

Communication in Virtual Teams: Ten Years of Experience in Education

—ANNE-FRANÇOISE RUTKOWSKI, DOUG VOGEL, MEMBER, IEEE, MICHIEL VAN GENUCHTEN, MEMBER, IEEE, AND CAROL SAUNDERS

Abstract—Engineering teams are often globally distributed and comprise participants from multiple disciplines and cultures who rely on professional communication support. Companies, organizations, and institutions increasingly embrace these virtual teams and use a variety of information and communication technologies to support synchronous and asynchronous team interaction (e.g., chat, videoconferencing, email, group support systems, instant messaging, and forums). More and more, communication takes place without being face-to-face. Students should be prepared for such a workplace. However, it is difficult to emulate the specifics of real-world projects in a 100-hour university course. One way to bring the real world into the classroom is by combining the efforts of 100 students into a 10,000-hour project. This paper describes the Hong Kong-Netherlands project (HKNet) as an example of an integrated learning activity among multiple international institutions that brings the reality of engineering management with professional communication into educational contexts. Virtual teams comprising students from different parts of the world build websites on specific software topics that are then integrated into a single product. HKNet has entered its tenth year, and over 1000 students have participated.

Index Terms—Communication, curricula, engineering education, experience, learning, planning, virtual teams.

The phenomenon of globalization stimulates the development in business of virtual teams that are dependent upon professional communication support. Virtual teams support the extension of activities around the world as well as outsourcing [1]. The need to innovate in education by offering students another perspective on the new sociocultural and technological requirements of a globalized world led to the development of a new kind of education—virtual classrooms. These classroom projects were the seeds of a new form of efficient distributed education facilitated by the emergence of new information and communication technologies (ICTs) [2], [3]. At a time when organizations understood the importance of experimenting with geographically distributed work teams to maximize the use of scarce resources [4], [5], educational projects spanning multiple institutions, particularly spanning time zones on several continents, were rare [6]. The technical constraints, such as unstable or expensive technologies, as well as the social requirement of a

time alignment and synchronization of agenda, were basic but were also real limitations to experiencing virtual teams in education. Fortunately, adapting the ancient and universal rules of education was recognized as an opportunity to maximize the learning experience for students in a global world [7].

Classically, when students are engaged in a course, either individually or in groups within their own cohort, they learn valuable theories, constructs, and methods. While the core of their knowledge of engineering concepts, for example, is merely individually constructed by reading books and selected articles, an efficient way to truly understand key concepts is by the ultimate test of being confronted with real development activities in teams. Group projects are commonplace in many development courses. The traditional educational rules—keeping the course content within the scope of a single course and the intellectual boundaries of the local student population—bring constraints that somewhat oversimplify such learning experiences.

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A.-F. Rutkowski is with the Department of Information Systems and Management, Tilburg University, 5000 LE Tilburg, The Netherlands (email: A.Rutkowski@uvt.nl).

D. Vogel is with the Department of IS - P7720, City University of Hong Kong, Kowloon, Hong Kong (email: isdoug@cityu.edu.hk).

M. van Genuchten is with the Department of Technology Management, Eindhoven University of Technology, 5600 MB Eindhoven, The Netherlands (email: genuchten@ieee.org).

C. Saunders is with the Department of Management Information Systems, University of Central Florida, Orlando, FL 32816-1400 USA (email: csaunders@bus.ucf.edu).

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These constraints can lead either to overconfidence or to boredom on the part of students who do not appreciate many real-world complexities. Little, if any, attention is given to integrating projects within a program and building on the efforts of others (e.g., in prior courses or from multiple disciplines). However, this is precisely what students typically encounter when they enter the job market. It is true that the end result of the lack of “learning by doing in real-life context” could later be integrated into the curriculum in the form of a traineeship;

however, we feel that earlier learning reduces frustration not only on the part of the faculty and students, but also on the part of the employers, who feel that much of the on-the-job learning that inevitably needs to occur could have been addressed in the educational process.

Many changes congruent with the development of new modes of communication have taken place in engineering projects over the past decades. A few typical characteristics of today's projects include the following:

- Engineering projects are more often globally distributed, with significant development activities taking place in the Far East (India and China), while major customer activities are in the West. Bridging this difference has been recognized as crucial to understanding the functioning of successful organizations [8].
- Engineering projects rely upon professional communication and use a portfolio of ICTs throughout the design process [9].
- The amount of software in many products increases rapidly and, as a result, software plays an increasing role in many engineering projects.
- Communication is occurring less often in a face-to-face mode and becoming more and more supported by ICTs. A range of communication technologies has become available to bridge distances and time zones, such as voice-over-internet protocol, email, and chat.

How ICTs such as audio and videoconferencing and email are used to communicate across time zones, disciplines, and national cultures is relevant for the education of today's students living in a more virtual world. However, as previously stated, offering such a rich learning experience to students requires bending traditional rules of education and overcoming constraints. Clearly, it is unlikely in a 100-hour course to prepare students for all the specifics of real-world projects. A 100-hour course typically equals a 3- or 4-hour course in US education, which has 45 or 60 hours of classroom time plus assignments. Even with the development of internationalization programs, the opportunity to meet and collaborate with students from different cultures is limited. Thus, achieving the primary goal of in-class education (e.g., building a solid core of knowledge) and defining professional specificities in the curriculum in conjunction with giving students the opportunity to collaborate across professional cultures are even more difficult.

How can real-life engineering management be taught to students? The ancient Chinese

philosopher Lao Tzu noted: "If you tell me, I will listen; if you show me, I will see; but if you let me experience, I will learn." There are many ways to provide students with real-life experience in engineering education settings [10], [11]. One way is to scale down a real project to a size that can be handled in the context of a 100-hour workload. The second is to combine the 100-hour workload of 100 or more students to create a 10,000-hour project in which students have greater likelihood of experiencing real-life problems. There is no silver bullet in bringing realism into education. Both approaches have their merit, and either approach could be applied in a curriculum. We have chosen to combine the workload of 100 students who have spent over 10,000 accumulated hours on an international project. The product the students deliver is a website. This enables students to experience what it means to work in a virtual team, plan a project, deliver a product, and deal with late deliveries—all this with the support of new ICTs.

Virtual teams supported by ICTs have been used for a decade to help increase students' awareness of working in a global context [6], [12], [13]. Several reviews now report a large number of such studies [14], [15]. Most reported studies are like ours in that they explore communication and collaboration in virtual teams. Often the teams collaborate to prepare a report on a well-defined topic. While the students' understanding of culture is expanded, they typically do not deal with complex projects. To date, much of the empirical research on virtual teams is based on student teams who meet an average of just 4 to 5 weeks [14] and work only on short-term tasks [15]. This project simulates larger projects that span multiple years.

In the following, we describe the Hong Kong-Netherlands project (HKNet) as an example of an integrated-learning activity between multiple international institutions that brings the reality of engineering management with professional communication solidly into educational contexts. The paper presents an educational training approach developed by us to prepare the students for new challenges in the real world. The course subjects at the participating universities range from software management to information systems development. The context chosen in the project is therefore a software project. Real-life planning, problem solving, and selection of a portfolio of technologies to reach maximum performance were the challenges and learning opportunities brought into the classroom. Delivering a rich and high-quality course in which the individual

performance of students can be evaluated has equally been a challenge to us, a source of frustration, and a tremendous learning experience. Over the last ten years, the acquisition of individual knowledge in a distributed environment and the development of mutual knowledge as in a real-life engineering team have been demonstrated to be successful learning experiences for the students as well as for the staff members involved.

The objectives of this educational training approach are multiple:

- (1) to provide the students the opportunity to work on a project with the level of complexity that they are likely to find in jobs after they graduate;
- (2) to expose the students to different cultures and provide guidance in resolving any conflicts arising from cultural diversity;
- (3) to allow the students to experience working remotely on global virtual teams;
- (4) to allow them to select and use a range of communication media to complete the tasks of their global virtual team project.

EXPERIENCING VIRTUAL COMMUNICATION IN THE CLASSROOM

In the initial years, the course addressed both the individual learning of core constructs and theory and the development of mutual knowledge through the continuous interaction among students who span different professional and national cultures. Through the years, the focus has been placed more on the engineering management of the project with the final goal of delivering a high-quality product in the form of an electronic book. Over the period of ten years, more than a thousand students have participated in the project, and we have previously reported outcomes in this journal [6], [7]. The following section focuses on communication in education, mainly drawing from experiences in the project since 2004.

Participants and Educational Context Each year about half of the students in this project have been part-time students from business, half full-time university students from engineering. The project started with the Technical University of Eindhoven and the City University of Hong Kong. The number of universities over the years expanded to include Tilburg University (The Netherlands), Beijing University of Technology (China), and the University of Central Florida (Orlando, FL). The number of students involved has ranged from 65 to

180, depending on the number of students enrolled at the various sites.

Typically, each HKNet team consists of 8 to 10 students in 2 to 4 locations. The team is assigned a software-related topic (e.g., "the impact of software defects," "TV on mobile phones," or "open source and software patents") viewed from different geographical perspectives in a structured process consisting of a number of divergent and convergent activities over an eight-week time frame. The different groups need to produce a website that discusses their topic from the European, Asian, and American perspectives. The websites of all the groups are then integrated into an electronic book. The end result is that the students learn not only about the process of website development, but also become experts in a content area that they self-select.

The process is illustrated in Fig. 1. The project is positioned as a multiyear effort where the results of previous years are used as repository knowledge, input for the current year. The teams can choose a topic from a list of current issues, allowing them to improve their individual knowledge on a more specified topic. Also, students have to define a number of research questions to focus their study. After three specific research questions have been selected, a plan is made and materials are collected. A website discussing their topic needs to be delivered in week six, after which each team's chapter is integrated into an e-book in week seven. The students evaluate each other's chapters in the e-book, as well as the process in their virtual team. They also evaluate the contributions of each team member. An individual written evaluation concludes the project.

As a demonstration of the project outcomes, in 2007 the results were presented as one of the websites that formed an electronic book of the software industry (see <http://www.bohknet.com>). BOHKNet stands for Beijing, Orlando, Hong Kong, and the Netherlands. The site also contains more information about the project, including videos of some of the lectures.

The technologies used in the course include videoconferencing, email, and an off-the-shelf learning-management system (Blackboard) that supports both chat and a forum. Videoconferencing is used several times: (1) at the start of the project, (2) halfway through the eight weeks to track progress and allow the students to resolve disputes, and (3) towards the end to celebrate the result.

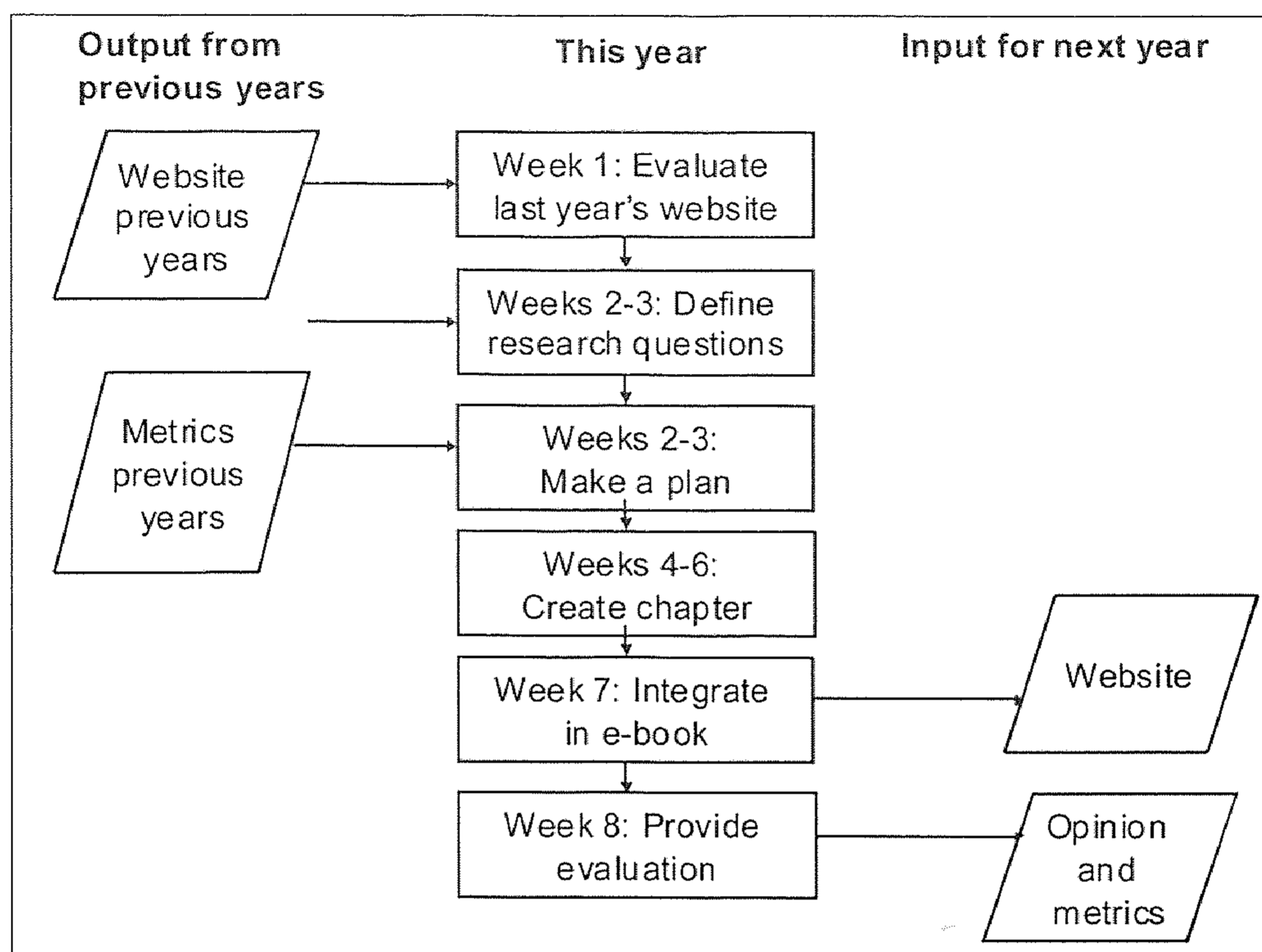


Fig. 1. The learning process.

Methods Related to Communication Working from remote locations as members of virtual teams is a fact of life in business today. Virtual teams by nature combine the classical challenges of face-to-face groups with the less traditional ones brought on by the use of an ICT in a complex task environment. Research has shown that in complex tasks, such as software design and inspection, virtual teams can outperform face-to-face teams in terms of quality and creativity [16], [17]. Research has also demonstrated that ICTs can efficiently support distributed teamwork when the critical aspects of social process are taken into account [18]. The body of literature about virtual teams is large, and volumes have been written. National culture, trust, temporal coordination, process of leadership, network structure, social loafing, and group history are some of the explicative factors of success in distributed teams. Nevertheless, experiencing working in a virtual team needs to be added to the bibliographic knowledge. Students have to face the realities of building mutual knowledge [19] and coordinating their vision of time and activities [20].

The learning goals for communication have been centered on some of the major changes in engineering management, as discussed earlier. The following discussion focuses on communication for

planning, communication across cultures, and the use of ICTs.

Communication for Planning: Many curricula contain lectures about project management. Project planning is typically a part of engineering courses. HKNet requires students to make a plan for their team project. They are asked to provide the following:

- an estimate of the size of the website (in terms of number of screens);
- a work-breakdown structure (who does what) and an effort estimate;
- the top five risks, including likelihood and impact.

An introductory lecture illustrating how to plan is delivered by one of the instructors. Metrics of previous HKNet projects are provided, such as the number of screens in the websites of their predecessors and the effort per screen. The lecture is recorded and is available online for the students at the various locations to ensure that the different members of the team have the same background information.

The students provide a plan for their team activity that is very different from planning exercises that they have done in the past: If their HKNet plan is ill defined or underestimated, the students have

a problem since the deadline is fixed. It is thus very motivating to get it right the first time. The difference is also significant between making a plan for a fictitious project and a project on which they will personally spend a lot of time over the next weeks. For many students, it is the first time that they experience what it means to negotiate and make a real plan in a working team. The instructors provide feedback after the first deadline and note weaknesses when required in order to help the team get started. Over the years, we have learned that the ability of the team to converge and deliver a well-conceived plan increases the likelihood of success in the final performance of the team and reduces task conflict. Accordingly, the plan is used as a team referent or contract for the team to follow.

Communication in a virtual team also requires considerable planning. The students learn that they have to plan their synchronous-communication time as they are required to spend a few hours a week synchronously on the project. This is, in fact, the lecture time when they are supposed to be in class. Experience shows that, especially for convergent activities, synchronous time allows students to make progress. They learn that they need to prepare the synchronous sessions in greater detail to make them more effective. They also learn that planning any additional synchronous sessions, for example on the weekend, is not a trivial matter. Another important lesson is that towards the deadline, the planning of communication needs to have matured to be able to meet the deliverable deadline.

Communication across Cultures: Many projects in business involve participants from multiple locations and cultures. The global redistribution of engineering work has led to the participation of Indian and Chinese engineers in many projects. Engineering curricula may contain a course on differences in cultures and their implications for creating a sense of web-based presence [21]. Exercises may involve role-plays where students are asked to represent their own or a remote culture. It is clear that role-playing is less realistic than working with real people from another culture over a period of eight weeks. Working together under the guidance of faculty encourages students to share their reactions to cultural differences and to work through problems arising from these differences. Without guidance, the teams may fall into a pattern found in many newly formed, cross-cultural virtual teams: The members may not recognize the existence of cultural differences or communicate about these differences [22].

Before the start of the project, the students get a lecture on cultural differences that is available online. The students then experience the real-life cultural differences and are confronted with the impacts of a wrong or incomplete understanding of the differences of these cultures. For example, an Asian may not say "no," even if he or she perceives a task as impossible [23]. The students can read this in a book or hear it from a professor. It becomes more emphatic if the "yes" is first interpreted as a commitment and then a few weeks later the schedule of the whole team is endangered because of the wrong interpretation of the original "yes." At that time, it is always interesting to hear from the students, "It is true. They do say 'yes' all the time, but they do not follow up." To the next question, "What shall we do now?" the instructors provide team feedback by discussing the nature of the problem with the local team and the distributed instructors. The students are one step further; they learn that cultural differences exist, and they learn how to overcome them.

The Use of Communication Technologies in a Virtual Team: The current generation of students has most likely spent more time in front of a computer than in front of a television. Messaging and chat are routine for them. Working and delivering an engineering result is, however, different. One aspect of this difference is selecting the tools that the teams use. The students use the Blackboard learning suite as the central repository for their work. They are free to use any additional tools they consider beneficial in keeping with established practice [20]. Tools that are typically used include chat, internet-protocol telephony, and videoconferencing. For the students, it is often the first time that they have to select their information technology (IT) tools and then live with the consequences in a real project. This also requires them to coordinate their choices and exchange of information on ICTs. Thus, they learn about new tools and language barriers; they also realize that they never have enough backups when the technology fails. For example, teams typically rely only on Blackboard to store email addresses and end up with a problem when the system is not available. Having no email or saved instant messaging (IM) addresses on the weekend before a deadline has already been a good lesson to a few students. Students can then also realize what they missed in their original risk planning and what solutions should have been applied.

Congruently with the body of literature, the students learn about the importance of task-technology fit. The well-known DeSanctis

and Poole model [24] is supported by online demonstrations, where students realize that the videoconference sessions will be unproductive without preparation. They learn that reserving time in their planning for the preparation of documents for discussion during the videoconferencing session is at the core of their success. They also learn that they must direct their questions to specific people [22]. For instructors, it is also rewarding. We all have experienced classrooms composed of a majority who have not read the required articles or prepared the case study. The course is less interesting and more difficult to run as a result. The students do not realize the effect that this lack of preparation has on the learning process. Online in a videoconference, they do.

Cultural differences also play a role in the choice of technology. Rarely have conflicts been solved in confrontations between Dutch and Chinese students via video; however, it has been useful to help American and Dutch students to resolve problems. Students are confronted with real-life issues in multicultural virtual teams that add to the necessity of finding the appropriate communication channel to support their task. This has also been demonstrated in the literature [25]. For example, leaving a videoconference room with no resolution to a conflict or to a next step is a worthwhile experience. The importance of videoconferencing is always overestimated at the start of the project. However, because the students need to connect socially, they all recognize its importance.

HOW TO USE VIRTUAL TEAMS SUCCESSFULLY IN EDUCATION

Delivering a rich and high-quality course in which the individual performance of students can be evaluated has been a challenge to us. Some traditional rules have to be bent to set up such a learning experience. The following section discusses the implications for students regarding the task, the grading process, and use of a portfolio of technologies.

Assignments and Grades In the traditional classroom, the instructors can closely follow the progress of their students. The distance from students is greater when they operate in virtual teams that are participating from various parts of the world. Assignments and grading require special attention. To minimize social loafing, recognized as the negative side of virtual collaboration [12], we developed two assignments based on the unified

paradigm of social facilitation and social loafing [26], as well as on Lewin's field theory [27].

The first assignment, building a website discussing the virtual team topic that is integrated into an e-book in week seven, is designed to be challenging and attractive [28]. The assignment places the participants in a situation of task and outcome interdependence within the virtual team where mutual knowledge has to be constructed. The virtual team members all receive the same grade, which is determined by a pool of independent instructors, who evaluate the quality of the web portal and rank it by comparison with the final product of the other virtual teams. The assignment is recognized to be complex, requiring pooled contributions and a high sense of coordination. Moreover, it induces relative intergroup competition between the teams, adding an incentive in the form of a reward to the best virtual team.

In the second assignment, the students evaluate (through a written individual document) the other chapters in the e-book, as well as the process of their own virtual team, that is, the contributions of each member of their own team. This second assignment is thought to be more traditional. The individual student contribution is clearly identifiable and is rated independently from the grading of the first assignment. This assignment reduces social loafing and has shown to be an efficient backup in case of major conflict and failure. In such a situation, the student expresses the lessons learned through a full-text reflection on the possible solutions that could have been proposed to reach the goal successfully. In general, students are very attached to their individual contributions and have a need for equality and recognition. This individual evaluation allows students who made a special contribution during the project to be rewarded; it also penalizes those who have acted inappropriately.

Portfolio of Technology It is especially important to provide a portfolio of ICTs from which the students can choose those that best fit the needs of the communication that they need to undertake. By so doing, the ICT does not get in the way of the team dynamic, and the team and subgroups within the team can maximize their productivity across time and space. Often, however, this will initially mean different technology preferences as a function of subgroup cultures within the team [20]. For example, a subgroup desiring more uncertainty reduction or concerned about loss of face in a synchronous interaction may well prefer an

asynchronous ICT. On the other hand, a subgroup wishing to move quickly and resolve disputes may well prefer a synchronous ICT. Interestingly, teams tend to converge rather quickly on an ICT solution that generally meets subgroup needs as they recognize the need to compromise and temper their individual preferences for the benefit of the whole team. Teams tend to establish their own culture and way of working together effectively that may involve creative use of an ICT portfolio. It is not unusual, for example, to have some team members using IM in concert with asynchronous forums, punctuated with additional exchanges over email and use of group-authoring software. Each team may differ in the extent and application of each form of ICT as meets their particular way of working. As such, the team generally achieves a good task-technology fit within the portfolio of ICTs available.

SALIENT ISSUES AND HOW TO DEAL WITH THEM

A number of issues have arisen over the years that deserve special recognition when using virtual teams in educational settings. These include plagiarism, the role of peripheral players, setting deadlines, and the need for intermediaries.

Plagiarism Plagiarism has long been a problem in education, but it takes new forms and shapes when global virtual teams enter the scene. In our case, plagiarism was most pronounced when we included students who had not historically been sensitized to the issue. While these students did not initially seem to comprehend the severity of using plagiarized work, the importance of recognizing the work of others became clear to them when it appeared that their entire team would receive a failing grade because of plagiarism.

Students are given ample warning: The severity is made clear in the first lecture and repeated several times afterwards. We also make it clear to the students that we have tools (e.g., www.turnitin.com) to check whether their contributions are original. Nevertheless, we experience plagiarism every year. Most of the cases can be traced easily by a Google search for "Shakespearean sentences" in the middle of student English. Another indication can be a virtual team that is struggling and then suddenly presents great text out of the blue. The plagiarism is often a cut-and-paste of a few lines without reference. This is not a reason to bring the whole team in front of an exam committee. We handle plagiarism by making the total group

responsible for removing the copied text and giving the student who contributed the plagiarized section one more chance to improve his or her act. The interdependence with the other team members makes this lesson hard to forget and certainly valuable. In rare cases students have been brought in front of the exam committee.

Peripheral Players Because of the 12- to 13-hour time difference between students in America and Hong Kong, the first year the Americans joined the teams, they did so as advisors. We anticipated that as native English speakers, they could fill the role of English editors—a role that was sorely needed for many of the teams. The Americans were eager to join the project, but they were not able to teleconference with their Dutch and Hong Kong teammates. Nor did they communicate synchronously. Thus, despite their numerous entreaties, they were not seen as core members, and they were often not included in critical communications. Because they were "silent" and did not participate actively in all synchronous events, they may have been seen as less important than team members who were more active in the online exchanges [29]. This has made it clear to us that the roles of all team members need to be clearly defined and reinforced, and all team members must participate in teleconferences and synchronous communications to demonstrate that they are, in fact, important members of the team.

Setting Deadlines to a Standard Time Used in the Course It did not take the students long to realize that when a deadline was set at midnight on a certain date, the midnight time selected was at the location with the latest midnight. That is, when given a deadline of midnight on a certain date, the teams would opt for Orlando midnight over Hong Kong midnight every time. Thus, we learned to state deadlines in terms of a baseline. Other strategies for dealing with time that proved helpful were providing a link to an online resource that contains an international time and date converter (e.g., www.timezoneconverter.com), which allows detailed class schedules with all necessary time and date conversions to be prepared in advance, thereby eliminating the need for students to use relative chronological terms like "yesterday," "today," and "tomorrow" [30]. In theory, the deadline is initially presented to the students as fixed and nonnegotiable; in practice, they are not penalized for a few hours or even days of delays. However, they are expected to communicate about any possible delays up front.

Need for Intermediaries To ensure the possibility of synchronous communications among the Dutch, Hong Kong, and American students, the classes all met at the same time: The American students met at 7:30 a.m., the Dutch had a class at 1:30 p.m., and the Hong Kong students' class started at 7:30 p.m. After daylight saving time, the American students and Hong Kong students experienced a 13-hour time difference, a difference that appeared insurmountable when the students were outside of class. In order to maintain communications, the Dutch emerged as intermediaries. The Hong Kong students would communicate synchronously with the Dutch, and later in their day, the Dutch would convey the substance of these communications synchronously to the Americans. This seemed to work well.

IMPLICATIONS FOR CURRICULA

During the last ten years of HKNet, we have provided students with real-life experiences in an engineering-management project to emulate a real-life environment in an organization. We are convinced of the relevance of such learning experiences for students, especially in regard to learning that is evaluated by means of their personal evaluations. The key communication lessons that the students state they learned are these:

- Working with people whom they have never met in real life and with whom they have to complete nontrivial tasks. Globalization has effects that are very difficult to emulate in a typical classroom setting. As previously noted, in a traditional classroom environment, it is indeed difficult to emulate working across time zones and with different cultures.
- Experiencing the difference between synchronous and asynchronous communication in a real-life setting.
- Selecting appropriate communication tools. This is not a trivial task with the abundance of tools available. The important aspect is that the students have to live with the consequences of their choices. The selection is more than a paper exercise.
- Appreciating the importance of planning their communication across time zones.

Not all courses can or should be taught in this way. As suggested by Piccoli, Ahmad, and Ives, "Considerable uncertainty remains regarding the subject matter and content type best suited

to delivery in the virtual environment" [13, p. 408]. Certain types of subjects may best be suited to virtual environments. For example, courses in disciplines with higher levels of paradigm development (e.g., engineering, physics, computer science) may be more suited to virtual environments; they are able to convey subject matter more succinctly and easily than courses in disciplines with lower levels of paradigm development (e.g., English, sociology) because there is greater agreement on concepts in the high-paradigm disciplines. Results of a study of a large number of web-based courses over a seven-year period suggest that student performance and satisfaction are significantly greater and withdrawal rates lower for courses with high-paradigm development than for courses with low-paradigm development. Even stronger relationships emerge when looking at the moderating effect of advanced versus introductory courses [31]. Hence, this educational approach appears especially conducive to virtual teams using the internet in advanced courses in a high-paradigm discipline (e.g., engineering).

There are many topics that are effectively studied by scaling the real-life problems down to a size that can be handled in the context of a 100-hour course. Therefore, we recommend including some experiential classes in the master's degree program of study for engineering students. They have, by then, accumulated enough of the engineering basics to be a credible member of a virtual team. They should be able to handle the additional complexities arising from a globalized team. It is important, as well, to consider how courses involving virtual interactions fit into the program of study within which students are enrolled. An opportunity exists at the program-of-study level to integrate learning activities across several courses and, thus, to provide extended student experiences that would further emulate real life in organizations. As such, transfer of learning from course to course can be enhanced, and longitudinal team behaviors can be better experienced. Unfortunately, the coordination necessary to achieve these results is difficult to achieve in practice. Teachers are generally reluctant to exert the extra effort needed. Worse still, multiple independent activities can actually dilute the uniqueness of the experience. Program-of-study design and leadership are crucial in creating an enhanced, integrated, student learning environment, and teachers must be carefully chosen.

NECESSARY CHANGES

A project like HKNet requires different input from the instructors. It is less about bringing content into the classroom since the content is out there and will be found and organized by the students themselves. It is more about stimulating the students to handle the uncertainties and helping them organize the abundance of information. We are not evolving into an electronic age where the instructors lose importance and are replaced by a computer. On the contrary, instructor involvement has to be high [32]. The professor-to-professor communication and the professor-to-student communication should parallel the student-to-student communication. This means a lot of online time for instructors as well. As good managers, they have to be present socially and professionally as the guides and guardians of the project. When this part of the responsibility is neglected, it damages the whole collaboration process. Our collaborations with some universities within the context of this project have failed. Looking back, the main reason for this was a lack of engagement of the instructors involved. The students were not the problem.

Finally, the exam rules at a typical university do not describe the case of a group project with virtual members on the other side of the world. For this reason, we recommend addressing plagiarism with the students until such a time when the exam rules of the universities have caught up with the introduction of virtual teams in education. Additional considerations involve collaboration among instructors at multiple sites to coordinate grading scales and expectations such that students recognize and appreciate marks given. Exam boards need to be comfortable with multi-institutional involvement. It is especially important that workloads are balanced; for example, problems arise if students at one site know the group assignment counts for 40% of their grade, while students at another site know it counts 80% for them.

CONCLUSION

The students definitely benefit from such a course when they enter the workplace. Today, job applicants regularly are asked whether they have experience in virtual teams. Discussing the HKNet project is more interesting in a job interview than explaining an MSN experience or talking about a theoretical classroom course about virtual workplaces. We know several companies

that ask applicants for a job interview via phone or videoconference to be able to evaluate applicants' virtual presence. Growing virtual presence in a real-life engineering experience is a worthwhile effort. We have been able to publish our findings and have brought several of the experiences to the business world, as either managers or consultants to management teams [33].

The ten years of experience in HKNet shows that it is possible to bring real-life experience of engineering management into a 100-hour education course. It is possible to let students experience what it means to work and communicate in a multinational virtual team that produces a real product. At the same time, there is still a lot to improve and more realism to be achieved in the project, on both the process side and the technology side. For those who are interested, the website www.bohknet.com provides the education material. It is available for those wanting to improve our approach further. We are interested in extended lessons and ideas to further enhance real-life experience in education. Continuing on this path is an interesting experience for the students as well as the professors involved.

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Anne-Françoise Rutkowski is an associate professor in the Department of Information Systems and Management at Tilburg University, Tilburg, The Netherlands. Since 1994, she has been involved in education and research activities on methodology of research and fundamental social and cognitive psychology. Since 1999, her research interests and publications have been oriented towards group support systems and bridge information systems and human sciences in addressing topics such as group decision making, processes of attention with ICTs, e-learning, and multicultural and virtual collaboration in teams. Her research is published in journals such as *IEEE TRANSACTIONS ON PROFESSIONAL COMMUNICATION*, *Small Group Research*, *Group Decision and Negotiation*, and *Decision Support System*.

Doug Vogel (M'07) was formerly with the University of Arizona and is currently Chair of Information Systems at City University of Hong Kong, Kowloon, and is an AIS Fellow. Prior to entering academia, he worked as a systems analyst and developer for large companies and also created and managed his own 50-employee company. He is widely published and is especially active in integrating technology into educational contexts. His

particular focus emphasizes integration of audio, video, and data in interactive distributed education. Additionally, he has been particularly active in the development, facilitation, and evaluation of group support systems.

Michiel van Genuchten (M'94) is a part-time professor at the Eindhoven University of Technology, Eindhoven, The Netherlands, and the manager of NXP Software. He previously had his own software company and worked for Philips Electronics. His professional interests include software as a business, software management, and IT support for virtual teams. Results of his research have been published in journals such as *IEEE Computer*, *IEEE TRANSACTIONS ON PROFESSIONAL COMMUNICATION*, *IEEE Software*, *Journal of MIS*, and *International Journal on Technology Management*.

Carol Saunders is Professor of Management Information Systems at the University of Central Florida, Orlando. She served as General Conference Chair of ICIS'99 and Telecommuting'96. She was Chair of the Executive Committee of ICIS in 2000 and inducted as an AIS Fellow in 2003. She was the editor-in-chief of *MIS Quarterly* from 2005 to 2007. Her current research interests include the organizational impacts of information technology, virtual teams, and interorganizational linkages. Her research is published in *MIS Quarterly*, *Information Systems Research*, *Journal of MIS*, *Communications of the ACM*, *Academy of Management Journal*, *Academy of Management Review*, and *Organization Science*.