2), pp. 83-88.

<sup>14</sup> McGourty, J & deMeuse, K.P. (2000). *The Team Developer*, John-Wiley & Sons.

<sup>15</sup> Greenberg, J & Baron, R.A. (2000). *Behavior in organizations*. Upper Saddle River, NJ: Prentice-Hall.

<sup>16</sup> Morehead, G., & Griffen, R.W. (1998). *Organizational behavior: Managing people and organizations*. NY: Houghton Mifflin Company.

consider using survey based data, (peer and self-reports) along with student journals as ways to measure the learning that occurred.

### **How is Stevens Institute preparing students for the “new workplace”?**

Stevens has established two Centers, one to address the needs for VR tools and the other providing Product Realization capabilities in rapid prototyping, etc., to promote the integration needed. The third component is an evolving program that encourages students to participate in international virtual teams that bring all the elements of the new workplace together.

#### Virtual Engineering Center

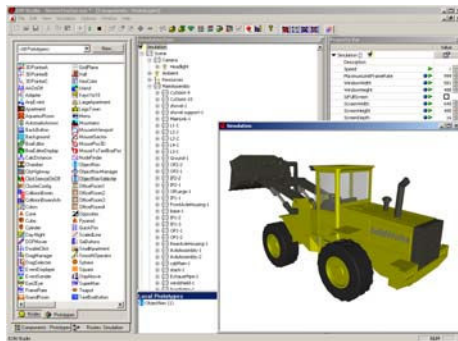
In addition to the exposure of all our engineering students, as part of their core requirements, to the common software tools of engineering, such as those for CAD (SolidWorks), data acquisition and analysis (LabView and Matlab) and programming (C++), Stevens has recently established a Virtual Engineering Center in collaboration with EON Reality Inc. This collaboration makes a comprehensive suite of EON VR tools available to students for use in project work for:

- Visual product exploration in 3D for fast access to detailed product information, drawings and procedures
- Visual product configuration development through intuitive steps on how to select components and configure products
- Design the product space in 3D and explore different layouts and a virtual product tour in the planned space
- Visualization of the simulated manufacturing environment
- Interactive evaluation of manufacturing steps and planning
- Visual demonstration, interactive practice, training and product evaluation

The Center resources:

- Reduce development overhead by utilizing existing 3D simulation component libraries
- Flexible - permit customization to meet individual scenario needs

- Standardize interfaces for data import and export between simulation systems, other software applications and databases
- Scalable - applications deployable on various publishing formats, including multi wall immersive systems, stereoscopic displays, head mounted displays, PC, Tablet PC and Internet
- Provide common user interfaces and enhanced capabilities, e.g., higher level programming languages



### Product Realization Center

The Product Innovation and Realization Center at Stevens<sup>17</sup> was established with the help of a \$1.3M grant from the New Jersey Commission on Higher Education together with significant Stevens matching support. The Center provides a teaching factory environment with access to computer-controlled rapid prototyping equipment, 3-D printing, CNC machining, mechanical testing, circuit board prototyping and associated electronic testing. There is even industrial-scale injection molding equipment. Virtual design and simulation can find a physical embodiment

<sup>17</sup> [http://www.soe.stevens-tech.edu/technogenesis/Innovation\\_Center/index.html](http://www.soe.stevens-tech.edu/technogenesis/Innovation_Center/index.html)

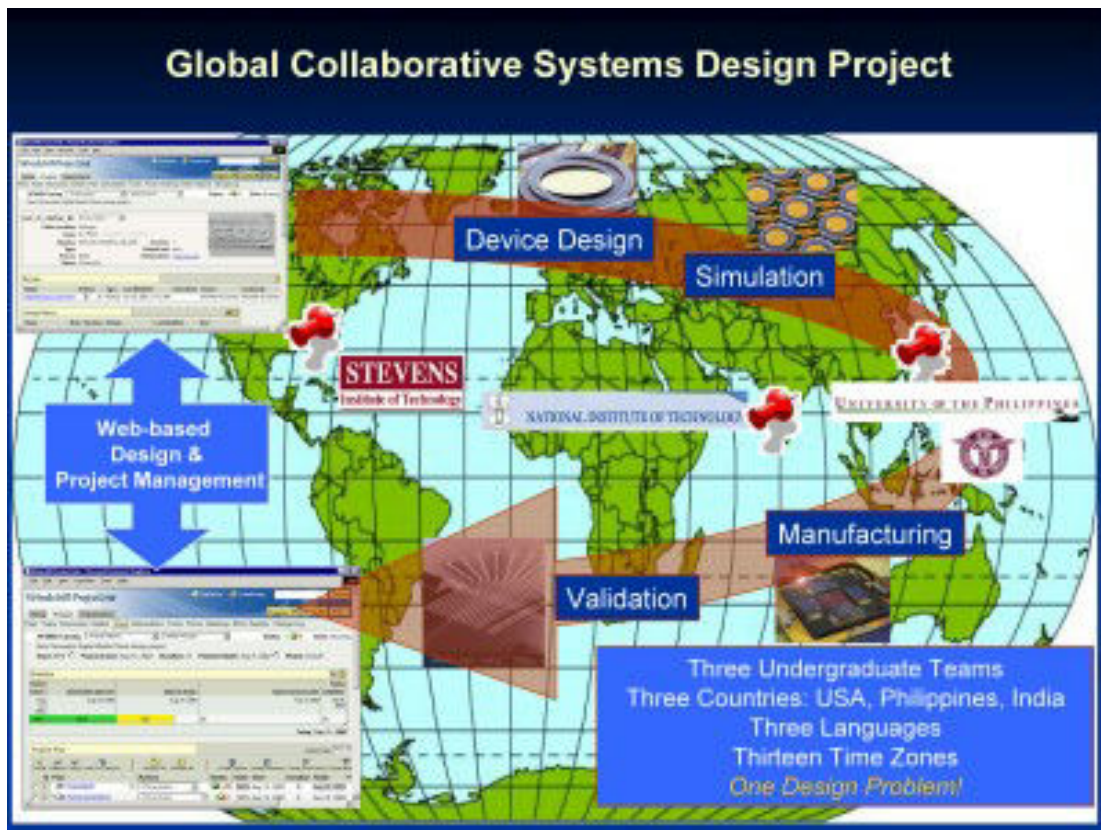
through the Center facilities, in most cases by a direct file transfer to the equipment that will make the part. Some of the facilities are illustrated below:



### International Virtual Team Projects

The pilot implementation at Stevens that brings all three environments (Virtual, Product Realization and Human) together in an international student virtual team project is one that is truly global in nature and involves undergraduate student teams in three countries. Participants are Stevens, which is providing overall design and project coordination, University of the Philippines (Quezon City, Philippines) manufacturing

lead, and The National Institute of Technology (Warangal, India) which is the simulation lead. The project is called the “MEMS across the Globe” project and forms part of a larger pilot in virtual student design undertaken by a consortium of schools in collaboration with PTC Inc., a producer of industry standard design and collaboration tools. The following figure summarizes the elements and participants in the project, whose goal is to design and prototype a MEMS product, in this case a rate sensing gyroscope:



The following focuses on the two aspects of the project, the collaborative tools and the team dynamics:

### Collaboration Tools

The MEMS across the Globe project identified that the collaboration software tools used for the project must have the following important attributes.

- Data interoperability
- Low bandwidth communication capability,

- Management of multiple data formats
- Scalable utilization of resources
- Security and user Authorization

Design teams grapple with multiple sets of data typically residing in Computer Aided Design (CAD) and Analysis (CAE) Systems. The CAD/CAE space has limited number of standards and multitude of data formats native and proprietary to CAD systems. Therefore, tools with a high degree of interoperability that allow open exchange of data between the systems have most utility.

As teams are geographically dispersed, Internet is used as the economical and available communication medium. The bandwidth of communication plays a significant role in the ease of transferring data between the members of the team and keeping the members of the team connected. While the available bandwidth in US to the last mile has increased considerably, team members in other nations still grapple with low bandwidth ramps to the Internet. Therefore, communications using under 1 MB (it takes 4 min on a typical dial up; 30 sec on a typical cable or corporate Ethernet connection to download 1 MB) data transfers at a time are desired. While a typical mechanical part file is under 1 MB, an assembly of parts can easily reach 100 – 250 MB. Therefore access to smaller segments of data and documents to lower the bandwidth required for transfer on the Internet is a significant issue.

As previously mentioned, enforcing tool homogeneity within a virtual team is inherently difficulty. As a virtual team forms, the experience of the team members with tools and techniques is an asset. Enforcement a single tool set across the team requires retraining of the team members and learning curves on sophisticated CAD or CAE tools are steep and long. Therefore, the integration of data produced in a variety of CAD/CAE tools is an important attribute. The ability to read, write and modify a variety of data formats including the standard STEP and IGES formats used in the CAD business space is must-have attribute.

Most projects start out with limited data and personnel involved. However, the resources required as well as the information generated and consumed reaches a peak during the detailed development phase. The ability of the tools to scale up and handle the

information throughput during the development process is important. Changing the tool set in the middle of the development will be an expensive and delaying proposition.

Last but not the least required attribute is access control. Design data tend to be proprietary and control of access at various levels is critical to security of data as well as definition of clear team roles. The authorization and access control therefore is a sought-after feature in collaborative environments.

To this end, the MEMS across the globe project chose the Windchill™ Project Link software for collaboration, Pro/Engineer Wild Fire™ for physical design and ANSYS™ and ALGOR™ for the CAE analysis. Both ANSYS and ALGOR work seamlessly with both the collaboration and design software.

#### *Team Management and Dynamics*

The MEMS around the Globe project is structured at three universities (and student teams) spanning the globe. At the outset we recognized that there are several constraints that the management model must meet in order to serve the student constituencies. All the students are performing the design work under the umbrella of courses taken for credit. While each university team has a separate but well defined course requirements and criteria to meet to satisfy the grading and evaluation criteria. Therefore clearly demarcated projects with separate definition and scopes of the projects are necessary.

To accomplish this, we chose local faculty-level team advisors who are responsible for the weekly work assignment and management of the team. Each team is structured similarly with a faculty advisor, a graduate student assistant and a team of 3- 4 undergraduate students. While the roles of advisor and the graduate student assistant are defined to be similar to non-collaborative projects with respect to the management of the course related requirements, they are also charged with facilitating the collaboration and communication among the teams. The graduate student assistants in all the three teams are especially charged with learning the collaborative tool (PTC's Windchill) and locally facilitate its use among the design team members.

The interaction between the faculty advisors is a key to success and continuity of the project. The three advisors serve as the technical as well as the communication backbone for the project. The team currently uses a monthly collaboration meeting over



the Internet in which everyone is encouraged to participate. The progress of the team as well as the agenda of the next 30 days is discussed.

The major difference between the student senior design teams and that of a corporate project is the complex dynamics of the distributed start dates, course requirements and performing work for a course grade. While the team at India starts their academic year in July and finishes by May; team in the US starts in September and finishes in June and that in Philippines began in November. These scattered calendars and examination dates leave very short time for all the teams to work together towards the project goals. Hence, the necessity and adopted model of distributed and demarcated project descriptions. The training of student teams, maintaining the continuity, interfacing with members of team and integration of the project work may be the charge of project advisors and graduate student assistants.

### **Final Note**

The MEMS around the Globe project has now been running for several months and is operating within expected parameters. The Stevens' Technology Management faculty who are co-authors of this paper will be evaluating the project in terms of the virtual team issues that have been discussed in this paper and in the more comprehensive treatment of Reference 3. A second international virtual team design project is in the planning stage for a Summer '04 start and will involve architecture students at Beykent University in Istanbul, Turkey together with civil engineering and engineering management students at Stevens. This project will be to design an aircraft display pavilion for a museum.

### **Biographical Sketches**

KEITH SHEPPARD is a Professor of Materials Engineering and Associate Dean of Engineering at Stevens Institute of Technology. He earned the B.Sc. from the University of Leeds, England and Ph.D. from the University of Birmingham, England, both in Metallurgy. As Associate Dean, Sheppard is primarily responsible for undergraduate programs. He is currently Chair of the ASEE Design in Engineering Education Division.

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SOURAN MANOOCHEHRI is a Professor of Mechanical Engineering and Director of the Design and Manufacturing Institute at Stevens Institute of Technology, which also incorporates the Virtual Engineering Center. He earned the B.S. in Mechanical Engineering from Illinois Inst. of Technology and Ph.D. from University of Wisconsin-Madison.

KISHORE POCHIRAJU is an Associate Professor of Mechanical Engineering at Stevens Institute of Technology and advisor to the MEMS across the Globe project. He earned his B.E. in Mechanical Engineering from National Institute of Technology, India and Ph.D. from Drexel University.

ELIZABETH MCGRATH is Deputy Director of the Center for Improved Engineering and Science Education (CIESE) at Stevens Institute of Technology. In this role, she works with partners in areas of organizational development, strategic planning, and project implementation for technology integration to improve teaching strategies and student learning. This has primarily been directed to STEM achievement in K-16, but has expanded to include initiatives in undergraduate engineering. She earned the B.S. from the School of Mass Communications at Virginia Commonwealth University and is currently pursuing the M.Ed. at the University of Maryland University College.

PETER DOMINICK is a Senior Lecturer at the W.J. Howe School of Technology Management at Stevens Institute of Technology where he teaches courses in organizational behavior and human resources management. He received his Ph.D. in Applied Psychology from Stevens, earned his MA in Organizational Psychology from Teacher's College, Columbia University and completed his undergraduate studies in Industrial and Labor Relations at Cornell University. Prior to joining Stevens he was a Research Scientist with the Fu Foundation School of Engineering at Columbia University. Earlier work experiences include corporate HR functions and work with organized labor. As a consultant, he has worked with a variety of corporate organizations and educational institutions on issues pertaining to selection, outcomes assessment and organization development. He co-authored Tools and Tactics of Design, John Wiley & Sons (2000).

ZVI ARONSEN is a Senior Lecturer at the W.J. Howe School of Technology Management at Stevens and teaches organizational behavior and the human side of project leadership. Zvi is currently researching the impact of project culture, attitudes and citizenship behavior on project performance. He is also investigating the influence of leader personality on team performance. Earlier work experiences at Bakara Ltd, Tel-Aviv, included training and selection. Aronson received his Ph.D. in Industrial Psychology from Stevens Institute of Technology, and completed his B.A. in Behavioral Sciences at Ben-Gurion University, Israel.

