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Int. J. Human-Computer Studies 60 (2004) 365–380

International Journal of  
Human-Computer  
Studies

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# Effects of culture on computer-supported international collaborations

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Received 11 April 2003; received in revised form 15 October 2003; accepted 22 October 2003

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## Abstract

This paper discusses results of a case study from an on-going project to investigate how cultural factors, as identified by the Cultural Perspectives Questionnaire (CPQ), affect the performance of distributed collaborative learning teams. The results indicate that a team's cultural composition is a significant predictor of its performance on programming projects. Cultural attributes most strongly correlated to group performance included those related to attitudes about organizational hierarchy, organizational harmony, trade-offs between future and current needs, and beliefs about how much influence individuals have on their fate. Moreover, the type of programming task affected the strength of the relationship between individual cultural attributes and performance. Participants in the study included computer science students from the University of North Texas (Texas, USA) and students from the Middle East Technical University in Ankara, Turkey. Students were divided into culturally diverse work-teams and assigned programming projects to be completed using special collaborative software. The programming tasks ranged from simple design projects to more complicated programs that required extensive collaboration. Cultural distinctions between work-teams were based upon the students' responses to the CPQ. Project performance was evaluated with respect to programming accuracy, efficiency, completeness, and style. The results presented here have important implications for the formation of distributed collaborations and, in particular, to educational institutions offering distance-learning programs that require team projects.

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## 1. Introduction

The Internet, along with collaborative software tools, has created new opportunities for companies to employ geographically dispersed work-teams. Manpower and financial advantages make these collaborations both necessary and attractive (Carmel, 1999). As more and more corporations undertake global projects, Universities are responding by initiating special courses that teach students to work with groups who are located at distant sites where there is little or no face-to-face interaction (Zack, 1993; Atkins et al., 2000). The collaborative projects assigned in these courses tend to vary, ranging from simple e-mail exchanges to more elaborate global interactions supported by complex, synchronous communication tools. While these educational experiences are helping to advance our knowledge of how technology can be used by geographically distributed groups, it is still too early to know exactly what works and what does not; theories are sparse, controlled studies are difficult to arrange, and the volume of data is overwhelming (Olson et al., 1993). One of the growing concerns among both educators and industrial project leaders is the question of how cultural differences may affect work/learner-team performance (Minor, 1999). Another concern is the recent finding that culture may be more associated with individual rather than group qualities (Sparrow and Wu, 1998). Cultural values constitute the framework within which acceptable solutions are negotiated and decisions made (Maznevski, 1994b; Adler, 1997; Herbsleb et al., 2000) and, as such, may be associated with either individual or group behavior. While differences in perspectives offer potential for multicultural teams to perform better, they also influence members' preferences for social interactions, which make cooperative decision-making more difficult. To successfully incorporate teamwork in both work and learning environments, business leaders and educators need guidelines on how to create team building exercises, use appropriate group-development models, monitor team progress, and design appropriate assessment mechanisms. Exploring these questions at the intersection of research on collaborative work and computer-supported collaborative learning can strengthen knowledge in all these areas.

This paper presents findings from a long-term (2-year) study of factors that contribute to successful distributed programming interactions between students enrolled at Middle East Technical University (METU), Ankara Turkey and the University of North Texas (UNT), Denton, Texas. We were particularly interested in a student's culture (i.e. Turkish vs. American or others) and how it affected collaborative problem solving performance. Using special web-based collaborative tools developed by the authors, computer science students at METU and the UNT were able to communicate with one another, share data, and engage in a number of different programming activities. The results of our 2-year study indicate that a team's cultural attributes, as defined by the CPQ, are a significant predictor of its performance on programming projects. The cultural attributes that were most strongly correlated to group performance were those associated with attitudes about organizational hierarchy, organizational harmony, trade-offs between future and current needs, and beliefs about the influence individuals have on their fate.

Moreover, the type of programming task also affected the strength of the relationship between cultural attributes and performance. The results presented here have important implications for the formation of distributed collaborations and to engineering programs offering distance-learning courses requiring team projects. We present both a description of the study, as well as a discussion of the pedagogical issues found to be important in global distributed learning situations. We also describe how our findings can be generalized to real world global software teams.

## 2. Relevant research

There have been a number of theories presented in intercultural research that attempt to determine the cause of successful and unsuccessful collaborations within cross-cultural settings. One focus of this research is to examine the relationship between culture and technology and how these relationships affect the acceptance and use of the artefacts of technology. Cultural anthropologists argue that technology is a culturally embedded, value-laden activity (Deans et al., 1991), which suggests that technology has a strong cultural component that affects how and whether it will be adopted, used, and managed (Lehmann, 1995). In order to understand cultural differences among nations, intercultural researchers have attempted to provide frameworks that identify and effectively organize specific dimensions of cultural difference (Gudykunst and Ting-Toomey, 1988). Among several available taxonomies of cultural variability, students of intercultural communication have given the dimensions elaborated by Hall (1976) and Hofstede (1980, 1991) the most consistent attention. Hall was the first to draw distinctions between cultures on the basis of abstract, generalized characteristics. To this basic framework, Hofstede (1980) suggests adding the dimensions of power distance, masculinity/femininity, uncertainty avoidance, individualism/collectivism, and Confucian dynamism. Taken together, these dimensions provide a means of characterizing and comparing different cultures as well as providing a meaning for the use or non-use of computer mediated software. For example, one author suggests that cultures reflecting more “collectivist” tendencies such as China and those in the Middle East (such as Turkey) may actually use collaborative software more effectively than individualistic cultures like those of the US or Australia (Chung and Adams, 1997). A contrasting view, however, contends that the phenomenon of globalization has led to the development of a “culture free” hypothesis that promotes the idea that organizations are converging on a Western style, thus making cultural factors in the work place, particularly for software developers, insignificant. For example, a comparative study done in 1996 concluded that there were no significant differences in choices of software development tools among US, Japanese, and European firms (Curley et al., 1996).

Results of studies on the relationship between performance and a team’s cultural composition have also been mixed. While some studies have found that cultural differences have hindered a group’s performance (Hofstede, 1980; Atkins et al.,

2000), others have shown that multicultural teams can perform as well as homogenous teams, particularly if the teams participate in formal training programs (Watson et al., 1993; Maznevski and Chudoba, 2000). These conflicting views may be due, in part, to the different ways culture is defined and how performance is evaluated. In particular, work-team performance is often evaluated with respect to team members' attitudes about how well the team collaborated and not necessarily with the actual outcome of the project (Elfenbein and O'Reilly, 2002). Moreover, how different characteristics of a team's task and its cultural composition interact to affect group performance is not clear. While several researchers suggest that communication among global distributed teams is affected by task type, they do not provide sufficient information about how this occurs (Zack, 1993; DeSanctis and Jackson, 1994; Maznevski and Chudoba, 2000).

Different views about the effects of culture can also be found in the research literature on geographically dispersed collaborative learning. For example, Jarvenpaa and Leidner (1998) found that culture was not a factor in their study of trust among globally distributed teams enrolled in a course at the University of Texas. They suggest that computer technology minimizes the cultural differences among groups because it allows nonverbal communication that renders users relatively anonymous. On the other hand, Atkins et al. (2000) found that cultural factors had a significant effect on the student groups' ability to develop trust. One reason researchers focus on the issue of trust is because virtual learning teams never meet face-to-face. Unlike teams in traditional classroom settings who already know each other, students within virtual learning environments have never met previously, but must learn to work together to complete tasks.

Unfortunately, no consistent definition of culture is used in studies on teamwork performance in the research literature on either geographically dispersed collaborative learning or computer-supported collaborative work. For example, Hofstede (1980) classifies people along a number of "dimensions of culture" that reflect attitudes toward their jobs and employers. While Elfenbein and O'Reilly (2002) use the terms organizational fit and demographic attributes to examine issues related to diversity and individual differences. In the study described here, cultural distinctions between work-teams were based upon the students' responses to the Cultural Perspectives Questionnaire (CPQ) developed by Maznevski (1994a). The CPQ measures a variety of respondent attitudes, from the value of traditions to the belief that events in life are predetermined. While the attributes measured by the CPQ correlate well with culture, these attributes could also be viewed as personality traits (that just happen to be fairly consistent within cultural groups). Regardless of the interpretation, the results described here indicate that these attributes are related to work-team performance.

This study specifically addressed how cultural attributes of geographically dispersed work-teams affect the performance of certain programming tasks, within the experimental environment of a distributed artificial intelligence course. The results indicate that cultural attributes can significantly affect the ability of work-teams to successfully complete certain programming projects. For example, work-teams for which all members favored rigid organizational power structures had

much higher odds of poor performance than other work-teams. This effect was most significant for tasks that required a high degree of coordination.

Since this study occurred within the context of a university course, the results have implications for educational institutions offering such experiences and for geographically distributed collaborations in general. Moreover, the computer-supported collaborative software used for the study represents a particular type of group interaction. A long-term objective of this work is to develop a version of the tool for business and educational institutions. Essential to this development is understanding how student work-teams interact using this technology and what role cultural attributes play in this interaction.

### 3. Methods

#### 3.1. *Work-teams*

Participants in the study were computer science students enrolled in an Introduction to Artificial Intelligence course at UNT and students from METU in Ankara, Turkey. It should be noted, that all students enrolled at METU speak English in all their classes and receive testing and other educational materials in English. Pedagogical differences were minimized because of the Turkish researcher's previous experience teaching at UNT. Each work-team consisted of one student attending UNT and one student attending METU. In all, the performance of 55 work-teams was studied over a two-semester period—34 work-teams during fall semester 2001 and 21 over spring semester 2002. The same instructors (one at UNT and one at METU) taught both semesters. Students were assigned work-team partners based on their responses to the CPQ (described below) and their grade point averages (GPAs). The CPQ was administered to both groups of students on-line. The Questionnaire had been pre-tested for several semesters prior to the start of the experiment to insure that it was understandable by both Turkish and US students. The overall goal was to obtain as many work-team representatives of cultural factors and GPA combinations as possible—for example, work-teams with both members scoring high in a particular cultural dimension, work-teams with one member scoring high and one low, and work-teams with both members scoring low.

#### 3.2. *Project descriptions*

Work-teams in each semester received similar collaborative exercises. The projects were designed to determine whether cultural factors were important during all the different phases of global software development. The first projects, assigned early in each semester, were “design only” exercises that required teams to hand in a single design document, but produce the code for the programs individually. These projects involved implementing heuristic search algorithms to solve a problem such as guiding a robot along a path through a grid while avoiding obstacles, or re-arranging railroad cars in a train yard. Team members were instructed to work together to

develop a common design document that indicated data structures and heuristics the group would use to solve the problem, as well as an overall program design. Work-teams were required to use the collaborative software to complete only the design portion of the program. The second projects were assigned towards the end of each semester. Work-teams were required to use the collaborative software throughout the project (i.e. design, program, and test phases). The second projects consisted of designing, implementing and testing a program that could play a game such as ACHI, a tic-tac-toe-like game, or hexapawn, a smaller version of checkers. As the final step in the game projects, team members were required to run a tournament and have their programs play each other. To successfully complete this part of the project, team members had to agree on an interface that would allow them to exchange moves with their partner and pass information between the two programs (i.e. between the game program of the META student and the game program of the UNT student).

### 3.3. *Work environment*

As previously stated, all work-teams were required to use special Computer Supported Collaborative Work (CSCW) software developed by the authors (see <http://zeus.csci.unt.edu>) for each assignment. The special cooperative interface relies on a shared, real-time window system (i.e. What You See is What I See) that allows groups that are geographically separated to execute controlled tools (Brazile et al., 2002a, b). The software is designed to run over the Internet. It supports collaborative activities through specially designed whiteboard, editor, chat, browsing, e-mail, and file/application sharing tools. The system is equipped with both management and record keeping capabilities that allow researchers to analyse the collaborative activities that occur during a group session. The collaborative tools used by work-teams varied by activity. Teams tended to use only the shared editor or whiteboard for design activities, while the application and file sharing tools were used for programming and testing activities.

### 3.4. *Work-team performance evaluation*

As mentioned, work-teams were required to provide a single design document for the first project, but develop code for the programs individually. For the second project, work-teams were required to turn in a single design document for the interface, code for the game, and a text document discussing the outcome of the tournament and a rationale for the heuristics used.

Projects were evaluated and an overall grade was assigned based on four criteria—accuracy, efficiency, thoroughness, and style. A design or a program was considered accurate if it satisfied the user's functional requirements and contained no errors. A project's efficiency score was determined by examining the number and type of program modules, whether the design or program was concise and contained few or no extraneous elements, and was easy to understand. A program's thoroughness was scored on whether the design or program included all the necessary elements

(e.g. tests for out-of-bounds data and incorrect input). Finally, good programming style was judged by use of proper documentation style, appropriate variable naming conventions, proper indentation, and the quality of the interface.

A principle objective of the analysis was to determine work-team characteristics that indicate potential for poor performance. So, for the logistic model discussed below, project grades were categorized either as poor—one standard deviation below the class average—or satisfactory—better than one Standard Deviation below the class average. Standardizing grades helped account for any differences in grading styles and class dynamics from one semester to the next. Twenty-seven percent (15 out of 55) of the work-teams performed poorly on the first project and 38% (21 out of 55) performed poorly on the last project.

### 3.5. *Cultural attributes*

Cultural attributes of students were measured with the CPQ developed by Maznevski (1994a). The CPQ measures a variety of respondent attitudes, from making decisions based solely on immediate concerns to the degree of belief in one's destiny. The CPQ consists of 92 questions and tests five cultural dimensions—Activity, Human Nature, Relationships, Relation to Nature, and Time. Responses for each question are scaled from 1 to 5, where 1 corresponds to strong disagreement and 5 corresponds to strong agreement. Each category is divided into subcategories that are tested by three to eight questions. The score for each subcategory is the average of the responses to those questions. For example, the Relation to Nature dimension has three subcategories—Mastery, Subjugation, and Harmony. High scores for Mastery indicate a belief that a person should control the environment to their advantage. For Subjugation, high scores reveal a belief that the future is completely pre-determined. Dimensions and subcategories are given in Table 1. Each of the cultural dimensions has been given a “factor name” to help the reader better understand the discussion.

The variables included in the analysis were the maximum and minimum of each work-team's GPAs and CPQ subcategory scores. The maximum and minimum work-team GPA and CPQ scores provide a concise way to characterize work-team CPQ-GPA configurations. For instance, if the minimum relation-to-hierarchy (i.e. hierarchy) score for the work-team is high, then both team members believe that work groups function best with rigid power structures, while a high maximum relationship-to-hierarchy (i.e. hierarchy) and low minimum indicates a work-team with very different attitudes about group power structures. Mean and standard deviations for GPA and CPQ subcategories over all students are given in Table 2.

The means of most CPQ subcategories were close to the mid-response of 3 and standard deviations were around a  $\frac{1}{2}$  unit. The notable exception was relationship-to-nature (i.e. Destiny-Predetermined)—the average score was close to 2 and it had the largest standard deviation of 0.84. There were no practical differences between the distribution of most CPQ subcategory scores between students from UNT and those from METU. Scores that were anticipated for ‘turkish’ culture such as high hierarchical, high pre-determined, and low individualism did not really materialize;

Table 1  
CPQ dimensions and subcategories

Dimension category	Factor name	What a high score means
Relationships		
Individualism	Individualism	This person will put his/her own needs before those of others.
Collective-family	Family oriented	This person feels a deep sense of responsibility towards family members.
Collective-general	Collective-general	This person believes society functions best when the focus is to ensure the well-being of each of its members.
Hierarchical	Hierarchical	This person believes society functions best when there is rigid power structure.
Relation to nature		
Subjugation	Destiny-predetermined	This person believes that his/her destiny has been predetermined and they can do nothing to change it.
Mastery	Free-will	This person believes that he/she decides his/her own future.
Harmony	Harmony	This person believes that it is important to strike a balance in life and work.
Activity		
Doing	Active-oriented	This person believes that it is important to perform tasks with tangible results.
Being	Live-for-moment	This person believes that the only way to be happy is to live for the moment.
Feeling	Feeling	This person believes it is best to listen to their feelings and take the feelings of others into consideration before acting.
Thinking	Thinking	This person believes that the most logical decisions are best.
Human nature		
Good/evil	Predestination	This person believes whether a person is good (or bad) is predetermined.
Changeable	Environmental	This person believes that a person's nature is shaped by his/her environment and experiences.
Time		
Past	Past-oriented	This person believes that it is important to look to the past for direction/guidance.
Present	Present-oriented	This person believes that only immediate concerns should be considered when making a decision.
Future	Future-oriented	This person believes that we should be concerned primarily with future consequences.

Table 2  
Mean and standard deviations for individual GPAs and CPQ subcategory scores

Factor	Mean	S.D.
GPA	3.07	0.50
Individualism	3.41	0.52
Family oriented	3.26	0.64
Collective-oriented	3.37	0.57
Hierarchical	2.86	0.65
Destiny-predetermined	2.19	0.84
Free will	3.57	0.57
Harmony	3.65	0.64
Activity-oriented	3.11	0.51
Live-for-moment	3.35	0.59
Feeling	2.97	0.63
Thinking	3.65	0.52
Predestination	2.84	0.49
Environmental	3.38	0.73
Past-oriented	3.19	0.61
Present-oriented	3.24	0.53
Future-oriented	3.21	0.56

although Turkish students had slightly higher scores in the hierarchical category. However, as discussed below, there was a noticeable difference between one of the important model variables for predicting work-team performance.

#### 4. Analysis

Logistic regression using SPSS statistical software was performed to relate CPQ and GPA variables to work-team performance. Separate logistic models were built for the first and second team projects.

##### 4.1. Logistic models

Bivariate logistic models were constructed using the work-team maximum and minimum for GPA and each CPQ subcategory. The GPA-CPQ subcategories for which either the work-team minimum or maximum variable was at least marginally significant ( $P$ -value  $\leq 0.25$ ) were initially included in the multi-variate analysis. This served as the standard univariate screening process for building the multi-variate model. Both the maximum and minimum GPA-CPQ variables were included to guard against missing associations between performance and dissimilar work-team members—that is, work-teams for which one member has a high CPQ subcategory score and the other has a low score. Based on a variable's Wald statistic and likelihood ratio tests for the difference between models with and without a variable, variables were eliminated from the initial multi-variate model to arrive at the final models given in Table 3 for the first project and in Table 4 for the second project.

Table 3

Logistic model variables for predicting satisfactory work-team performance for the first project

Variable	Coefficient ( <i>B</i> )	S.E.	<i>p</i> -value	Odds ratio for a change in 0.2 units
Maximum GPA	2.65	1.05	0.012	1.70
Minimum Destiny-Predetermined	2.55	1.07	0.017	1.67
Maximum Destiny-Predetermined	-2.15	0.10	0.031	0.65
Maximum Hierarchical	-3.05	1.32	0.021	0.54
Maximum Harmony	3.29	1.52	0.031	1.93

Table 4

Logistic model variables for predicting satisfactory work-team performance for the second project

Variable	Coefficient ( <i>B</i> )	S.E.	<i>p</i> -value	Odds ratio for a change in 0.2 units
Maximum GPA	4.16	1.47	0.005	2.30
Maximum Hierarchical	-6.06	2.19	0.006	0.30
Minimum Hierarchical	-2.60	1.18	0.027	0.59
Minimum Destiny-Predetermined	3.33	1.29	0.010	1.95
Maximum Future-Oriented	3.37	1.42	0.018	1.96

The significance of each pairwise interaction term was tested. For the first project, only the interaction between “Maximum Harmony” and “Maximum Hierarchical” scores were significant at  $<0.1$  level. There were not any significant interactions for the second project. Inclusion of a “Maximum Harmony”–“Maximum Hierarchical” interaction term produced an over-fitted model with numerically unstable parameter estimates. One approach to handling this is defining a new variable based on categorized combinations of “Maximum Harmony” and “Maximum Hierarchical” values and substituting this variable into the model for “Maximum Harmony,” “Maximum Hierarchical” and any interaction term. However, this did not produce a model that fit substantially better than the more straight-forward model given here. Similarly, while a standard interaction term representation for the relationship between “Maximum Hierarchical” and “Minimum Hierarchical” scores in the second project was not significant, a less straight-forward representation was. But, this produced a less easily interpretable model, with no substantial improvement in fit, than the model given in Table 4.

Both the models presented here had model  $-2$  log-likelihood  $\chi^2$  significance levels  $<0.001$  and all the model variables were significant at  $<0.05$  level. Assessing the models’ goodness of fit, 85.5% of all work-teams were correctly classified by the first project model (66.7% of poor performing work-teams and 92.5% of satisfactory), and 94.5% were correctly classified by the second project model (95% of poor performers and 94% of satisfactory) using a 0.5 classification cut-off. Both models do substantially better at correctly predicting performance for those work-teams that performed poorly than models based solely on GPA—first and second project

models based only on GPA correctly predicted only 33% of poor performing work-teams.

Each model had an “outlier” work-team. The outlier for the first project model had an estimated probability of 0.991 of performing satisfactory, yet the work-team performed poorly. The estimated probability was mainly the result of a high GPA (i.e. MAXIMUM GPA) of 3.9. With this outlier removed, the model had a Hosmer–Lemeshow  $\chi^2$  significance of 0.92, indicating a model that fits quite well. The outlier for the second project model had a 0.983 estimated probability of doing poorly, yet the work-team performed satisfactory. The estimated probability was the result of a very low “Minimum Destiny-Predetermined” value of 1 and a relatively high value for “Maximum Hierarchical” of 3.14. With the outlier removed, the model had a Hosmer–Lemeshow  $\chi^2$  significance of 0.82, again indicating a model that fits well.

Thirteen of the 21 work-teams that performed poorly on the second project also performed poorly on the first project. So, it would be expected that many of the same variables would be significant for both first and second project models. On the other hand, the “Maximum Future-Oriented” factor was not even moderately significant for the first project, indicating an important difference between the work-team characteristics necessary for success with the two projects. Work-team “Hierarchical” attitudes were also a more important factor in predicting performance for the second project than in the first.

#### 4.2. *Interpreting the models*

The model coefficients indicate that work-teams with at least one member with a high GPA have greater odds of performing satisfactory. This is not surprising. However, it is interesting that once the Maximum GPA is given, knowing the GPA of the low-GPA team member does not add to the predictive power of the model. Work-teams with a member that strongly believes in rigid organizational hierarchy (high “Hierarchical” score) have greater odds of poor performance. This was particularly evident for the second project where all work-teams for which both members had “Hierarchical” scores above 3 performed poorly and 52% performed poorly when both members scored above 2.5, compared to 27% when at least one scored below 2.5. Maximum GPA values for the poorly performing work-teams with “Minimum Hierarchical” > 3 were distributed fairly uniformly from 2.6 through 3.6 and from 2.5 through 3.9 for poor performance teams with “Minimum Hierarchical” > 2.5. Thus, the relationship between “Hierarchical” scores and performance seems to hold regardless of GPA. Work-teams that have a member with a low “Destiny-Predetermined” score have higher odds of performing poorly, and these odds are increased if the other team member has a high “Destiny-Predetermined” score (this held for both projects but the “Maximum Destiny-Predetermined” factor was not statistically significant for the second project). That is, work-teams with noticeable differences in attitudes about their predetermined destiny have greater odds of performing poorly. Work-teams for which there is a team member with a high harmony score have greater odds of performing satisfactory on the first project. Finally, for the second project, work-teams for

which at least one member has a high “Future-Oriented” score have greater odds of satisfactory performance.

Typically, a variable’s estimated odds ratio gives the change in the odds for a unit change in the variable’s value. However, work-team values for many variables were concentrated within a narrow range, reflective of a general tendency of survey respondents to avoid extreme responses. For example, the 25th percentile, median and 75th percentile for “Maximum Harmony” were 3.83, 4.00 and 4.33, respectively. The estimated odds ratios in [Tables 3 and 4](#) are given for a change of 0.2 units for a more applicable interpretation of the model. For example, the odds of performing satisfactory on the first project for a work-team with a 3.0 maximum GPA are 1.7 times greater than for a similar (with respect to CPQ scores) work-team with Maximum GPA = 2.8. Conversely, the odds of performing satisfactory on the second project for a work-team with “Minimum Hierarchical” = 2.5 decreases by 0.59 times compared to similar work-teams with “Minimum Hierarchical” = 2.3.

## 5. Discussion

Cultural attributes appear to be valuable predictors of work-team performance. Moreover, the results indicate that the characteristics of programming tasks affect which cultural attributes are most strongly associated with performance. The models presented here are substantially better at identifying poorly performing student work-teams than models based solely on GPA. Important CPQ attributes for predicting work-team performance were “Hierarchical”, “Harmony”, “Destiny-Predetermined”, and “Future-Oriented”. Although there was no practical difference between the US and Turkish student scores on the CPQ in these categories, there is some indication that the “Hierarchical” scores were higher for Turkish students. The more general conclusions, however, are:

- Work-teams for which both members had high “Hierarchical” scores had higher odds of poor performance. This was especially true for the second project. The second project demanded effective collaboration between work-team partners. In particular, a critical element to the success of the project was collaboration on how information was to be exchanged between programs to play the game. If the original interface was inadequate, then one or both of the members had to “repair” the program quickly. Thus, work-team Hierarchical scores may provide a very good indicator of the potential for poor performance for programming projects requiring close coordination for time critical tasks.
- Work-teams with a low “Destiny-Predetermined” member have greater odds of performing poorly. The odds of poor performance are increased further if the other team member has a high score. A low “Destiny-Predetermined” score indicates strong disagreement with the idea that the outcomes of events are predetermined. So, work-teams with divergent attitudes about their Destiny have fundamental differences on the ability to control events and on how to manage unexpected problems. Computer-supported collaborative work environments are highly

susceptible to unexpected problems. Groups constantly encounter network, scheduling, and work difficulties. Groups whose members feel in control of their destiny can do much better within this particular programming environment.

- “Harmony” measures attitudes about organizational harmony. Not surprisingly, work-teams with at least one member with a high “Harmony” score had greater odds of performing satisfactory (statistically significant for the first project).
- Success on the second project was dependent on both team members completing tasks on time. The project was given towards the end of the semester—so there was a hard deadline—and all the project tasks had to be completed before the tournament could be played. If one of the partners failed to complete the programming assignment, then the tournament could not take place. Further, scheduling towards the end of the semester became increasingly difficult. Correspondingly, work-teams with both members scoring low in Future-Oriented questions had greater odds of poor performance. So, Future-Oriented factors provide another good indicator of the potential for success on time-critical projects.

The study also provides some qualitative insights into the pedagogical aspects of teaching geographically dispersed groups. Important pedagogical patterns discovered include:

- Students need a different model of group work for global distributed learning. Students learned quickly that team projects set in traditional classrooms were very different from team projects assigned within a global environment. In traditional settings, students know each other; they can schedule meetings quickly; and they often justify a single student doing all the work. In our study, none of the students knew each other previously; they had to learn to schedule meetings in advance (at least 1 day); and they had to learn to share workload responsibilities, since the experimental collaborative software could detect inequalities in team participation. To alleviate some of the scheduling problems, we developed a web-based scheduling tool that was designed to help students identify their availability on specific days. While the tool was somewhat helpful, students continued to have difficulties coordinating work and class schedules to accommodate meetings with their group.
- Students lack a deep awareness of different cultures. Initial discussions with the two groups indicated that students had several misconceptions about each other’s culture. This lack of understanding can lead to distrust between group members. To help establish trust between the students, we instituted an exercise in which the partners were required to use the collaborative software to exchange personal information with each other. The assignment was designed to introduce team members to each other as well as establish communication between the students.
- Global distributed learning requires more administrative overhead than traditional group learning. It obviously requires additional administrative overhead to coordinate assignments between two different schools with two different start times, different holidays, and different test times. But other problems encountered that must be considered include unequal class sizes, unhappy groups, and interrupted schedules caused by ice storms and/or unanticipated events. To cope

with these different situations, we developed a number of administrative tools that enabled us to communicate quickly with the different student groups. These administrative tools helped alleviate many of the initial administration problems.

- Global distributed learners need to contact each other quickly and frequently. As claimed by other researchers (McLellan, 1997; Atkins et al., 2000), we found that groups who communicated with each other during the early stages of the project and then continued this communication throughout the project performed better than those groups who tended to wait until a few days before the project was due. Frequent interaction provides information about others' actions that can help reduce uncertainty about future events. It also seems to increase awareness of others and the task.

In summary, these results provide evidence that it is possible to integrate team projects within a geographically distributed learning environment. These environments, in many cases, simulate globally distributed industrial organizations. While our research took place within the context of higher education, the results should apply to any environment that employs virtual teams.

## **6. Conclusion**

The results reported in this study document the importance of the cultural composition of the group. Cultural attributes that were most strongly correlated to group performance were those associated with organizational hierarchy, organizational harmony, trade-offs between future and current needs, and beliefs about the influence individuals have on their fate. The type of programming task also seems to have affected the relationship between culture and team performance. As the task switched from the design phase to programming and testing activities, students who were less rigid about organizational structures and who were more "future oriented" outperformed those students who were more hierarchical and less future oriented.

This study also confirms previous research regarding the importance of developing early and frequent communication among cross-national collaborative learners (Kirchmeyer and Cohen, 1992). It also reinforces studies that highlight the difficulties of scheduling work across several time zones (Herbsleb et al., 2000). While our web-based scheduler allowed users to see the appropriate clock, calendar, and person information for their team, many students complained about the scheduling problems and delays.

While the current study offers the benefits of assessing cultural effects on team computer-supported collaborative programming, there are several weaknesses that should be acknowledged that may limit the generalizability of the findings. First, since the effects for culture depend importantly on how similar or different an individual is to others in a group or organization, the composition of the sample is a critical determinant of any findings. This means that variation or lack of variation across samples in terms of demographic composition can easily affect reported outcomes. It can be argued that the US versus Turkish sample was not particularly different

according to the means reported by the CPQ. While this is not desirable, it also means that the results can be applied to individual groups, not entire cultural groups. Second, there is a growing concern that cultural attributes, as described in [Elfenbein and O'Reilly \(2002\)](#), may be more descriptive of personality and not group traits. This means that some relational effects, such as harmony and/or future orientation, may have less to do with country orientation than personal preferences. While this remains a concern, it is a controversy that must be left to the anthropologists who specialize in this area. Finally, there remain questions about whether a two-person group, as described in this study, constitutes a “group”. It is certainly true that the dynamics of a group changes as more members are added, but it is also important to establish baseline data on the effects of culture on group communication within a small group setting before testing these theories on larger groups.

Overall, the findings reported here, both empirically and qualitatively, show that it is possible to teach groups of computer science students who are geographically distributed how to use a suite of computer-supported collaborative tools to design, program, and test programming projects. The study also demonstrates that critical to the success of such an initiative are the cultural attributes of the group, technology factors such as adequate information and scheduling infrastructure, and human resources such as training, on-site coordination support, and administrative support. Results from this study are now being used to customize the collaborative software to recognize and facilitate successful collaboration. Expert rules developed using an expert system shell have been programmed into the collaborative software to identify when a team needs help or when to tailor the interface to accommodate different profiles. During the next semester, we will be evaluating the effectiveness of our strategies by determining whether they actually minimize unsuccessful collaborations.

As several studies have observed ([Watson et al., 1993](#); [Adler, 1997](#)), diversity within teams is a reality for managers, educators, and organizations. It is also an important social value for our society. For these reasons, it is important that research clearly and accurately elucidate the true impact of culture and diversity in work-teams. This requires moving beyond studies of simple demographic effects and broad generalizations about the effects of culture on teams to understanding how these differences arise and are experienced in specific contexts. Only then will we be able to manage differences effectively and to understand in detail how demographic differences really affect individuals in different types of organizations and cultures.

## Acknowledgements

This work was partially supported by NSF Computation and Social Systems grant CSS-9988605.

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