

Emotional intelligence provides indicators for team performance in an engineering course

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As the Architectural Engineering and Construction (AEC) industry embraces new ideas and new technologies, there is an escalated need for integration. Unfortunately, the incorporation of highly functional collaborative skills within a team-like framework is not often a specific focus in collegiate engineering classes. This contrasts with industry, where an increased awareness of the advantages of teams and collaboration skills is well appreciated. This paper provides an introduction to emotional intelligence (EI) and the importance of EI to the AEC community. Here, we describe an exploratory study, which was undertaken to identify which EI traits of students were linked to success in a team-based undergraduate construction engineering course. Ninety-five students were randomly divided into teams to complete projects during the Spring 2008 semester. Individual exam scores, project scores, and team member evaluations were compared with individual trait assessments, using the Bar-On Emotional Quotient Inventory (EQ-i). The resulting analysis identifies specific individual team member traits that may lead to improved performance in team projects. The relationship between team performance and EI was explored from a three-pronged perspective, using the mean, the maximum and the range of each of the aggregated EQ-i components for the team as a whole. The results showed three areas with significant correlation to team performance, with all three involving the range of team-aggregated EQ-i traits. The outcomes suggest a balance in a team, when team selection is based on EI scores, can impact team outcomes. The results of the study will be used to improve professional and collaborative skills in the undergraduate engineering curriculum at Penn State and may be extended to other institutions.

Keywords: Emotional intelligence, engineering education, high-performance teams.

Introduction

To design and construct nearly any facility, a team of individuals must work together. With the increased interest and usage of integrated organizational structures, be they design-build (DB), integrated project delivery (IPD), or other contract methods, the interdisciplinary relationships that require collaborative competencies are growing in complexity. The development of different versions of IPD contracts suggests both a strong interest in and general acceptance of these integrated approaches (Leicht *et al.*, 2011).

As the Architectural Engineering and Construction industry embraces new ideas, such as IPD, and the use of new technologies, such as building information

modelling tools, there is an increasing overlap of information and communication, resulting in an ever-increasing degree of interdisciplinary interaction (Fox *et al.*, 2010). A person in a complex field cannot always understand all of the technical problems they face, and thus, it is widely accepted that ‘the more complex the job, the more emotional intelligence matters’ (Goleman, 1998). As the level of complexity of the architecture, structure and building systems increases, the need for coordination and communication between disciplines grows (Leicht *et al.*, 2009). This increased interaction has created the need for improved team and collaboration skills. Bucciarelli (1994) suggested a framework for approaching collaborative work. In this ‘social process of design’ employees are divided into teams, wherein they define

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problems and work together to develop solutions. Individual team members may possess their own collections of technical expertise; however, to be brought to bear, these understandings must be communicated effectively to the rest of the team. The resulting completed design thus represents the culmination of those understandings, and not simply a summation, of the participants' individual intellectual contributions. Unfortunately, the collaboration and teamwork skills that engender this communication are often not a focus within an architecture, engineering or construction student's curricula.

Here, we describe an exploratory study that was recently completed which was designed to gain a better understanding of how the individual traits and competencies of a single person relate directly to the performance of their team during an engineering project. The study was piloted in the Spring of 2008 in an undergraduate Architectural Engineering course entitled *Introduction to the Building Industry*. The primary objective of the course was for students to learn and apply principles for planning and managing construction projects. The course incorporated concepts from business, project organization and contracting methods and covered problem-solving methods for topics such as cost estimation and critical path method scheduling. The class was organized into three learning modules, each culminating with a project submission and exam. Each team of students provided a submission to each of the three projects, and the same teams persisted throughout the semester.

To perform the exploratory study emotional intelligence (EI) was evaluated as a set of independent variables, which was coupled with assessment of both the individual and team performance. The use of EI was chosen because it has been successfully employed in both the construction industry (Darnell, 2004; Butler and Chinowsky, 2006) and other academic settings (Crowley *et al.*, 2001). The following research questions were identified to guide the analysis of the results:

Do a higher total EI scores for individual team members correspond to a higher performance outcome of a team as a whole?

Do higher individual technical competencies (e.g. exam scores) for individual team members translate to a higher team performance?

Are there other individual traits or competencies that are indicative of higher performing teams?

History and development

EI was promulgated by Goleman (1995) after being coined by Salovey and Mayer (1990) as a form of

social intelligence, based on the rationale that there are multiple types of intelligence (Cerniss, 2000). Bar-On (2006), developed a common measurable test for EI, and describes emotional-social intelligence as 'a cross-section of interrelated emotional and social competencies, skills and facilitators that determine how effectively we understand and express ourselves, understand others and relate with them, and cope with daily demands'. That is, EI is the ability to recognize, understand and cope with personal emotions, as well as those of others, and the relationships between them (Goleman, 1998). The scientific explanation of EI is based on the concept that every thought that occurs in a brain has an associative emotional response (Goleman, 1995). These responses are developed before the brain has started its analytic processing to understand a thought. The brain is predisposed to this reaction because its neurons are wired to go through the emotional sentinel of the brain, the amygdala, before being processed through the neocortex (Goleman, 1995). To characterize EI Bar-On uses five subscales: intrapersonal, interpersonal, stress management, adaptability and general mood. These five main subscales of the EI have additional subcategories to them, each with associated competencies and skills, as illustrated in Table 1 (Bar-On, 2006).

Academic environment and performance

In an academic setting, problem-solving skills are learned in technical majors, such as engineering. This type of education is an example of intellectual intelligence, which is measured by the intelligence quotient (IQ) (Brown, 2003). Majors established in the liberal arts are still cultivated on personal and social competencies. Studies of this nature are considered along the lines of creative intelligence, also known as EI quantifiably measured by the emotional quotient (EQ). The ability to effectively test for EQ is a debated topic amongst psychologists. One notable EI measurement technique is the Multifactor Emotional Intelligence Scale, yet it is a performance-based test using the results of twelve, time-intensive tasks (Van Rooy and Viswesvaran, 2004). In general, the most common measurement tool for EI is the Bar-On Emotional Quotient Inventory (EQ-i). The EQ-i is a validated, self-perception instrument composed of a 133-question survey on a five-point Likert scale. The subscales and subcategories of the EQ-i reflect the same titles of competencies and skills per describing EI in Table 1 (Bar-On, 1997). The EQ-i results are delivered through a third party calculator and reported at three different levels: the total EQ-i score, each subscale score and each subcategory score. For the purposes of this analysis, only the total EQ-i score and each subscale score were statistically

Table 1 Emotional intelligence subscales

Subscales	EI	
	Subcategories	Meaning
Intrapersonal	Self-regard	'Ability to respect and accept oneself as basically good'
	Emotional self-awareness	Ability to recognize one's feelings and share them appropriately
	Assertiveness	Ability to express feelings, beliefs, thoughts and to defend one's rights in a constructive manner
	Independence	Ability to be self directed and free from emotional dependency
Interpersonal	Self-actualization	Ability for one to realize their potential and to be generally satisfied with their life
	Empathy	To be aware of, understand and appreciate the feelings of others
	Social responsibility	To be a cooperative, contributing and constructive member of a group
Stress management	Interpersonal relationship	'Ability to establish and maintain mutually stratifying relationships'
	Stress tolerance	Ability to not fall apart when adverse and stressful situations occur
Adaptability	Impulse control	Ability to resist or delay an impulse, drive or temptation to act
	Reality-testing	Ability to see the real situation, not being overly optimistic or pessimistic
	Flexibility	Ability to adjust one's emotions, thoughts and behaviour as a situation changes
General mood	Problem-solving	Ability to identify and solve problems and implement effective solutions
	Optimism	Ability to look on the bright side, maintain a positive attitude, even when faced with adversity
	Happiness	Ability to feel satisfied with life, to enjoy oneself and others, to have fun

analysed. The various EQ-i scores appear similar to those of an IQ score, with a mean of 100 and range of normal functionality between [90, 110] (Bar-On, 1997). The EQ-i scores can change based on the learned experiences and improved with time, hence why EI develops with age (Goleman, 1999; Brown, 2003). Culver describes the learning of EI in a four-stage process: (1) unaware of absent EI skills, (2) becoming aware of EI skills, (3) a conscious practice improvement on specific EI skills and (4) unconsciously acting upon the improved, specific EI skill (Culver, 1998). To refine and enhance EI skills on an individual basis can improve collaboration and communication skills (Butler and Chinowsky, 2006; Sunindijo *et al.*, 2007). It is important then to consider these dynamic EI skills and their implications to a job, leadership and teams (Cerniss, 2000; Newsome *et al.*, 2000).

Within a decade of Goleman's New York Times and The Wall Street Journal bestseller book, 69 independent studies have reported a direct correlation to performance and EI (Van Rooy and Viswesvaran, 2004). For example, a study conducted on the Norwegian Navy, found that more research should be considered with relating personality, leadership and EI in prospective design (Eid *et al.*, 2007). Additionally, a recent pursuit with the US Air Force proved that millions of dollars could be saved if using EI as an indicator of completing a rigorous, 2-year training programme (Bar-On,

2010). When examining phases of group development and their implications, EI was found to be a prominent factor between leaders and their subordinates (Agazarian and Gantt, 2003). Collaborative and communication skills are vital to the success of an organization, and Butler and colleagues provided evidence that EI and these transformational leadership skills can help keep a company competitive (Butler and Chinowsky, 2006). Furthermore, it was proved that EI's effect on leadership effectiveness based on performance was directly correlated, though at a modest level (Rosete and Ciarrochi, 2005). Yet, when looking at an individual performance, between testing EI's influence with respect to two models measuring emotional perception and facilitating cognition, the results were inconclusive (Lyons and Schneider, 2005). With respect to the engineers and construction managers, EI can have an even more substantial impact based on the complexity of the tasks (Goleman, 1998). Sunindijo *et al.* (2007) discovered that individuals with higher EQ-i scores tend to have traits that stimulate team performance. When assessing these project manager and engineers, the researchers explained that the traits of open communication, ability to delegate and more motivated leadership styles emerged. The focus of this paper is on EI and how team profiles can potentially impact the success of a project team in the academic construction engineering curriculum.

In 2000, Newsome et al. published an article that concluded that there was no statistical significance between EQ-i and academic performance (Newsome et al., 2000). Bar-On refutes this (Newsome's) result based on a small sample size and presents four independent studies conducted in South Africa, Canada, and the USA that demonstrate evidence to the contrary (Bar-On, 2006). In addition, the compilation of these studies results suggests that the EQ-i survey has indeed identified and predicted successful students in an academic setting. The academic settings of these four tests varied from high school (Canada) to general university students (South Africa) to freshman communication majors at American university (USA). Bar-On (2006) continues to explain that the EQ-i results should be used in an academic environment 'in identifying students who are in need of guided intervention'. Yet, it is difficult to establish where EI is learned. Although certain curricula in universities and colleges are adapting to incorporate the concept of EI as a 'soft skill', it is difficult to understand how EI grows within the higher realms of academia. A longitudinal study at the University of Colorado at Boulder tested the growth of EI throughout 50 student's academic careers (Brown, 2003). The results indicated that EQ-i growth only changed during the first 2 years of the student's undergraduate experience, but not the remaining time until graduation (Brown, 2003). This exploratory study investigates the relationship between project teams and EI in an undergraduate construction engineering curricula.

Methodology

Experimental design

To study the potential impact of EI traits and competencies on team performance, an exploratory study was undertaken. An undergraduate course in architectural engineering, *Introduction to the Building Industry*, was used to evaluate the current status of EI competencies in the undergraduate population and to begin exploring the potential impact that individual member EIs may have on team performance on projects. The course utilized both individual examinations and team projects to evaluate students' performance. The course was divided into three main subject areas: Topic #1: Industry Overview and Project Delivery Methods, Topic #2: Construction Estimating and Topic #3: Construction Scheduling. Each portion of the course had a team project and an individual examination. Randomly assigned four-member teams worked together on all three projects throughout the semester. The course was restricted to third-year students in architectural engineering, and

had the following demographics: 95% 20–21-year-old students, 80% male students and over 95% Caucasian students. Of the 95 students in the course, 35% had some construction or design-related industry experience, typically less than three months.

To assess the current status of the students' EI competencies, the students were asked to take the EQ-i. Of the 95 students in the course, 94 students took the assessment. The assessments were taken in the second month of the course. The overall results and individual scores were provided to the students at the end of the course for their own edification, shortly before submission of the final team project. In addition to assessing the students EI competencies, the students were surveyed regarding the team's interaction after submission of each of the three projects, prior to receiving their project grade. The timeline for the course projects, examinations, feedback and EI data collection is illustrated in Figure 1. Each post-project survey asked the students to evaluate both themselves and their team members on six characteristics related to their contribution to the project, using a five-point Likert scale ranging from strongly disagree to strongly agree, for the following statements based on (Riley et al., 2008):

- contributed ideas to the project;
- attended meetings;
- initiated activities to complete assignment;
- accountable to complete tasks;
- asked for group feedback on their work;
- deserves equal credit for group work.

Converting individual scores into team scores

For each of the five subscales categories of the EQ-i test (intrapersonal, interpersonal, stress management, adaptability and mood), the scores from individual team members were combined together to generate statistics for their team as a whole. Thus, each team acquired three metrics for each EQ-I subscale: a mean team member score, a range of scores, and a maximum score of its members. Together these metrics are referred to as the team subscale scores.

In addition to this objective measure of team EI, the individual group members were asked to give other ancillary evaluations, which were then used to generate a subjective measure of the team's ability to operate effectively. For each project, individual group members were asked to evaluate both their own performance and the performance of their collaborators, using a survey of six questions with a Likert scale (see Methods section). The scores an individual gave to his or herself after each project on this survey, regardless of the particular survey question were averaged together to yield an average 'self-score' for that student. Similarly, the evaluation scores of that

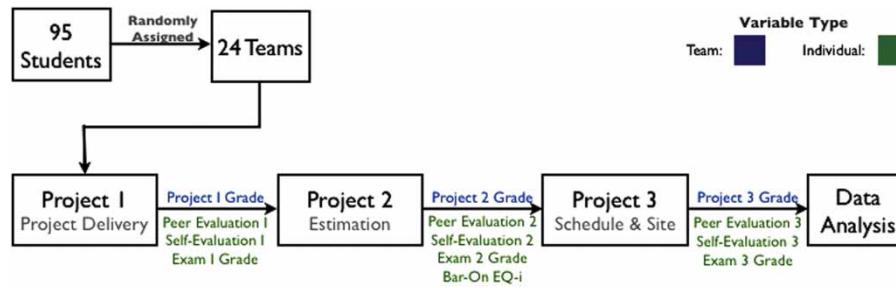


Figure 1 Sequence of data collection of team and individual variables

student provided by his or her teammates following every project were also averaged to give the student an average ‘peer score’. The difference between a student’s peer score and his or her own self-score was also tracked, a value referred to as the ‘agreement score’ for that student. These three student metrics for each member of the team were averaged together for all three projects to give the team a ‘team peer score’ (PS), ‘team self-score’ (SS) and ‘team agreement score’ (AS). Together, these three team values are referred to as a team’s subjective properties.

Two final objective measure of team performance were also recorded, namely the ‘team intelligence score’ (TI) and the ‘team project grade’. Three exams were given over the course of the semester, and each student took the examination individually, without collaborating with their teammates. The TI was simply the average of each team members’ examination scores throughout the semester. The team project grade was an average of the grades the team received on its projects throughout the semester. The team project grade was the response variable, which was chosen to judge a team’s overall effectiveness.

For clarification purposes, Table 2 was established of the summary variables being utilized throughout this exploratory data analysis, along with an explanation of their meaning.

Data cleaning

A total of 95 architectural engineering students were enrolled in the course, and thus eligible for analysis, however, one student did not complete the EI score evaluation. The student’s self- and team-evaluation scores were, however, still included in the analysis in order to prevent the exclusion of data for the entire team and its other members. Other notable areas of incomplete data were in the students’ peer and self-evaluations. An acceptance criterion was, therefore, established that at least two members of each team must have data present throughout the semester to have their data be included in the final analysis. The

data from one three-person team was eliminated due to this condition. Statistical analysis of the final model results showed that these omitted results would not have significantly altered the conclusions that were drawn from the data.

Based on the 94 data points, there was high variability in the time students took to complete the 133-question EI survey. The longest total time to complete the Bar-On EQ-i was approximately 72 min and the shortest was 90 s. A major concern, therefore, became that 18% of students completed the Bar-On exam in suspiciously short time, i.e. less than 10 min. To locate potentially skewed trends in the Bar-On data from these students, the correlations between the total time to complete the Bar-On and all the EI scores were calculated. Weak linear relationships were found between total time taken and the following EI subscales: intrapersonal, emotional self-awareness, assertiveness, and flexibility, with the linear correlations in these areas between -0.260 and -0.235 . These weak negative linear relationships indicate that individuals who took a longer time to complete the examination were slightly more likely to have weaker scores in these areas. Notably, the subscale of ‘Inconsistency Index’ that is associated with each student’s EI scores was found to have a correlation of 0.093 , suggesting nearly no relationship to time. Although these weak trends with time were noted, none exhibited a correlation which was deemed statistically significant (i.e. above 0.7), thus all student data were included regardless of the total time associated with their Bar-On exam completion. This deduction is validated based on the fact that the EQ-i questionnaire would be a poorly designed assessment if time to take the test were a significant factor, which it is not.

The use of gender and age were not included in the data analysis. Gender, a binary variable, made little sense to be aggregated from an individual level to the team level, particularly with the small percentage of female students in the course. Age had little variability and was thus eliminated from the analysis based on the homogeneity of the students.

Table 2 Summary of emotional intelligence variables

Categorization	Variable	Meaning
	<i>Mean</i>	
Team subscale scores	Intrapersonal	Mean aggregation method for the subscales of the EI and subsequent EQ-i
	Interpersonal	
	Stress management	
	Adaptability	
	Mood	
	<i>Maximum</i>	
	Intrapersonal	Maximum aggregation method for the subscales of the EI and subsequent EQ-i
	Interpersonal	
	Stress management	
	Adaptability	
	Mood	
	<i>Range</i>	
	Intrapersonal	Range aggregation method for the subscales of the EI and subsequent EQ-i
	Interpersonal	
	Stress management	
	Adaptability	
	Mood	
Team subjective properties	Peer score ^a	Average team members' peer evaluation per project
	PS	Average peer score per semester (three projects)
	Self-score ^a	Average team members' self-evaluation per project
	SS	Average self-score per semester (three projects)
	Agreement score ^a	Difference of peer score minus self-score
	AS	Average agreement score per semester (three projects)
TI	TI	Average of team members' exam score per semester (three exams)
Team project grade	Team project grade	Average of team members' project score per semester (three projects)

^aNot analysed, simply shown to improve understanding of calculations of PS, SS and AS.

Analysis and results

The data were analysed using two complementary techniques described below. Briefly, the first technique involved determining whether clusters of teams existed which all shared similar traits, and whether a given cluster resulted in a more effective team (i.e. a higher average team project grade for the semester). For simplicity, in this cluster analysis, no EQ-i scores were taken into account. In the second analysis method, an analysis of covariance (ANCOVA) model was performed. An ANCOVA is used to test the combination of categorical factors and continuous data, known as covariates, in a model. This ANCOVA model evaluated the possible statistical significance of any team characteristics (a factor), exam scores (covariate), and EQ-i scores (covariate). Thus, more simply stated, the first analysis determined the presence of any obvious indicators of team performance, whereas the second more statistically vigorous analysis would tease out the more subtle influences of EI on team performance.

Cluster analysis

To comprehend a team's performance, the classification of how the team functions on variables external to EI scores was examined. With the correlations demonstrating a moderate linear relationship (0.572–0.772) suggests that the group size, TI, PS and AS variables were appropriate for team classification. A Wards clustering analysis utilizing an iterative pairwise comparison of Euclidean distance batched the 24 teams by maximizing the distance from dissimilar groups, while minimizing the distance amongst similar groups (Garson, 2008). To appropriately use the Wards clustering algorithm, a set number of groups was given in order for the iterations to terminate. The result was four main team classification types, summarized in Table 3: high-performing teams, over-rated teams, hardworking teams and low-performing teams.

High-performing teams had the highest TI, the highest PS scores and the tightest AS range, the

Table 3 Team classification clustering results

Team performance classification	Overall PS	Overall AS	Team intellect
High	[4.66, 4.97]	[-0.16, 0.11]	[88.00, 94.89]
Overrated	[3.98, 4.57]	[-0.48, -0.03]	[83.92, 89.42]
Hardworking	[4.66, 4.98]	[-0.14, -0.02]	[82.67, 85.50]
Low	4.04	-0.7	79.67

complete opposite of the low-performing teams. The overrated teams quantified their level of work much higher than displayed by their team performance outcomes, while still maintaining a respectable TI. The hardworking teams had half the intellect range of the overrated team, yet outperformed them with a higher PS and a tighter AS range. These classification results introduced a new variable of team characteristic, based on the group type, seen in Table 3. Note that because the low-performance team significantly underperforms, and because there was only one team within this classification, this classification category is not included in the variable team characteristic. Hence, the team characteristic is a factor composed of three different performance groups: (1) high, (2) overrated and (3) hardworking. There is a noticeable tendency, in Figure 2, which depicts the downward trend of the average project scores per team characteristic.

Statistical analysis

The major question of interest explored in the following analysis then became: which of the nineteen-team characteristics (five-team subscale scores per the three types of aggregation, three-team subjective properties and one-TI) significantly affected the chosen response variable, which was the team project grade. The analysis was performed using an ANCOVA, with Team ID ran as the random variable, to find the solution to the Equation 1. The statistical significance of each input variable was tabulated three times: the mean (Equation 1) and altered with two other types of team EQ-i subscale scores, maximum and range. Note, the only variables that remained the same were the team project grade (average of all three project grades) and the team characteristic (the categorical factor). Interactions between the factors and the covariates were included in the model to find any difference in the shape of the slopes between the three different types of team

classification. Discussion of these significance results is provided in the sections below.

$$\begin{aligned}
 \text{Team project grade} = & X_1(\text{team characteristic}) \\
 & + X_2(\text{mean team intelligence score}) \\
 & + X_3(\text{mean intrapersonal}) \\
 & + X_4(\text{mean interpersonal}) \\
 & + X_5(\text{mean stress management}) \\
 & + X_6(\text{mean adaptability}) \\
 & + X_7(\text{mean mood}) \\
 & + X_8(\text{team characteristic}) \\
 & (\text{mean team intelligence score}) \\
 & + X_9(\text{team characteristic}) \\
 & (\text{mean intrapersonal}) \\
 & + X_{10}(\text{team characteristic}) \\
 & (\text{mean interpersonal}) \\
 & + X_{11}(\text{team characteristic})(\\
 & \text{mean stress management}) \\
 & + X_{12}(\text{team characteristic}) \\
 & (\text{mean adaptability}) \\
 & + X_{13}(\text{team characteristic}) \\
 & (\text{mean mood}).
 \end{aligned} \tag{1}$$

Mean statistic

The multiple linear regressions, run with the team subscale means, found that none of the variables in the full model were significant. As a secondary attempt, another multiple linear regression model was ran not using the team subscale means, but the total EQ-I mean, to test if EI as a whole had significance. The results remained the same; no variables in the model had any statistical significance on the project score. Therefore, the analysis produced no apparent conclusive relationships from EI to project scores when using the mean scores as the aggregator.

A tertiary model was completed for simply analysing the average project scores and team characteristics. A marginally significant relationship, a p -value of 0.0529, was discovered between these two variables. This result declares that the type of team is a minimal indicator of team performance, thus certain classifications of teams, based on the assessment metrics, can predict better project scores. The argument makes sense and since it is independent of the Equation 1 model, its relationship will carry throughout the statistical analysis.

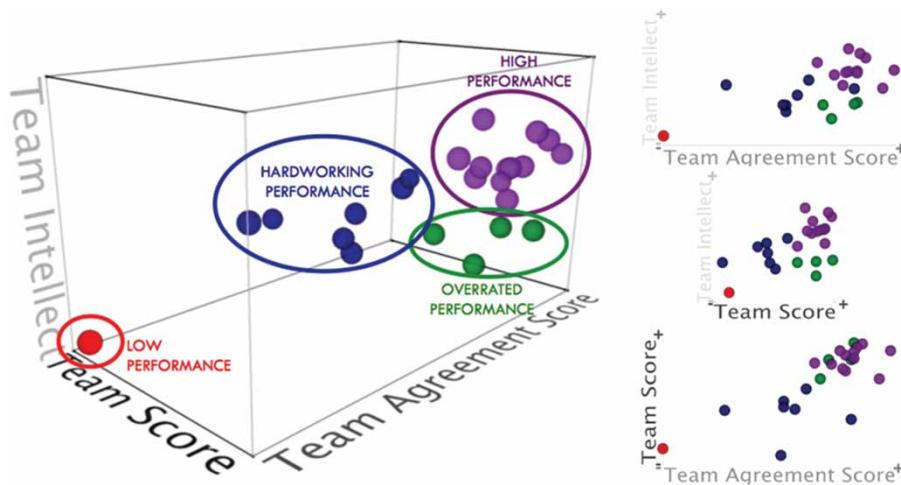


Figure 2 Team characteristic trends in average project scores

Maximum statistic

The full multiple linear regression model was processed using the maximum team subscale scores, instead of the mean. Again, the results determined that no variables had a significant relationship to project score. By converting the team subscale scores into a single independent variable, the maximum total EQ-I score, the regression was repeated. The outcome produced an interaction effect between the maximum total EI score and the team characteristic, significant at a *p*-value equal to 0.0348 (a 97% confidence). This relationship indicates that, potentially, the team’s project score depends on the team’s highest individual summation of their EQ-i score. The equation model was re-run to test for significance, without the other independent variables, but none of the Bar-On scores tested in a level of significance.

Range statistic

In addition to the mean and the maximum values related to the EI scales, the range of team subscales within the team profiles was considered. The multiple linear regression model was used a third time, testing the range of scores available for each EQ-i subscales. The results indicated that three different EI scales related significantly to the project scores: intrapersonal, stress management and mood. At a 95% confidence, each of these ranges when combined in the regression model predicts the outcome of the average project scores.

With a probability value equal to 0.0488, the significance of the Intrapersonal skills section is indeed statistically significant. The correlation found that Intrapersonal has a negative linear relationship with

respect to the team project score, illustrated in Figure 3. This indicates that the larger the range of a team with differing intrapersonal EI capacity the lower the teams’ project score. Teams, thus, function at a higher level when all members have a similar ability to recognize and understand their emotional status and implications, or conversely when there is greater disparity in the levels of intrapersonal skills there is greater likelihood of the team not performing at their highest level. For example, a team with a diverse set of intrapersonal skills will have some people that do not acknowledge their feelings along side those team members that are strongly in touch with their emotions, resulting in frustration; whereas a team in which individual members understand their emotions at a consistent level can easily avoid unnecessary conflict.

With a 96% confidence (*p*-value of 0.0456), the range of the stress management subscale of the EQ-i was also determined to be statistically significant. Displayed in

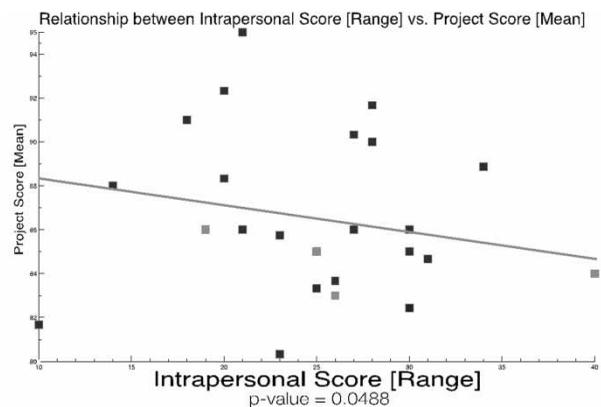


Figure 3 Significant relationships between the range of intrapersonal and project scores

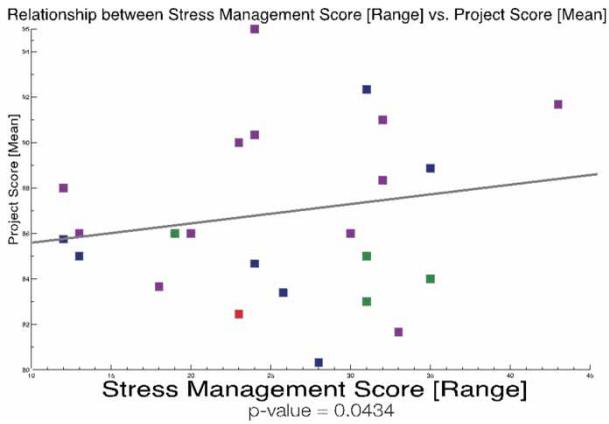


Figure 4 Significant relationships between the range of stress management and project scores

Figure 4, stress management has a positive linear relationship to team project score, meaning that the balance in the range of a team, with differing stress management skills, will result in the teams' higher project score. This correlation indicates that a team functions better when all team members have wide variety of stress tolerance and impulse control. The balance of individual members in a team with respect to stress tends to increase the teams project score. For example, a team with people that are inclined towards becoming stressed out will not perform well, since the entire team will undergo undo strain. On the contrary, a team of individuals who do not experience stress will most likely not function well because they will not feel any pressure to exceed expectations or meet deadlines. Hence, the recommendation of a balanced team with various skills in dealing with stress and associated situations results in a better outcome for the project.

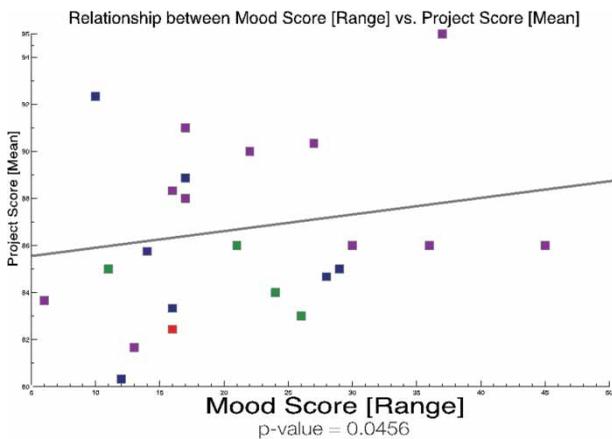


Figure 5 Significant relationships between the range of mood and project scores

At another 96% confidence level (p -value of 0.0434), the range of the Mood subscale of the EQ-i was also determined to be statistically significant. The correlation found that Mood has a positive linear relationship with respect to the team project score, shown in Figure 5. The larger the range of a team with differing moods will result in an increase in the teams' project score. Demonstrating that when team members' mood predisposition is diverse and balanced, teams will have a higher performance level. For example, a team with all highly optimistic or highly pessimistic people will not function at the same level as a team with a variety of both optimistic and pessimistic team members. Thus, a well-balanced team of individuals with an emotional capacity towards both ends of the mood spectrum is suggestible.

Conclusion

The construction industry's standard operating procedure has created a significant impact on the EI profiles of its constituents. Historically, construction managers did not need to be aware of how other people felt within a competitive low cost award system. Therefore, there was no emphasis placed on social responsibility in the daily routine (Darnell, 2004). Instead, it was considered almost acceptable to take advantage of others for one's own gain (Butler and Chinowsky, 2006). Additionally, the same practice proceeded to trickle through to the selection of subcontractors—the low bid wins. However, today the relationship between the contractor and subcontractor is becoming more important as is the relationship between the construction and design industries.

The results presented indicate that, while not the sole indicator of project outcomes, the collaborative skills and competencies represented by the individual and team EI can impact the team's performance to create an outcome greater, or worse, than would be predicted by the individual technical skill sets. Regarding the proposed research questions,

Does a higher total EI score indicate a higher performance outcome by the team? There was a relationship identified between the max team member score for the aggregated EI scales and the project performance, suggesting that a team member with very strong social skills may help bring about a better team outcome. More significant, however, was not the higher EI, but seemingly the balance of skills. Developing a team that balances optimism and pessimism along with balancing levels of stress management helps to create better team outcomes. In addition, similarity in intrapersonal skills was beneficial in identifying a higher performing team.

Does a higher individual technical competence (e.g. examination score) for all team members indicate a higher team performance? Technical competence clearly showed continued importance as demonstrated by the correlation of the team classifications to the project outcomes. Teams predicted to be high performing based on the individual technical skills and agreement within the team assessment showed significant correlation to higher project scores. However, the hardworking team classification outperformed the overrated team classification, with equivalent or lower individual scores this demonstrates that team characteristics do help to differentiate the high-performing teams when the compared teams have the same level of technical competence.

Are there certain traits or competencies that are indicative of higher performing teams? Yes, as shown by the results, a balance in stress management and mood and a team of similar intrapersonal focused individuals helped to create a higher performing team than predicted by the technical skills demonstrated through examination performance.

While the results of this research are both informative and valuable, there are some clear limitations in the conclusions that can be drawn. First, the Bar-On Emotional Quotient is a self-assessment tool. While the data were tested for normality, the potential bias of the participants to alter their answers to perceived correct answers could impact the outcomes. In addition, while focusing on the ability of teams to balance technical and interpersonal skill sets, the teams used in the study were not truly interdisciplinary teams, and were in fact students. This limits the ability to generalize the results in exactly this form to industry. The outcomes are still suggestive that these competencies are important in an industry setting, but how these skills translate when integrated into differing levels of technical competence, differing levels of importance or difficulty to the given project, and the balance of different interdisciplinary needs is not certain.

The potential impact of these results in industry is quite interesting to consider. Recent trends such as the use of IPD contracts have allowed novel team selection approaches to arise. For instance, IPD typically differs from DB projects in that key firms joining the multiparty agreement may be selected for the project through agreement of the current team. This selection approach provides a variety of means which could allow for the best fit of team members to the project and goals based on both technical capability and team chemistry. This selection strategy allows for the fit of the individuals presented for the project in addition to the technical skills and history of the individuals and firm. In most DB projects,

the project is awarded to a team who has been self-selected. While the difference is subtle, the ability to select the best firm for the project offers the potential to couple the technical skill with the collaborative competencies rather than requiring firms, particularly firms that fall into the second tier in the DB structure, to 'pick their horse' for the competitive RFP. These changes could have significant impacts on project environments and project leadership styles.

Further, the implications for engineering education are considerable. Much of the engineering curriculum does not prepare students for the highly collaborative global workplace (McCabe *et al.*, 2000). The challenge becomes defining how engineering education should address developing at least the fundamental skills needed for working in team environments. While EQ-I proved a valuable assessment for this research, it may not be necessary to base an engineering education team development initiative on it. The important element is for engineering education programmes to have a concerted effort to develop team and collaborative skills within their students to appropriately prepare them for work in a team and project-based industry.

Beyond the outcomes identified, several further research areas were discovered for further and more in-depth analysis as this initiative progresses. First, further study of the low-performing team classification to better understand what critical characteristics, when missing, cause a set of capable individuals to perform drastically below expectations. In addition, what are the roles of high-performing individuals in turning average teams into high-performing teams, while the maximum EI score indicated the presence of this relationship, how strong is this relationship and what traits or competencies facilitate this team dynamic? Also, what role does the high-performing individual take—leader, manager, facilitator or some other role or combination. And Finally, how can these pieces be brought together to profile and potentially engineer the team dynamics to improve project outcomes.

References

- Agazarian, Y. and Gantt, S. (2003) Phases of group development: Systems-centered hypotheses and their implications for research and practice. *Group Dynamics: Theory, Research, and Practice*, 7(3), 238–52.
- Bar-On, R. (1997) *The Emotional Quotient Inventory (EQ-i): A Test of Emotional Intelligence*, Multi-Health Systems, Toronto.
- Bar-On, R. (2006) The Bar-On model of emotional-social intelligence (ESI). *Psicothema*, 18, 13–25.
- Bar-On, R. (2010). Preliminary Report: A New US Air Force Study Explores the Cost-Effectiveness of Applying the Bar-On EQ-i, available at <http://www.reuvenbaron.org>

- Brown, H.M. (2003) Emotional intelligence: Thinking out of the box, in *ASCE Conference Proceedings of Construction Research Congress, ASCE Construction Research Congress—Winds of Change: Integration and Innovation of Construction*, Honolulu, Hawaii, 19–21 March 2003, pp. 64–71.
- Bucciarelli, L.L. (1994) *Designing Engineers*, MIT Press, Cambridge, MA.
- Butler, C.J. and Chinowsky, P.S. (2006) Emotional intelligence and leadership behavior in construction executives. *Journal of Management in Engineering*, **22**(3), 119–25.
- Cerniss, C. (2000) Emotional intelligence: What it is and why it matters. Paper presented at the Annual Meeting of the Society for Industrial and Organizational Psychology, New Orleans, LA, 15 April 2000, pp. 1–14.
- Crowley, L., Dolle, J., Litchfield, B. and Price, R. (2001) Engineering emotional intelligence: Course development and implementation, in *ASEE Annual Conference Proceedings, 2001 ASEE Annual Conference and Exposition: Peppers, Papers, Pueblos and Professors*, Albuquerque, NM, 24–27 June 2001, pp. 285–4309.
- Culver, D. (1998) A review of emotional intelligence by Daniel Goldman: Implications for technical education, in *Frontiers in Education Conference*, Tempe, AZ, 2 (Part 2), 855–60.
- Darnell, G.B. (2004) *The People-Profit Connection: How Emotional Intelligence Can Maximize People Skills and Maximize Your Profits*, Sweet Tea Publishers, Atlanta.
- Eid, J., Johnsen, B.H., Bartone, P.T. and Nissestad, O.A. (2007) Growing transformational leaders: Exploring the role of personality hardiness. *Leadership & Organization Development Journal*, **29**(1), 4–23.
- Fox, S., Leicht, R.M. and Messner, J.I. (2010) Assessing the relevance of media synchronicity theory to the use of communication media in the AECO industry. *Journal of Architectural Engineering*, **16**(2), 54–62.
- Garson, D. (2008) *Cluster Analysis*, available at <http://www2.chass.ncse.edu/garson/PA765/cluster.htm> (accessed 5 June 2008).
- Goleman, D. (1995) *Emotional Intelligence: Why it Can Matter More than IQ*, Bantam Books, New York.
- Goleman, D. (1998) *Working with Emotional Intelligence*, Bantam Books, New York.
- Goleman, D. (1999) What makes a leader?. *IEEE Engineering Management Review*, **27**(1), 4–11.
- Leicht, R.M., Lewis, A., Riley, D.R., Messner, J.I. and Darnell, B. (2009) Assessing traits for success in individual and team performance in an engineering course, in *Proceedings from the ASCE Construction Research Congress*, Seattle, WA, 5–7 April.
- Leicht, R.M., Enache-Pommer, E. and Franz, B. (2011) Carrying over integrated project delivery concepts to a non-IPD project: A comparative case study, in *Proceedings from the ASCE Construction Research Congress*, Ottawa, Canada, 14–17 June.
- Lyons, J.B. and Schneider, T.R. (2005) The influence of emotional intelligence on performance. *Personality and Individual Differences*, **39**(4), 693–703.
- McCabe, B., Ching, K.S. and Savio, R. (2000) Strategy: A construction simulation environment, in *Proceedings of 6th Construction Congress*, Orlando, FL, ASCE, Reston, VA, pp. 115–20.
- Newsome, S., Day, A.L. and Catano, V.M. (2000) Assessing the predictive validity of emotional intelligence. *Personality and Individual Differences*, **29**(6), 1005–16.
- Riley, D.R., Horman, M.J. and Messner, J.I. (2008) Embedding leadership development in construction engineering and management education. *Journal of Professional Issues in Engineering Education and Practice*, **134**(2), 143–51.
- Rosete, D. and Ciarrochi, J. (2005) Emotional intelligence and its relationship to workplace performance outcomes of leadership effectiveness. *Leadership & Organization Development Journal*, **26**(5/6), 388–99.
- Salovey, P. and Mayer, J.D. (1990) Emotional intelligence. *Imagination, Cognition and Personality*, **9**(3), 185–211.
- Sunindijo, R.Y., Hadikusumo, B.H.W. and Ogunlana, S. (2007) Emotional intelligence and leadership styles in construction project management. *Journal of Management in Engineering*, **23**(4), 166–70.
- Van Rooy, D.L. and Viswesvaran, C. (2004) Emotional intelligence: A meta-analytic investigation of predictive validity and nomological net. *Journal of Vocational Behavior*, **65**(1), 71–95.