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# Success Factors for International Students in Capstone Design Teams*

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As the number of international undergraduate students in U.S. universities grows, more students will be required to work on multicultural Capstone teams. The increase in multicultural teams is an opportunity to provide student experiences in diverse teams with their associated increase in successful, innovative solutions, if managed properly. A total of 237 previous Capstone design project teams were studied to determine relationships between the number of international students on a team and outcomes such as prototype completeness and writing grade. This database provides objective information to investigate the accuracy of anecdotal observations and to develop strategies to improve student outcomes. Other factors such as previous experience with group members, language proficiency, and whether or not a team was student formed were also investigated. Results show that international students tend to perform better on student formed teams, and that their ability to create a student formed team tends to correlate highly with English language proficiency. The results of this investigation provide insight for mentoring actions to improve student outcomes and to provide positive experiences for all students while remaining sensitive to cultural differences.

**Keywords:** international students; team formation; multicultural teams; capstone design

## 1. Introduction

Team work, particularly in the design process, is an essential skill for engineering that is taught in capstone design [1]. The literature contains a number of capstone team formation schemes that have been used over the years, including teams based on GPA, project interest, and self-selected teams [2]. Other studies have used Myers-Briggs personality testing [3] or web based tools such as CATME [4] to form teams. While some authors have found that student formed teams perform less well [5], other researchers have found that instructor formed teams have no particular advantage [6]. Many tools have been developed for dealing with difficult students [7], but these often focus on mental health issues and work ethic, without a large amount of detail on international student issues. Work on student/professor dynamics with international students notes differences in competitiveness and reluctance to ask questions between students of different nationalities, but does not specifically address group work [8]. In addition, many international team initiatives in capstone design involve two teams in separate countries collaborating on a project [9], and thus much of the work on these initiatives focuses heavily on the logistics of working across time zones and with disparate academic calendars [10]. The capstone design literature does not seem to address the integration of multiple nationalities on a capstone design team in a North American university to a great extent.

Work on managing multicultural teams in the literature focuses heavily on the corporate setting. One such study found that regardless of ethnicity, individuals who can tolerate uncertainty do well in the early stages of team formation, while those who value relationships do better later in the team process [11]. Another author observed that while some cultures value succinct style more than others, country of origin and native language cannot explain all communication style preferences [12]. Yet another study showed that surface level diversity issues such as gender and ethnicity can be overcome by individuals with a strong preference for team work, whereas issues such as individuals' sense of time urgency and degree of extraversion require more active intervention, often from outside the team [13].

The book "Managing Cultural Differences'" by Moran et al. discusses a number of factors which influence how individuals from different cultures interact in groups [14]. They referenced Hofstede's work [15] where various countries were classified based on how they viewed power distance, uncertainty avoidance, individualism, and collectivism. Power distance was defined as how accepting a society is of unequal power distribution between individuals and those in authority. Uncertainty avoidance was defined as how members of a society deal with ambiguous or uncertain situations. Individualistic societies tend to focus on taking care of themselves and their immediate families, versus collectivistic societies which value loyalty to a larger group or tribe. This book also discusses cultural factors such as whether communication is



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high context or low context, and how various cultures handle time and power structures. These factors might have an impact in how groups form teams and how successful teams will be once formed. For example, team members from cultures that expect a lot of preliminary chatting before getting down to business, or for whom being on-time is not valued, may be seen as wasting time by cultures for whom punctuality is highly valued.

A common denominator in both corporate and educational settings is the need for, and problems caused by, communication. Project work has been shown to help international students both with their English skills, and their socialization to the majority culture [16]. These studies recognize the language and cultural barriers to speaking in public which must be specifically addressed in order to allow international students to reach their potential. Native speakers can assist in the socialization process by scaffolding team assignments for the non-native speakers and taking time to work past language barriers. The role of native speakers in incorporating non-native speakers into active participation in their teams may prove to be a key factor in the ultimate success of a multicultural team. Cultural attitudes toward shame and embarrassment may prevent students from seeking to form a team for fear of rejection, or may prevent students from speaking out in team sessions. A study by Lee identified 5 main issues identified by international grad students that affect their performance in American universities [17]. These issues are: listening ability, differences in culture background, oral communication skills, vocabulary, and writing skill. Most of these are also soft skills that capstone design aims to develop in all students, and interventions that improve these skills are typically part of the capstone design toolkit. However, if student team formation occurs early in capstone design, these skills may need further development for international students prior to their arrival in the class.

## 2. Program context

The Mechanical and Industrial Engineering department at Northeastern University has a required two semester capstone design sequence. Senior students work in teams of 4–5 members, each with a faculty advisor, with the goal to produce a functional prototype at the end of the second term. Prototypes are assessed at a point, 2 weeks prior to the end of term on a 10 point scale; 5 points for completeness of the prototype at that point, and 5 points for completeness of verification and/or testing. This validated prototype scoring rubric has been presented previously [18] and has been shown to be a good representation of project quality and project management success. Students are also assessed on written and oral communication, and how well the delivered product meets the initially developed specifications. Projects can be proposed either by faculty advisors, industry sponsors, or by students themselves. Regardless of who proposes the project, the projects are vetted and approved by the capstone coordinator to ensure they are properly scoped for the available time. In addition, all projects have equal financial and technician support available.

Group formation happens at the beginning of the first term. Students are asked to form teams of 4–5 people and submit a preference form in which they rank all of the projects from most to least desirable. Students who are unable to form groups may submit preference forms as individuals, pairs, or groups of three. The instructor forms these students into teams based on project preference. An effort is made to not isolate female or international students on teams, however this is not always possible. Students or student teams who propose projects are given preference for those projects.

Two factors that may affect students' ability to form teams are the student's cohort and their prior group project experience in a required junior level Measurements and Analysis lab course. Northeastern University has a 5 year program, in order to accommodate up to three 6 month long co-op experiences. Students are split into two cohorts, and one cohort is on co-op at any given time. The majority of students remain with their cohort throughout their college experience. However, some students end up taking capstone 'out of sequence' due to various reasons. Because of this, these out of sequence students are often less familiar with their classmates, which may lead to difficulty in forming or joining teams.

The laboratory course in Measurements and Analysis is typically taken one year prior to capstone. This course requires extensive group work and an independent experimental design project. This provides students with an opportunity to work closely with some of their classmates. The ability to learn other students' skills, strengths, and weaknesses may have an influence on future group work and capstone team member choices. Although in theory students should take Measurements before capstone, some students take Measurements concurrently with capstone, and some take it after capstone.

## 3. Methods

### *3.1 Research questions*

A previous study by one of the authors [19] found that student formed teams seem to perform better on measures of passion and commitment to the

project, particularly when students choose teams based on skills and with an eye toward complementary work styles. Students who formed their own teams also tended to demonstrate more ownership of the project, which leads to more complete projects in the time allotted. The current work investigates the performance of groups containing international students. Casual observation by the instructors seems to indicate that groups with a higher percentage of international students often perform less well. However, no data had previously been collected to validate these observations. Specific questions include:

- Do student formed teams earn higher writing grades and higher prototype grades?
- Are international students more likely to be on instructor formed teams or student formed teams?
- For student formed groups containing international students, what factors lead to success?
- What are the characteristics of groups containing only international students?

### *3.2 Study demographics*

The data for this study was gathered from capstone groups that had taken the course from Spring 2011 to Spring 2016. A total of 237 groups were studied. Course records were examined to determine the number of international students on each team. The number of student and instructor formed groups were noted. Due to incomplete records, not all of the industrial engineering (IE) teams were included in the study, and there were some teams for whom the method of group formation was unknown. Students were sorted into the regions discussed in the book by Moran et al.: North America, Asia, Central and South America, Middle East, European Union, and Africa [14, pp. 251–252]. The number of groups with female students was noted, as were the number of groups that contained only mechanical engineers, those that contained only industrial engineers, and those that contained both mechanical and industrial engineers. Table 1 shows the number of groups in the various categories, along with the percentage of the total number represented by each group. Student formed groups made up 51.9% of the total, and 32.9% of the groups had at least one international student. Only 5.1% of the teams contained solely international students.

The groups were examined using ANOVA ($\alpha$ = 0.05) to determine if there was significant term-to-term variation among the teams. There was no significant difference in the number of countries represented per team (P = 0.11), the number of female students per team (P = 0.52), the average English Proficiency per team (P = 0.56), the type of team formation (P = 0.11), or the writing grade (P = 0.07) over the period of study. There were significant differences in the number of team members (P = 0.008), which can be explained by enrollment numbers — terms with only just enough projects to fit the student numbers have a larger proportion of 5 person teams. There has been a steady increase in the number of international students over time, and the difference is slightly significant (P = 0.042). As the number of international students has increased, the number of team members sharing a common native language has decreased significantly (P = 0.004). There was also a significant difference in prototype scores over the period of the study (P = 0.03). This can be attributed to a large number of teams which suffered from project scope changes in Spring 2011, as well as an unusually successful class in Spring 2013. These differences, while significant to varying degrees, did not alter the overall trends observed.

**Table 1.** Groups Studied

| | Number of Groups | % of Total Number of Groups |
|---|---|---|
| Total Number of Groups Studied | 237 | 100.0 |
| Total Number of Student Formed Groups | 123 | 51.9 |
| Total Number Instructor Formed Groups | 84 | 35.4 |
| Total Number of Groups with Unknown Formation | 30 | 12.7 |
| Total Number of Groups with at least one International Student | 78 | 32.9 |
| Total Number of Groups with at least one Student from Asia | 63 | 26.6 |
| Total Number of Groups with at least one Student from Central or South America | 27 | 11.4 |
| Total Number of Groups with at least one Student from the Middle East | 31 | 13.1 |
| Total Number of Groups with at least one Student from the European Union | 14 | 5.9 |
| Total Number of Groups with at least one Student from Africa | 6 | 2.5 |
| Total Number of Groups with at least one Female Student | 118 | 49.8 |
| Total Number of Groups with only International Students | 12 | 5.1 |
| Total Number of Mechanical Engineering (ME) Groups | 199 | 84.0 |
| Total Number of Industrial Engineering (IE) Groups | 34 | 14.3 |
| Total Combined ME/IE Groups | 4 | 1.7 |

The groups studied included a total of 1080 students, with demographics as shown in Table 2. Of the students studied, 80.8% were from North America. The largest group of international students (8.1%) was from Asia, which includes China, Japan, India, Thailand, Indonesia, and Vietnam. Students from Central and South America made up 4.1% of the total, with Mexico included with Central America. Students from the Middle East (4.9%) included those from Saudi Arabia, Iran, United Arab Emirates, Egypt, and Israel. Students from the European Union made up 1.5% of the total; Turkey and Russia were also included in the European Union tally. Finally, 0.6% of the students were from Africa. In terms of male to female ratio, 81.7% of the students were male and 18.3% were female. Age was not known or considered in the study. The time in the program, transfer student status, and other factors of that nature were not considered, nor were factors such as GPA.

In addition to the basic demographics presented above, teams were assessed on:

- Number of international students per team
- Number of different countries represented
- Number of students on team sharing a common native language
- Overall English language proficiency of students on team
- Team writing grade
- Team prototype grade
- Student involvement in team formation (0 = completely instructor formed, 1 = completely student formed)

The language proficiency of the students was assessed based on instructor observation of oral presentation and written work and was rated on a three point scale, where 1 = low, 2 = medium, and 3 = high. Specifically, individually written lab reports in Measurements, as well as the group capstone reports were examined for number of grammar and wording errors present as a measure of English language proficiency. Over the period of observation, the same instructors assessed the writing grades, English proficiency and prototype grade using the same grading rubric [18]. One instructor would assign the prototype grades, which were then discussed among the course coordinators for consistency. The instructor assigning the prototype grades was not associated as an advisor with any particular team, providing an outside perspective on the team performance.

In addition, the teams from both the previous Measurements and Analysis course and capstone were analyzed to determine how many students were on capstone teams with previous teammates. Additional data was gathered for individuals including:

- Previous experience with partners (0 = no experience, 1 = term long Measurements experience)
- Out of sequence with classmates (0 = completely in sequence, 1 = completely out of sequence)
- Order of Measurements/Capstone (0 = Measurements first, 1 = Measurements/Capstone Simultaneously, 2 = Measurements after Capstone)

All factors were examined using the Pearson Product-Moment Correlation Coefficient implemented with the Excel correlation analysis. Factors were ordinarily ranked in order to satisfy the assumptions of the Pearson's correlation analysis. Scatter plots also showed compliance with the Pearson's correlation assumptions.

## 4. Results

### *4.1 Instructor vs. student formed teams*

Table 3 shows the correlation coefficients for the various group factors. Only factors with a correlation coefficient > 0.20 are shown. Any probability $<10^{-10}$ was set to zero. Student formed teams were positively correlated with the number of students with a common language and with high English proficiency. Student formed groups were also positively correlated, although more weakly, with high writing and prototype grades. Having a student formed group was negatively correlated with both the number of international students and the number of countries represented. International students were very negatively correlated with having a high number of students with a common native

**Table 2.** Student Demographics

| | Number of Students | % of Total |
|---|---|---|
| Total Number of Students | 1080 | 100.0 |
| Total Number of Students from North America | 873 | 80.8 |
| Total Number of Students from Asia | 88 | 8.1 |
| Total Number of Students from Central and South America | 44 | 4.1 |
| Total Number of Students from Middle East | 53 | 4.9 |
| Total Number of Students from European Union | 16 | 1.5 |
| Total Number of Students from Africa | 6 | 0.6 |
| Total Number of Male Students | 882 | 81.7 |
| Total Number of Female Students | 198 | 18.3 |

language (r = –0.74). Also, as expected, the fewer students with a common language, the more countries represented (r = –0.81). Large numbers of international students on the team correlated with low English proficiency, low writing grades, and to a lesser extent low prototype scores, although the correlation with prototype scores was weak (r = –0.14). English proficiency was lower as the number of countries represented increased, and the writing grade also decreased. In general, language and country of origin factors were most significantly correlated, positively or negatively, with both group formation and outcomes.

Certain factors were found to have little or no effect on either group formation or outcomes. The number of female students seemed to have very little effect, with the exception of a slight positive correlation with writing and prototype grade. Prototype grade was in general not strongly affected by any of the factors. In particular, diversity in country of origin, number of students with a common language, and English proficiency had nearly no effect on the prototype scores when the entire data set of groups was considered. This is encouraging, as it confirms that there is no lack of engineering ability among the groups, however diverse they are. The issue seems to be more that of communication and team formation ability.

Table 4 shows key correlations when students were considered as individuals, rather than as groups. Only correlations greater than 0.20 are shown. International students were less likely to be on a team with a previous partner (r = –0.30). This is interesting because international students are unlikely to be out of sequence (r = –0.16). Out of sequence students have stated in the past that group formation was difficult, due to lack of familiarity with their classmates. Since international students are less likely to be out of sequence, one would expect that they would be more likely to form their own groups. It was found in fact that international students, again considered as individuals, were less likely to be on student formed groups (r = –0.29) and also less likely to have high writing grades (r = –0.38). International students were weakly associated with lower prototype scores (–0.14). Positive correlations with writing grades, prototype grade, and student formation of teams were seen when students were on teams with previous Measurements partners, while out of sequence students were highly negatively correlated with being on the same team as a previous partner. It would appear that previous experience with one's capstone team members leads students to be more likely to form their own groups, and also leads to improved writing and prototype outcomes. These observations may be a result of positive experiences working with the capstone team members as to internal communication among the members, similar or complementary work styles and a familiarity with

**Table 3.** Pearson's Correlation Coefficients for Group Factors

| Paired Factors | Pearson's Coefficient ($R^2$) | P-value ($\alpha$ = 0.05) |
|---|---|---|
| # International Students/Student Involvement in Team Formation | –0.34 | 0.04 |
| # Countries Represented/Student Involvement in Team Formation | –0.38 | 0.003 |
| # Students with Common Language/Student Involvement in Team Formation | 0.35 | 0.01 |
| English Proficiency/Student Involvement in Team Formation | 0.39 | 0.003 |
| # Countries Represented/# International Students | 0.83 | 0 |
| # Students with Common Language/# International Students | –0.74 | 0 |
| English Proficiency/# International Students | –0.60 | 0 |
| Writing Grade/# International Students | –0.54 | 0 |
| # Students with Common Language/# Countries Represented | –0.81 | 0 |
| English Proficiency/# Countries Represented | –0.48 | 0 |
| Writing Grade/# Countries Represented | –0.45 | 0 |
| English Proficiency/# Students with Common Language | 0.52 | 0 |
| Writing Grade/# Students with Common Language | 0.50 | 0 |
| Writing Grade/English Proficiency | 0.45 | 0 |
| Writing Grade/Student Involvement in Team Formation | 0.29 | 0.009 |

**Table 4.** Pearson's Correlation Coefficients for Individual Factors

| Paired Factors | Pearson's Coefficient ($R^2$) | P Value ($\alpha$ = 0.05) |
|---|---|---|
| Previous Partner Experience/International Student | –0.30 | 3.17E-9 |
| Writing Grade/International Student | –0.38 | 8.63E-5 |
| Out of Sequence with Classmates/Order of Measurements & Capstone | 0.32 | 0 |
| Out of Sequence with Classmates/Previous Partner Experience | –0.63 | 0 |
| Writing Grade/Student Involvement in Team Formation | 0.39 | 0 |
| Student Involvement in Team Formation/International Student | –0.29 | 2.07E-8 |
| Previous Partner Experience/Order of Measurements & Capstone | –0.22 | 1.9E-6 |
| Writing Grade/Previous Partner Experience | 0.29 | 1.88E-8 |
| Prototype Grade/Writing Grade | 0.28 | 3.55E-8 |

each other. It is also possible that the students who had a negative experience with team members in Measurement and Analysis avoid forming capstone teams with them. Overall, the international students seem less likely to join a team with a previous partner, which indicates a need for some sort of intervention.

### *4.2 Teams with international students*

Teams containing at least 1 international student were considered as a subgroup, with the regions of the world represented on each team considered in detail, as shown below in Table 5. There were no strong correlations between any particular region and whether the team was student formed, although there was a slight negative correlation with more students from the European Union. Students from Central and South America, and the Middle East were strongly correlated with groups that had large numbers of international students, and all regions except for Asia tended to be positively correlated with a large number of different countries on the team. Asian students were slightly positively correlated with having more students sharing a common language on the team, whereas Central and South American, European, and African students were negatively correlated with a common language. Of the groups of international students, those from Africa were a very small subset (See Table 1). English proficiency for the group as a whole tended to be slightly higher on teams with Asian students ($r = 0.27$), but this may be attributed to students being on teams with multiple North American students. Writing grades had a negative correlation with the number of Central and South American students but a positive correlation with the number of Middle Eastern students, which may be a reflection on English language instruction in their home countries or historical common use of English as a second language (See Section 5 for further discussion). Since high prototype grades and high writing grades are positively correlated for teams with international students, it is a benefit to have groups with the ability to communicate their ideas in English. For teams with international students there is a weak negative correlation with prototype scores ($r = –0.29$) which seems to support this idea.

A single factor ANOVA was performed comparing prototype scores between groups with 0, 1, 2, 3, 4, and 5 international students. Significant differences were found between the prototype scores ($P = 0.009$) and the writing scores ($P = 0$) when all groups were considered. Further examination showed that differences in prototype scores between groups containing 0–3 international students were not significant. However, teams containing 4 or 5 international students did have significant differences in prototype scores. For writing scores, any number of international students produced writing scores with significant differences compared to groups with 0 international students.

### *4.3 Student formed teams with international students*

Teams that had international students and were able to form teams on their own were examined as a subgroup. These teams had an average of 2.6

**Table 5.** Correlation Factors for Teams containing International Students

| Paired Factors | Pearson's Coefficient ($R^2$) | P value ($\alpha = 0.05$) |
|---|---|---|
| # International Students/# Central & South America | 0.49 | 1.25E-6 |
| # International Students/# Middle East | 0.62 | 0 |
| # Countries Represented/# Africa | 0.35 | 0.0004 |
| English Proficiency/Student Involvement in Team Formation | 0.30 | 0.003 |
| # Countries Represented/# International Students | 0.53 | 1.93E-7 |
| # Students with Common Language/# International Students | –0.41 | 1.76E-5 |
| Writing Grade/# International Students | –0.43 | 4.7E-6 |
| # Students with Common Language/# Countries Represented | –0.60 | 0 |
| Writing Grade/# Students with Common Language | 0.30 | 0.003 |
| Writing Grade/English Proficiency | 0.38 | 0.001 |
| Prototype Grade/Writing Grade | 0.33 | 0.002 |
| English Proficiency/# Asia | –0.27 | 0.005 |
| # Countries Represented/# Central & South America | 0.28 | 0.003 |
| # Students with Common Language/# Central & South America | 0.26 | 0.007 |
| Writing Grade/# Central & South America | –0.24 | 0.01 |
| Prototype Grade/# Central & South America | –0.22 | 0.02 |
| # Countries Represented/# Middle East | 0.22 | 0.03 |
| Prototype Grade/# Middle East | –0.22 | 0.03 |
| # Countries Represented/# European Union | 0.20 | 0.04 |
| # Students with Common Language/# European Union | –0.25 | 0.009 |
| # Students with Common Language/# Africa | –0.29 | 0.002 |
| # Students with Common Language/Student Involvement in Team Formation | 0.28 | 0.006 |
| Prototype Grade/Student Involvement in Team Formation | 0.23 | 0.02 |
| English Proficiency/# International Students | –0.28 | 0.003 |
| Prototype Grade/# International Students | –0.29 | 0.002 |

**Table 6.** Correlation Factors for Student-formed Teams containing International Students

| Paired Factors | Pearson's Coefficient ($R^2$) | P Value ($\alpha = 0.05$) |
|---|---|---|
| **Statistically Significant Correlations** | | |
| # Central & South America/# North America | –0.33 | 0.04 |
| # Middle East/# North America | –0.66 | 5.35E-6 |
| # International Students/# North America | –0.94 | 0 |
| # Students with Common Language/# North America | 0.43 | 0.006 |
| English Proficiency/# North America | 0.40 | 0.01 |
| Writing Grade/# North America | 0.56 | 0.0002 |
| # International Students/# Central & South America | 0.32 | 0.04 |
| # Students with Common Language/ Central & South America | –0.39 | 0.01 |
| # International Students/# Middle East | 0.69 | 1.33E-6 |
| Writing Grade/# Middle East | –0.34 | 0.03 |
| # Countries Represented/# European Union | 0.48 | 0.001 |
| # Students with Common Language/# European Union | 0.41 | 0.008 |
| # Students with Common Language/# International Students | 0.32 | 0.05 |
| English Proficiency/# International Students | –0.37 | 0.02 |
| Writing Grade/# International Students | –0.50 | 0.001 |
| # Students with Common Language/# Countries Represented | –0.62 | 2.75E-5 |
| Writing Grade/English Proficiency | 0.58 | 9.83E-5 |
| # Central & South America/# Asia | –0.49 | 0.001 |
| # Middle East/# Asia | –0.37 | 0.02 |
| **Statistically Insignificant Correlations** | | |
| # Countries Represented/# Central & South America | 0.27 | 0.10 |
| English Proficiency/# Middle East | –0.27 | 0.10 |
| # International Students/# European Union | 0.20 | 0.22 |
| # Countries Represented/# Africa | 0.27 | 0.09 |
| # Students with Common Language/# Africa | –0.26 | 0.11 |
| # Countries Represented/# International Students | 0.21 | 0.20 |
| Writing Grade/# Students with Common Language | 0.23 | 0.16 |
| Prototype Grade/# Students with Common Language | –0.20 | 0.23 |
| Previous Partner Experience/# Countries Represented | –0.26 | 0.19 |
| Prototype Grade/Writing Grade | 0.28 | 0.08 |

North American students on the team and an average of 1.9 international students per team, with an average of 4.5 total students per team. There was an average of 2.2 different countries per team, and an average of 3.1 students with a common native language. The English proficiency of these teams tended to be high as well, with an average English proficiency of 2.5/3. The basic makeup of these teams indicates that students with moderate diversity, good English proficiency, and team members with whom they share a common native tongue tend to be on student formed teams.

The correlation factors for the student formed teams with international students can be found in Table 6 below. In Table 6, the statistically significant correlations are separated from the insignificant correlations located at the bottom of the table. Moderate to strong positive correlations existed between the number of North American students and the number of people with a common language, English proficiency, and writing grade, which is to be expected. There were also moderate to strong correlations between the number of international students and the number of students from Central and South America (r = 0.32) and the number from the Middle East (r = 0.69), with a slight, and insignificant, correlation between number of international students and those from the European Union (r = 0.20). This would seem to indicate that students from these three regions have a tendency to end up on teams with fewer native English speakers. It should be noted however that while students from Central and South America and the European Union tend to be positively correlated with more countries represented, students from the Middle East have a weak negative correlation with the number of countries represented. This would indicate that students from the Middle East tend to cluster with other Middle Eastern students. The correlations seem to indicate that Asian students are more likely to be isolated on teams with North American students, and are less likely to be on teams with Central and South American or Middle Eastern students. Writing grades were positively correlated with the number of North American students, and most negatively correlated with the number of total international students and the number of Middle Eastern students. This may be explained by the Middle Eastern students tending to congregate on teams in larger numbers, leaving fewer native English speakers to rely on for writing. Although the correlations were not significant, there was some evidence that teams which had previous experience with a team member tend to be less diverse in terms of number of countries. This fits the observations of the authors as well.

### *4.4 Teams containing only international students*

Table 7 shows the correlation factors for the teams with only international students. This subset is a small sample size compared to the other subsets investigated in this study, and thus generated less significant results. However, the authors felt that it was important to investigate these correlations for the small subset. Of the teams studied, 12 were composed solely of international students. There were 6 student formed teams, 5 faculty formed teams, and 1 team of unknown formation. This subgroup had an average English proficiency of 1.83/3 and had an average of 2.58 people on the team with a common language. The average number of countries represented was 2.60. There were 5 teams that had only one region represented: 1 team with Asian students, 1 team from Central and South America, and 3 teams from the Middle East. The Asian and Middle Eastern teams were student formed, while the Central and South American team was instructor formed.

Asian students were highly unlikely to work with Central and South American or Middle Eastern students, and also highly unlikely to have high English proficiency. However, this did not seem to strongly influence their writing or prototype grades. This is an interesting observation, and one not readily explained. Central and South American students were highly unlikely to be on teams with Middle Eastern students, and were highly unlikely to be on student formed teams or with many students with a common language. Consequently, Central and South American students were found to be on teams with a large number of countries represented. The prototype scores were also negatively correlated with more Central and South American students. Middle Eastern students tended to cluster on student formed teams, where they shared a common language and a higher English proficiency. European Union students tended to be on faculty formed teams, with a large number of countries represented and few students with a common language. However, there were strong positive correlations with the number of European Union students and prototype scores. There were very few students from Africa in the study and usually appeared as lone students in a given term. African students tended to be on faculty formed teams which were diverse and had few students on the team with a common language. The number of African students was negatively correlated with both writing and prototype grade. The more students with a common language, the more likely the team was to be student formed ($r = 0.60$), which seems to speak to communication being one of the most necessary factors in team formation.

**Table 7.** Correlation Factors for Groups with Only International Students

| Paired Factors | Pearson's Coefficient ($R^2$) | P Values ($\alpha = 0.05$) |
|---|---|---|
| **Statistically Significant Correlations** | | |
| English Proficiency# Asia | –0.91 | 3.94E-05 |
| # Students with Common Language/# Countries Represented | –0.77 | 0.003 |
| # Countries Represented/Student Involvement in Team Formation | –0.55 | 0.04 |
| **Statistically Insignificant Correlations** | | |
| # Middle East/# Asia | –0.56 | 0.06 |
| # Students with Common Language/# European Union | –0.56 | 0.06 |
| # Students with Common Language/# Africa | –0.56 | 0.06 |
| # Students with Common Language/Student Involvement in Team Formation | 0.60 | 0.07 |
| Prototype/Student Involvement in Team Formation | 0.49 | 0.08 |
| English Proficiency/# Middle East | 0.49 | 0.1 |
| # Middle East/# Central & South America | –0.49 | 0.11 |
| Student Involvement in Team Formation/# Central & South America | –0.42 | 0.14 |
| Writing Grade/# Africa | –0.43 | 0.17 |
| Prototype Score/# European Union | 0.41 | 0.18 |
| # Countries Represented/# Central & South America | –0.4 | 0.2 |
| #Students with Common Language/# Middle East | 0.39 | 0.2 |
| # Students with Common Language/# Central & South America | –0.35 | 0.27 |
| # Countries Represented/# European Union | 0.34 | 0.28 |
| # Countries Represented/# Africa | 0.34 | 0.28 |
| Student Involvement in Team Formation/# European Union | –0.35 | 0.34 |
| Student Involvement in Team Formation/# Africa | –0.35 | 0.34 |
| Student Involvement in Team Formation/# Middle East | 0.37 | 0.36 |
| # Central & South America/# Asia | –0.28 | 0.39 |
| Prototype Grade/# Africa | –0.27 | 0.39 |
| Writing Grade/# European Union | 0.27 | 0.4 |
| Prototype Grade/Writing Grade | 0.26 | 0.42 |
| # European Union/# Middle East | –0.23 | 0.48 |

## 5. Discussion

Asian students in this study tended to be reluctant to form teams, with few exceptions. When on teams that included North American students, Asian students tended to be relatively isolated, with only 1 or 2 Asian students. This was despite efforts made by the instructor to group Asian students together as much as possible. Initially, it seems as if Asian students had a reasonably high English proficiency, but this is due to the averaging effect of 1 Asian student combined with 3–4 North American students. Upon examining Asian students in teams without any North American students, the English proficiency is rather low, and there are no particular benefits or drawbacks seen in the prototype or writing scores. It was also observed that Asian students who did form teams tended to be more proficient in English, and also slightly more likely to be on a team with a previous team member from Measurements. This may indicate that Asian students who have strong English communication skills are able to form lasting connections with other students which contribute to their being sought out by other students when the time comes for team formation.

Middle Eastern students form their own teams more readily, and often with an eye toward working with other Middle Eastern students. This may make them more comfortable, but may deny them some of the benefits of diversity which could improve their prototype and writing scores. Central and South American students are much less likely to form their own teams. This may be due to variance in English language instruction in the countries of origin. Middle Eastern countries increasingly emphasize English as a foreign language starting as early as Kindergarten [20]. In Central and South America English language instruction varies wildly from country to country. For example, Venezuela begins basic English language instruction relatively early [21], but Mexico tends to delay it until later and English instruction is not universal [22]. The role of English language use is different between Middle Eastern and Central and South American countries, which may impact their interactions with other students during the team formation process.

Several interventions have been proposed by the authors in order to assist students in team formation, with the realization that much work needs to be done prior to the beginning of capstone. Currently students take a course in Technical Writing in the Discipline that comes relatively late in their college career. Moving this course earlier in the curriculum, followed by additional writing intensive laboratory classes in subsequent terms will provide international students additional time to improve their written English skills prior to capstone. Adding more opportunities for oral presentation, either as individuals or groups, would also provide students with the skills that seem to lead to student team formation. However, improved English skills may not overcome the reluctance of North American students to actively seek international team members, nor give the international students the ability to overcome ingrained cultural behaviors that prevent them from taking a more active team formation. Actively promoting a diverse team to the North American students emphasizing the benefits that are associated with a diverse team is another avenue to overcome this barrier. The prerequisite design course and previous project course could include a section on team formation and introduce the students to the benefits of having a diverse team.

An idea that could potentially bridge some of the cultural and language gaps within the capstone course itself would be to use social media. It has been proposed to establish a Facebook page or similar social media outlet that would introduce potential capstone project topics and team formation suggestions well in advance of the start of the course. This would allow students to seek other students with common interests in a less threatening environment where spoken English would not hinder understanding. It would also provide an opportunity for students to build on prior team partnerships in other courses. Another idea would be to present the projects initially as an interactive poster session, so that students will meet and mingle with other students who have similar project interests. This would be a change from the usual PowerPoint style presentation of the projects, and would be a natural way for students to find others with common interests.

## 6. Conclusions

Multicultural students are entering North American universities at increasing rates. The increase in multicultural teams provides students with experiences working in diverse teams and can lead to innovative solutions if managed properly. The 237 design groups over 5 years were studied from the perspective of what affects the success of multicultural teams in capstone design. The collected data suggests that having students form their own teams leads to more successful projects. English proficiency seems to aid with both project success and group formation. Diversity of viewpoints does have a positive effect on outcomes, particularly when coupled with the ownership of the project found in student formed teams. International students who have higher English proficiency tend to form their own groups. Students from countries in

the Middle East were particularly able to form their own groups, however there is evidence that some multicultural groups had difficulty forming or joining teams. This indicates that intervention prior to capstone in the form of increased team work, English language presentation, and opportunities for social networking among students is needed to improve the experience for all capstone students.

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