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Preparing Engineering Students for the New Business Paradigm of International Teamwork and Global Orientation*

KEITH SHEPPARD
Charles V. Schaefer, Jr. School of Engineering, Stevens Institute of Technology, Hoboken, New Jersey, 07030, USA

PETER DOMINICK and ZVI ARONSON
Wesley J. Howe School of Technology Management, Stevens Institute of Technology, Hoboken, New Jersey, 07030, USA. E-mail: ksheppar@stevens-tech.edu

Business is increasingly conducted in a global environment, not only in terms of markets but also design, production and service. It is therefore essential that engineering graduates have an orientation towards this globalization and are prepared to operate effectively within it. One manifestation of this new environment is the increasing need for engineers and others to collaborate internationally on projects, whether they are within the same international organization or in another relationship, such as with sub-contractors or between end customers and suppliers. Also in this context we are increasingly seeing the expression '24-hour engineering' used as business takes advantage of time zones around the world to effect efficient hand-off of a project between international teams. Significant challenges must be overcome as engineers learn to work in the international environment. These challenges include those associated with different cultures and languages as well as the problems associated with what has been termed 'virtual teams', which comprise physically separated individuals or groups that are connected through various communications links and information technology tools. This paper explores how industrial psychology and other literature from the business world can provide insights into the challenges and possible solutions that should be addressed in providing engineering students with an appropriate experience to prepare them for the new international teamwork paradigm. How this information can be used in implementing an effective program for international student project collaboration is also discussed.

INTRODUCTION

IN TODAY'S WORKPLACE the nature of how people 'work together' is evolving. The terms 'teamwork' and 'collaboration' no longer imply that individuals are necessarily sharing the same space or even time as they coordinate their efforts in the pursuit of common goals. Instead, coworkers who are geographically dispersed may never even see each other yet they are organizationally linked through telecommunications and information technologies as they attempt to achieve interdependent organizational tasks [1].

A number of factors have driven this reconceptualization of teamwork. They include advances in technology, mounting time pressure, and the demands of increasingly global and dynamic markets. In the 1960s only 7% of the US economy was exposed to international competition, but in the 1980s that number had increased to over 70% [2]. Today, this number is, no doubt, still growing. Further fueled by ever more frequent mergers and acquisitions as well as international trade agreements (e.g. the North American Free Trade Agreement, the European Union), knowledge workers around the world are relying upon advances in information technology to join together in a virtual or boundary-less space wherein they share skills, efforts and information.

Consequently, the international virtual team has emerged as an important way to structure work, especially for such knowledge-driven professions as engineering. For instance, the use of virtual teams is a cornerstone of The National Air and Space Administration's (NASA) Intelligent Synthesis Environment (ISE), a strategic initiative focused on enhancing their program development and engineering design efforts. As they describe it:

> *To meet NASA's unique needs the future product and mission development environment must accommodate different groups of people, such as engineers, designers, scientists and technology developers. These groups must be able to work together collaboratively, and must also be able to integrate both customers' and suppliers' requirements into the process. These diverse teams will collaborate in utilizing new computational resources in innovative and meaningful ways. Teams will not be in one location, so the design environment must support collaboration of geographically distributed teams. (NASA [3])*

Many other organizations are also conducting

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research and development projects by electronically linking experts from across the globe. Similarly, at Microsoft virtual teams support corporate sales and services to clients of global corporations [4]. Countless other organizations are also utilizing virtual structures to conduct meetings whose purposes range from information sharing to idea generation to implementation planning [5].

In short, 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. Jones *et al.* [6a, 6b] have been strong advocates for the use of distance-learning techniques as a means of providing 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 this paper we draw upon literature from organizational psychology and behavior to elaborate on the challenges and possible solutions related to providing engineering students with learning experiences that can help prepare them for the global virtual workspace. In particular, we have attempted to identify key factors and issues to consider when structuring engineering design projects that involve collaborating across time, space and national boundaries.

A SYSTEMS FRAMEWORK

We are using an open-systems framework to organize our discussion. 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. For instance, if we want to understand the nature of interaction amongst members of an accounting department, it would also help to know something about the organization of which the department is a part. Similarly, we would obtain

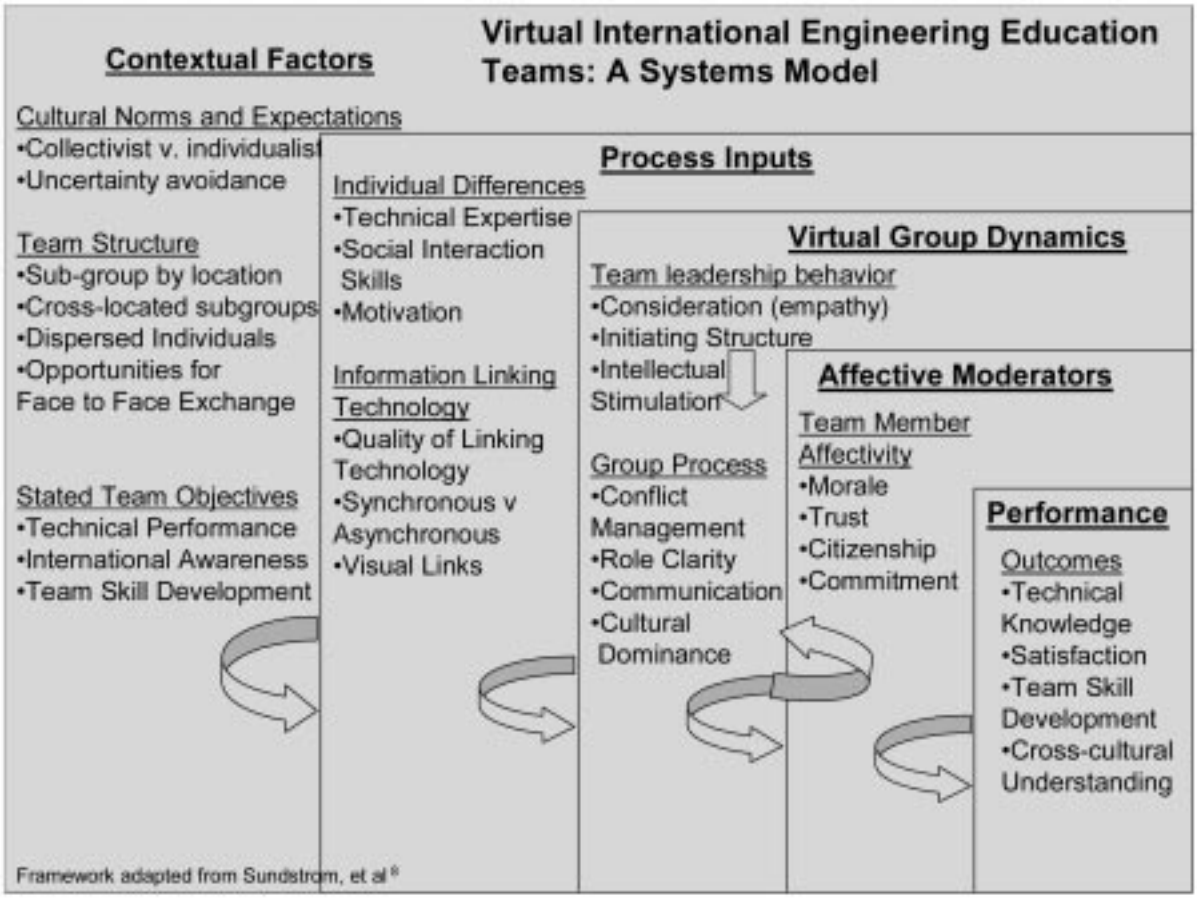

Fig. 1. A systems model of key factors influencing the dynamics and performance of international engineering education teams.

a better understanding of the organization if we knew something about its environmental conditions, such as market characteristics, customer demands, government regulations and so on [7].

In terms of understanding virtual collaborations amongst international students, an open-systems approach enables us to identify several levels of interdependent issues that could impact global team dynamics, performance and student learning.

Contextual factors refer to general aspects of the environment in which the team will function. They include the cultural norms and expectations of team members (students) and faculty, the structure of the project team and the explicit and implicit objectives toward which the team should be working. Process Inputs include the characteristics of the individuals on the team, such as their various levels of technical expertise, motivation and social skills. Also included at this level of analysis is the nature of the technology and other resources used to connect people across time and space so that they can share information and ideas. A third level, virtual group dynamics, refers to specific behaviors and the nature of interaction that occurs amongst team members. Leadership behaviors on the part of both students and faculty are of particular importance at this level of analysis. Affective moderators represent a fourth level of analysis in our model. They include the resulting attitudes and mood states of individuals collaborating together in a virtual setting. Performance outcomes make up the fifth and final level of analysis. In this case we are referring to the results obtained by global virtual student teams. Examples include the amount and nature of technical learning that occurred, team skills development and even the nature of cross-cultural awareness that was imparted to individual students.

CONTEXTUAL FACTORS

Cultural values

Cultural values help to shape the kinds of behaviors that are considered to be normative and 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 amongst students from different countries and backgrounds.

One major dimension of cultural variability is the distinction between collectivist and individual values. In individualistic cultures (e.g. the United States), the individual's goals and needs take precedence over those of the group. In collectivist cultures (e.g. Japan), it is the needs and goals of the group that take precedence [9]. Research regarding face-to-face interaction suggests that, among other things, people from individualist cultures are less likely to be influenced by group membership, are more adept at entering and leaving new groups and tend to communicate more openly and precisely than those who are from collectivist cultures [9, 10]. They also tend to be more comfortable responding to ambiguous messages and social cues.

These findings suggest there may also be some important differences in what occurs in a virtual team setting. While research is limited, one study found that those with individualist values were more receptive to distance learning [11], which typically requires more independent work. It is also conceivable that, given the greater level of openness that is found to occur in face-to-face interactions, people from individualist cultures would also be more trusting and open in virtual communications. However, a study investigating this particular question found no difference with regard to perceived trust in global virtual teams [12].

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 structures. Cultural differences along these lines may have implications for how people perceive the need for task and role structures. For instance those from high uncertainty avoidance cultures may be more inclined to seek early closure on the clarification of roles, accountabilities and task structure.

It is important to note that culture moderates but does not override individual personality. Moreover, prior experience in interacting with different cultures can change the effect of the original cultural influence [13]. Nevertheless, at the very least, instructors should have some awareness of the kinds of cultural differences that might exist amongst students who are involved in virtual collaborations. They should also consider guiding students in a discussion of such differences as a means of heightening awareness and understanding. Such discussions are sometimes used during the early stages of international team development in organizational settings [13].

Stated team objectives

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 [14]. When people are aware of the outcomes and standards toward which they should be working, they will be more likely to behave in ways that support goal

attainment. Moreover, to the extent that team members share a common understanding of overall team objectives, it can help in transcending cultural differences [13].

It would seem that making team effectiveness skills and international awareness explicit learning objectives increases the likelihood that students will attend to them. Some related practices that might also help to foster collaboration and team development include building cross-cultural understanding into project deliverables, requiring teams to establish common ground rules for how they will work together and having teams periodically review team process effectiveness relative to their ground rules. As a means of measuring progress toward their goals, it will also help to use peer feedback tools. These tools can provide people with confidential feedback on their cultural awareness and or interpersonal effectiveness. When administered confidentially, peer feedback is an effective tool for helping people improve their behavioral skills [15].

Project group structure

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 amongst them. There are at least four distinct organizational models that may be relevant for structuring international student team projects. 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 [16]. In such situations, the work practices and decision-making style of the dominant group overrides the approach of others and can leave individuals in the subordinate group(s) feeling ostracized and alienated. This kind of distorted dynamic has the potential to undermine learning satisfaction and the quality of the collaboration.

Instructors and student team members should be mindful that such a dynamic can occur and may want to implement practices to prevent it. Examples could include rotating leadership for project deliverables across locations. Establishing team ground rules can also help. Such ground rules are often used in face-to-face teams and are arguably even more important in virtual settings [17]. They should address topics like: what constitutes balanced and regular participation, time requirements for responding to one another, what constitutes constructive feedback, general conflict management, and decision-making procedures.

Another helpful approach may be to use a different kind of structural arrangement. Rather than establishing sub-groups by location, a second approach would be to use cross-located sub-groups. In this case, members from different international locations would form project sub-teams (as opposed to having sub-teams being located by geography). Promoting sub-group identity based upon project task rather than national origin might help to shift the focus away from cultural distinctions and patterns. On the other hand, there may be additional logistical challenges posed by this approach. Furthermore, instructors and team members would still need to be mindful of culturally dominant norms that might develop within sub-groups.

A third structural arrangement might be to have dispersed individuals—none of whom are co-located. While this arrangement is more typically associated with a traditional distance-learning course (as opposed to an international project), its implications for behavior and performance should be considered. Some have noted that one challenge faced by many virtual team members is avoiding the sense of isolation and loss of camaraderie that comes with living and working apart. If not carefully managed, this isolation can undermine creativity, can make it more difficult to establish trust, and can lead to misunderstandings about work styles and other issues [17]. Along the same lines, Jarvenpaa and Leidner [12] reported that trust perceptions of team members were sometimes harder to establish under these more dispersed conditions.

A greater extent of geographic dispersion heightens the importance of having the team establish clear task procedures and ground rules early on. In addition to articulating behavioral expectations, doing so can help to establish a sense of team identity and commitment, thereby minimizing the potential effects of isolation and low trust.

A fourth structural arrangement is to combine virtual communication with some level of face-to-face communication 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. For instance, a student collaborative experience may start with live interaction but continue through the use of electronic interaction. This kind of experience brings with it a high level of fidelity in terms of what graduates might experience in the workplace. In addition, many practitioners acknowledge that face-to-face interaction can help to enhance the development and effectiveness of a team that has to function virtually for extended periods of time [16, 18].

PROCESS INPUTS

The two process inputs we describe 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. This system consists of two separate but related parts: a social part that 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 [7]. 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).

Individual differences

Most instructors will likely agree that individual differences play an important part in student learning and interaction. The proliferation of distance learning has led to a growing volume of literature on how individual differences moderate computer-based student learning. Our goal in this paper is to provide an exemplary rather than exhaustive discussion of this topic. The kinds of individual differences likely to be of particular relevance to our present discussion include technical expertise, subject matter expertise, personality characteristics, prior experiences and general attitudes.

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. Therefore, a key issue for instructors of international collaborations to consider is the extent to which student team members in all locations share a common skills level. Some effort on the part of instructors to both assess and or develop student skills should probably be undertaken early on in the collaboration.

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. Differences that do exist across locations may actually present opportunities to involve students in educating one another. Such exchanges can be powerful parts of the overall learning process and, if managed constructively, can help to build constructive collaborative norms amongst student team members.

There is evidence that other personality, behavioral style, and attitudinal differences also shape how students 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 [19]. While these findings have not necessarily been based upon studies of international student teams, we suspect that they are relevant factors to consider nevertheless.

Gender differences may also be relevant. Blum [20] reported that male and female messages exchanged in computer-mediated environments mirror traditional face-to-face communication. Males tended to control online discussions, post more questions,
express more certainty in their opinions and were more concrete. Females tended to be more empathetic, polite and agreeable. They also used more niceties such as 'please' and 'thank you' that tend to maintain and build relationships.

There are some aspects of underlying personality that may also be relevant. For instance, the trait of openness to new experience correlates with interest in other cultures and learning new technologies. Similarly, the trait of agreeableness has been found to correlate with one's perceived effectiveness working in a team environment. Others have speculated that introverted individuals who prefer to process information internally and express themselves in writing may be more adept in the virtual world [21].

Finally, there may also be important differences among students in terms of their levels of experience working with and/or living with people of different cultural backgrounds. Such prior experiences are also likely to impact how students interact with one another. In our view, personality, style, and attitudinal and gender differences, such as those described above, should almost never be used to screen people out of the opportunity to participate, or for that matter to even assign students to teams. Instead, efforts should be made to promote self-awareness and an understanding of how to deal constructively with others who view situations from a different perspective. Instructors should consider having team members complete one of the many interpersonal style instruments available (e.g. Team Fitness Test [22], the online Keirsey Temperament Sorter [23], the Modified Belbin Group Role Questionnaire [24], the Group Style Inventory [25], and the ubiquitous Myers-Briggs Personal Profile System) followed by a general discussion of their results and implications for team performance. Other helpful techniques include having students share brief biographies and descriptions of their interests, learning objectives and prior experiences with one another. Establishing team ground rules that celebrate individual differences can also help (e.g. encouraging students to consider several alternatives before making decisions). Instructors may also want to consider having students keep personal journals in which they describe some of

the experiences and challenges they encountered when working with their international team members [26]. Maintaining a journal can be a helpful way to promote self-awareness on the part of students.

Information linking technology

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 [12] 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 [27]. 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 [26].

In the asynchronous environment, characterized by nonlinear, multi-threaded asynchronous communication, team members may also experience information overload and/or struggle to put a particular message into the appropriate context. Such communication challenges are likely to be even more pronounced in global virtual teams, because of the natural tendency for people to filter information through their own cultural biases [28].

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.

Given the increasing importance of virtual teams, it should be no surprise to know that research focusing on the interpersonal dynamics and challenges of virtual teamwork is growing. It is, however, still in its nascent stages. As others have noted, 'although it is clear that virtual teams will play an important role in shaping future organizations, we know relatively little about them' [27].

Existing empirical research does provide some valuable guidance, particularly in relation to the importance of leadership behavior. For instance, studies of group decision-making facilitated through computer-mediated communication systems (CMCS) suggest that team leadership in these settings is highly important [29, 30].

As is the case for leadership in general, it appears that leaders of global virtual teams need to attend to the management of both task and relationship aspects of team function. In terms of relationship behaviors, Kayworth and Levine [28] reported that effective global team leaders conveyed messages that indicated a willingness to mentor others and exhibited a high degree of understanding (empathy). In terms of task management, some important behaviors and characteristics include being able to assert authority without being perceived as overbearing or inflexible, being extremely effective at providing regular, detailed and prompt communication with peers and the ability to clarify role relationships [12, 28]. Intellectual Stimulation (e.g. asking provocative questions and encouraging people to challenge assumptions) is also important in a computer-mediated environment [30]. A leader's role in conveying the overall vision for the team is also particularly important in a virtual setting. Given the lack of face-to-face interaction, a clear shared vision of team goals and deliverables can be key to establishing and sustaining shared identity amongst members [17].

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 the 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 potentially be exacerbated in a virtual context [31]. More

recently, Montoya-Weiss [32] reported that asynchronous virtual communication among team members moderated the way people experienced and resolved conflicts. Some negative, 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 [16].

Students' experiences in global virtual team projects present valuable opportunities for them to learn how to lead and work collaboratively with others. Therefore, it is important for them to take on some of the process challenges described above. In doing so, they should be encouraged to remain aware of their own behavioral style and interactions. Similarly, they should maintain an awareness of the extent to which basic cultural preferences impact the way the team works. Establishing general ground rules and norms that encourage participation will also help. Instructors should also consider providing teams with computer-based tools that enable students to give each other constructive behavioral feedback (e.g. The Team Developer [13]).

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 of working together. Several particular attitudes may be especially relevant. *Citizenship* refers to the extent to which team members engage in behaviors that go above and beyond their formal requirements, yet promote effective team functioning [34]. Citizenship creates and maintains the psychological, social and virtual team environment in which the project tasks take place. *Commitment* is an indication of the extent to which people identify with their teams and desire to remain in them [35]. *Satisfaction* is the extent to which team members 'feel' gratified and fulfilled by their work [36]. Prior research (e.g. Podsakoff et. al. [37]) points out that when employees are satisfied with their jobs they are more likely to engage in extra-effort behaviors.

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. Another attitude, *trust perception*, has, however, received some attention in terms of virtual team performance. As noted earlier in this paper, it appears that trust perceptions are strongly related to the nature of communication in a virtual setting (especially task-oriented communication). Trust among team members is likely to be higher when communication is timely and consistent throughout the life of the project [12].

Instructors guiding international team projects should also be cognizant of the fact that differences in cultural values may shape affect as well. For example, Hui, Yee, and Eastman [38] found a positive relationship between collectivist cultural values and job satisfaction. With regard to the link between team culture and commitment, commitment to the virtual team may stem from a team member's assessment of the congruence between what he or she prefers or values (e.g. team orientation, collectivism) and the predominant principles or behaviors espoused in the team.

PERFORMANCE

A final discussion of performance outcomes in many respects returns us to some of the points presented in the introductory parts of this paper. Certainly, in the context of engineering education, 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 develop 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 also want to consider using survey-based data (peer and self-reports), along with student journals, as ways to measure the learning that has occurred. We do not generally advocate grading students, for instance, on the extent to which they are good communicators or able to display empathy. It is, however, conceivable in our view to hold students accountable for making the efforts to track their behavior over time and or participate in development efforts and experiences.

SUMMARY AND CONCLUSIONS

While imparting discipline-specific knowledge will always be fundamental to engineering education, there are additional leadership and interpersonal skills that will profoundly contribute to one's success. In this paper we have argued that global virtual teams are likely to be a fixture in the life of professional engineers. Moreover, advances in communication technology are also making it more feasible to offer students international learning experiences and/or to extend the life of international collaborations that start in a face-to-face setting. Therefore, incorporating such experiences into engineering education can help prepare students for their future. An additional benefit

could be that experience on a virtual international team might well prompt students to actually pursue a study or working abroad experience. Any trend in this direction is highly desirable, given the miserable statistics associated with US students engaging in foreign study or work.

Cultural awareness and behavioral skill development play an important role in effective global virtual team experiences and learning. An understanding of these factors and the relationships between them is important for both educators and students. Using an open systems framework, this paper has offered a review of these factors and how they might relate to one another. Addressing them poses new and interesting challenges for educators and students alike. To that end, we have also tried to offer some general suggestions that can help make these dynamic processes a constructive part of the learning experience. While the literature offers an important starting-point, we hope this paper will encourage educators to build upon these ideas by putting them into practice.

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Keith Sheppard is a Professor of Materials Engineering and Associate Dean of Engineering at Stevens Institute of Technology. He received his B.Sc. from the University of Leeds, England, and his Ph.D. from the University of Birmingham, England, both in metallurgy. As Associate Dean, he is primarily responsible for undergraduate programs. He is currently chair of the ASEE Design in Engineering Education Division.

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, his M.A. 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*, published by John Wiley & Sons (2000).

Zvi Aronsen is a Senior Lecturer at the W. J. Howe School of Technology Management at Stevens Institute of Technology 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.