AC 2008-1946: ENHANCING ENGINEERING EDUCATION: LEARNING TO
SOLVE PROBLEMS THROUGH SERVICE-LEARNING PROJECTS

Mary McCormick, Tufts University
Mary McCormick is currently pursuing her Master of Science degree in Civil and Environmental
Engineering at Tufts University. Her current research interest is in the development of assessment
methodologies to measure the educational benefits of experiential learning.

Chris Swan, Tufts University
Douglas Matson, Tufts University
David Gute, Tufts University
John Durant, Tufts University
Enhancing Engineering Education:  
Learning to Solve Problems through Service-Learning Projects

Abstract

Over the last few years, concerns have escalated among many national organizations over whether today’s engineering students are being adequately prepared for future challenges; globalization, sustainability, complexity, and adaptability. To address this situation, the National Association of Engineers (NAE), the Accreditation Board for Engineering and Technology (ABET) and the American Society of Civil Engineers (ASCE) have all generated reports aimed at reforming the existing engineering curriculum. As a result, the NAE’s Engineer of 2020\(^1\), ABET’s Engineering Criterion 3 (EC 2000)\(^2\), and ASCE’s Body of Knowledge (BOK)\(^3\) all aim at shifting the existing paradigm of engineering curriculum towards a more well-rounded education. The commonality among these three documents is improving students’ problem solving techniques. The future will inevitably bring unanticipated crises; engineers will need to identify the problems and collaboratively formulate innovative, feasible solutions. This research hypothesizes that service-learning can serve as a mechanism that will allow students to develop the necessary problem solving skills. To investigate this hypothesis, an education assessment instrument is employed to examine whether students who have participated in service-learning projects have stronger analytical, practical, and creative abilities than students who have only been exposed to the conventional “classroom” education.

Introduction

It has been noted that service-learning is recognized by students and faculty as a “valuable pedagogical tool”\(^4\); however, the existing data supporting this claim are primarily qualitative. This paper presents a more quantitative assessment to demonstrate the benefits of PBSL by collecting and systematically organizing data that supports the theoretical basis of this form of experiential education. Reaching this goal entails implementation of innovative measurement techniques that provide quantifiable justification of service-learning benefits. The instrumentation used in evaluation is based on the “tricial theory”\(^5\), prescribed by Sternberg and other well known researchers in fields of education and cognitive psychology\(^5,6,7,8,9,10,11\). It is believed that the numerical data and pedagogical theory, along with efficacious synergy of achieving a balanced engineering curriculum that prepares engineers for the future will strengthen the argument for service-learning institutionalization in college-level engineering curriculum.

In addition to proposing a method of assessing service-learning outcomes, this study aims to determine whether the students who become engaged in service-learning projects do in fact enrich their engineering education by developing and strengthening problem solving skills. Sternberg’s triarchic theory is based on an intelligence model comprised of analytical, practical, and creative abilities. Since these skills cannot be accurately evaluated through conventional testing methods, reality-based open-ended questions with follow-up group dynamic self-assessments are used to compare the skill sets of engineering students who have participated in service-learning with those who have not.
Background

In chartering the Engineer of 2020 project, the NAE’s primary goal is to develop a curriculum framework that will provide engineers with the necessary skill sets “overcome future challenges”\(^1\). This combination of skills will require engineers to integrate technical knowledge with practical ingenuity to identify problems and develop solutions. Engineers will need to communicate to both technical and public audiences while exhibiting an intuitive understanding of management and leadership with high ethical standards. ASCE’s BOK and ABET identify specific requirements that engineering programs must fulfill to be an accredited program, most of which are steps geared towards achieving the same goals as the NAE report. Although not explicitly stated, problem solving ability is inherent to acquiring accreditation, as shown in the following ABET EC (2000) requirements:

- (a) an ability to apply knowledge of mathematics, science, and engineering
- (b) an ability to design and conduct experiments, as well as analyze and interpret data
- (c) an ability to design a system, component, or process to meet desired needs
- (d) an ability to function on multi-disciplinary teams
- (e) an ability to identify, formulate, and solve engineering problems
- (f) an understanding of professional and ethical responsibility
- (g) an ability to communicate effectively
- (h) the broad education necessary to understand the impact of engineering solutions in a global and societal context
- (i) a recognition of the need for, and an ability to engage in life-long learning
- (j) a knowledge of contemporary issues
- (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

The ASCE BOK (2004) recommends four additional outcomes to address technical specialization, project management, business, and leadership:

- an ability to apply knowledge in a specialized area related to civil engineering.
- an understanding of the elements of project management, construction, and asset management.
- an understanding of business and public policy and administration fundamentals.
- an understanding of the role of leader and leadership principles and attitudes.

Every requirement entails solving some aspect of a problem; this research is going to focus on the skills students must develop to solve any problem. These skills are most clearly evidenced in requirements (b), (c), (e), and (k), which involve identifying problems, generating a wide range of possible solutions, and analyzing all solutions to determine the most effective and feasible solution.

Significance of Research

In mobilizing the shift in engineering education, the NAE claims that the Engineer of 2020 will need to possess specific attributes, such as “strong analytical skills” and “practical ingenuity.” The third “indispensable quality for engineering” is creativity, which, “given the growing scope
of the challenges ahead and the complexity and diversity of the technologies of the 21st century, will only grow in importance.” The second phase of NAE’s report focuses on adapting engineering education to prepare the Engineer of 2020. According to the report, the curriculum must shift from teaching available knowledge to assisting students in skill development, which involves a new teaching dynamic. As Jean Piaget, a pioneer in cognitive psychology, stated “Development and instruction have different rhythms. These two processes are interconnected, but each of them has its own measure.” The role of the instructor must also shift from center of instruction to the facilitator of learning that occurs outside the classroom. Lastly, education must no longer be an individual action; in overcoming the abounding challenges of the future, engineers will need to work with diverse teams of engineers and nonengineers to formulate innovative solutions collaboratively. This importance of teamwork is reinforced by ABET and ASCE in criteria (d) and (g). Thus, in a short twelve years from now, engineers will have to practice problem solving techniques in methods that will achieve synergy between technical and social systems.

Sternberg introduces the “triarchic theory of human cognition,” involving a three-part model corresponding to analytical, creative, and practical cognitive skills. Interestingly, the NAE’s three main attributes for the Engineer of 2020 coincide with the three attributes that Sternberg claims will help students achieve “successful intelligence.” According to Sternberg, intelligence is demonstrated when one is capable of balancing one’s skills in adapting to, shaping, and selecting the environment that best matches one’s strongest skills, values, and desires. Success is ultimately achieved through harmonizing three aspects of intelligence: analytical, practical, and creative skills. Each person, however, is unique, and consequently, each person will orchestrate skills at varying levels to create a unique harmony. When a person is able to fine tune his or her skills to maximize effectiveness in the most suitable environment, that person has achieved a deepened sense of self-awareness. For Sternberg, this entails (1) recognizing one’s own strengths and finding a way to capitalize on the strengths and (2) knowing one’s weaknesses and finding a way to compensate or remediate weaknesses. Sternberg’s formula for success leaves only one lingering question: Can this be taught to students? According to Sternberg’s research, allowing students to learn triarchically is not only possible; it puts them at an advantage over students taught in a variety of other ways. Furthermore, it has been found that students who approach coursework triarchically actually “learn the material better than students who are taught either just for analytical thinking or just for memory.” The classrooms that focus on teaching for memory limit students’ learning capacities by reducing the ways in which they can encode new information. Students who have excellent learning skills may not be able to apply them in a classroom setting because their preferred modes of learning do not match the conventional mode of teaching. When students are prevented from experiencing new approaches to learning, the opportunity to figure out their own strengths and weaknesses is neglected. As Sternberg explains, “Good teaching involves activities that may draw more or less on a particular kind of skill, but ultimately, that involves the same kinds of complex integration that we need to learn in order to survive.” It is clear from Sternberg’s research that classroom teaching geared towards memorizing techniques is not only an ineffective method for teaching, it inhibits students from conceptualizing abstract theories, absorbing the maximum amount of retainable information, and perhaps most importantly, learning about themselves. As another educational psychologist affirms, “It is sometimes difficult for students to let go of the idea that problems have a single solution and can be solved using memorized knowledge.”
Therefore, extracting students from the classroom setting and allowing them to solve complex, real-world problems together not only induces creative methods of applying abstract theories, it engenders a new awareness for practicality, constructability, and social impact\(^\text{15}\). From an academic curriculum standpoint, service-learning projects are thereby fulfilling ABET criteria (f), (h), (i), (j), and (k).

The conflicts encountered in service-learning projects provoke a higher level of thinking and problem solving; rather than retrieving information from memory, the student must generate innovative solutions and overcome unforeseen challenges. Project-based service-learning is unique in that it presents the students with a problem that does not have an obvious solution; the “unanticipated” is crucial for student development. “It is the child’s own effort to resolve a conflict that takes him or her to another level of thinking.”\(^\text{18}\)

**Justification of Assessment Methodology**

Although it is not defined as “successful intelligence” in the NAE report, the centrality on skill development, specifically analytical, practical, and creative skills, is prevalent in the report. As stated\(^\text{1}\), “We must focus on shaping analytic skills, problem solving skills, and design skills. We must teach methods and not solutions. We must teach future engineers to be creative…” The evident similarities between the NAE’s report and Sternberg’s research on education are not likely by happenstance; this overlap suggests that analytical, creative, and practical skills and figuring out one’s own unique balance is a recognized method of achieving success. By applying Sternberg’s assessment methodology to evaluate the skill sets of engineering students who have and have not participated in service-learning, a numerical comparison can be drawn based on his triarchic model. The results of the comparison can then be used to determine whether students who have participated in service-learning projects have developed the skills that comprise the Engineer of 2020, thereby achieving a heightened level of “successful intelligence”.

**Methodology**

Sternberg’s triarchic model, which “can be applied to any subject matter at any grade level”\(^\text{19}\), is utilized in assessing the skill levels of students who have participated in service-learning projects and will be compared to the skill levels of those who have not. Reality-based open-ended questions were designed to facilitate measurement of analytical, practical, and creative skills. In brief, analytical skills encompass the abilities of one to judge, evaluate, compare and contrast, and critique. Practical skills include one’s ability to implement, use, apply, and put into practice what they have learned. Creative skills entail the abilities to invent, discover, imagine and suppose\(^\text{6,7,8}\).

**Data Collection**

An “Engineering Challenge Night” was held on October 10, 2007 to recruit students to participate in our evaluations. A random sample of 44 engineering students (sophomores through seniors) was asked to answer two questions. Table 1 displays the demographics of the sample. The aim of this event was to apply a new measuring technique that can be utilized on a larger scale; not to definitively prove that students involved in service-learning projects have enhanced
their engineering ability. Given the lack of diversity in the sample of Tufts University students and the size of the sample, we do not expect to have a high level of confidence in broadly applying the results of the evaluation.

Table 1: Demographics

<table>
<thead>
<tr>
<th></th>
<th>Female</th>
<th></th>
<th>Male</th>
<th></th>
<th>Total N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>% of</td>
<td>N</td>
<td>% of</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>Total</td>
<td>Male</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>Service-Learning</td>
<td>8</td>
<td>72.7</td>
<td>3</td>
<td>27.3</td>
<td>11</td>
</tr>
<tr>
<td>Non Service-Learning</td>
<td>13</td>
<td>39.4</td>
<td>20</td>
<td>60.6</td>
<td>33</td>
</tr>
<tr>
<td>Total N</td>
<td>21</td>
<td></td>
<td>23</td>
<td></td>
<td>44</td>
</tr>
</tbody>
</table>

Logistics of Data Collection

Since there were both individual and group tests administered at different times, the testing process necessitated a well-planned sequence and effective execution. As the 44 participants entered the study area, each person was assigned a number and asked to fill out demographical information as well as detail their service-learning experience. As the demographic information was collected, each student answered one reality-based open ended question on an individual level. After they handed in their answers, the students were given a 20 to 30 minute break for refreshments. During this time, groups were formed by the evaluators based on each student’s identification number and service-learning experience. After the break, students were assembled into their assigned groups; all of the groups comprised of service-learning students moved to a different classroom, while the non-service-learning students remained in the initial classroom. Each group was then given one question to answer collaboratively.

To address the social aspect of this research, another evaluation was conducted during “Engineering Challenge Night” to assess the efficacy of each group. Each member of every group was asked to fill out a “Group Assessment” survey, comprised of Likert Scale questions pertaining to group dynamic, challenges, and the group’s ability to collaborate, coordinate, communicate, and apply classroom concepts to realistic situations. Lastly, a final short survey was given to participants before they left to collect feedback on the “Engineering Challenge Night” to provide information on how to improve this assessment methodology.

Evaluation Instrumentation

Four open-ended questions were created (Appendix A); each one was designed to encourage utilization of different engineering skills. Two parallel questions were designed to facilitate measurement of analytical, creative, and practical ways of approaching problems. Similarly, two reality-based and slightly more complicated questions were designed for group assessment. Two parallel questions of comparable difficulty level were designed in both individual and group cases to encourage variety of answers and to discourage students from sharing answers with neighbors or other groups.
Four parallel rubrics were designed based on the questions and student responses to facilitate accurate and unbiased assessment of analytical, creative, and practical skills. Students were also awarded points for providing contingency plans, since testing of solutions and development of alternative solutions is vital step in the Engineering Design Process\(^\text{20}\). Since the group questions had more identifiable conflicts, the rubric was based on a scale of 0 to 7, whereas the individual question rubrics are based on a scale of 1 to 5, as shown in Appendix B.

**Data Analysis**

When evaluating the educational benefits of service-learning, it is important to detach the service aspect to examine only the learning. “Assignments rooted in the service must be assessed and evaluated accordingly…We are grading the learning, not the service”\(^\text{2}\). Furthermore, “the presumption is that community service does not necessarily, in and of itself, produce learning”\(^\text{14}\). As part of the curriculum, students are receiving academic credit for the learning, not for the service. Therefore, the underlying challenge is to distinguish these interdependent elements from each other.

Data analysis entails examining both the test itself and the comparisons that may be drawn from the results. In evaluating the assessment instrument, each item must be analyzed. The *Standards for Educational and Psychological Measurement*\(^\text{21}\) states that evidence of an instrument’s psychometric properties (e.g., reliability, validity) must be provided to substantiate the use of obtained scores. This section presents preliminary evidence of reliability and validity of the scales based on our current data collection.

**Proper Scaling**

In examining the test construct, it is important to substantiate fittingness of the scale. In the quantification process, numbers are assigned to each attribute; in this case, analytical, practical and creative skills. The scale must display qualities consistent with the assumptions of being unidimensional and measuring only one construct. A good scale, then, should produce numbers that correspond to individual differences in the attribute. For each skill type, a proficiency scale was created based on the number of possible solutions; for individual questions, analytical, creative, and practical skills were all on a 1 to 5 scale (a score of 5 indicates all possible problems and solutions were recognized and addressed), whereas for the group questions, all skills were on a scale ranging from 1 to 7. The scale for the group assessment was higher because there were a greater number of possible solutions.

**Reliability and Validity**

A reliable test yields consistent numbers when the attribute is stable. Interrater reliability was verified by having a trained assessor from the Tufts University *Center for Enhanced Learning and Teaching* (CELT) use the rubrics to evaluate the questions. As shown in the Appendix C, the correlation coefficients for all questions ranged from \(r = 0.92\) to \(r = 1\), indicating very strong agreement.
After establishing interrater reliability, the parallelism of each set of questions was tested. Student responses were analyzed with a 5% significance level using a two-tailed test. Results from the t-tests indicate very high probabilities; the statistically insignificant differences in the mean values warrant acceptance of the questions as parallel and justify comparisons. Similarly, a comparison of results from the two group questions verified consistency in question difficulty and required skill level.

Validity is the ability of a procedure to measure the attribute, an undertaking that becomes increasingly difficult when measuring critical thinking. Two forms of validity measurements that are applicable to this research are content and attribute validity. Content validity assesses whether the questions cover the range of behaviors normally considered to be part of the dimension you are assessing, whereas attribute validity of a question can be established by showing that the question’s results agree with the predictions based on the theory. Content validity is confirmed by examining the range and standard deviations of answers. As is shown in the graphical representations presented as Figures 1 through 6, the student’s abilities are highly varying for all questions and have standard deviations that are twice the mean value. Validating the attribute is a slightly more complicated process. An attribute takes meaning from the theory that specifies the attribute’s conceptual nature, manifestation of the construct, and confirmation of the hypothesized relationship of the measure to other constructs. In this case, the attributes are analytical, practical, and creative abilities. Since the triarchic theory has not been previously employed in assessing service-learning students, this study seeks to generate a new theory connecting the triarchic abilities to education involving service-learning projects.

Results

Each question was developed with the intention of encouraging creativity in solution formulation. Consequently, not only were the answers diverse, the students’ approaches to solving the problems were highly variable. While the creative students excelled with their freedom to imagine numerous possibilities, those who were accustomed to reiterating a problem solving approach they had memorized were clearly frustrated.

Before examining results, it is important to note that the sample used in this study may be slightly biased towards a service-learning effort; thus, the statistical analysis is only descriptive of this particular group, rather than inferential of the entire student engineering population. As one statistician claims, “If the research is based on [service-learning] class, or one institution, or one type of institutions, then there is less confidence in the broad conclusion that a finding holds for all college students”. This negates forming a generalization from the data from which broad conclusions can be drawn. Theoretical propositions, however, are a legitimate type of analysis that may be formulated based on the specific data set.

The preliminary results consist of comparing service-learning and non service-learning abilities of students on individual and group levels. The third comparison is of the differences in group-dynamic; this social skills aspect requires a more in-depth analysis and will not be discussed in the results of this paper. The results of individuals’ abilities are shown in the Figures 1, 2, and 3 respectively, and the groups’ abilities are shown in Figures 4 through 6.
The preliminary results suggest similar skill levels between service-learning and non service-learning students. Figures 1 through 3 show a comparison of the individual questions for the three constructs. The results indicate service-learning students scored higher on analytical and practical, while the average creative score was almost identical. Statistical analyses were performed for a more detailed comparison. Results of one-tailed t-tests indicate statistical significance (p<.05) between service learning and non-service learning only in the practical construct; the differences in the average analytical and creative scores were insignificant between groups.

Conversely, the group results shown in Figures 4 through 6, indicate that when working collaboratively, the service-learning students demonstrate stronger analytical, practical, and creative skills. Analyses of these results are in the preliminary stage; a more comprehensive statistical review will be completed post result-validation.
Conclusions

There are two main conclusions that can be drawn from this study: (1) applying Sternberg’s Triarchic Model is a viable assessment tool for quantifying the skills of engineering students who participate in service-learning projects, and (2) preliminary results indicate that when working collaboratively, service learning students have a higher skill level than those who have not had a service-learning experience. While the first conclusion shows promise for assessing the skills of engineering students, the second requires further evaluation. For example, if this assessment technique is used on a larger sample with a more diverse group of students, would the same
conclusion be drawn? Furthermore, does the type of project, the amount of experience, or the student’s personal background play significant influential roles in the test results? And ultimately, does service-learning more adequately prepare students for the future challenges while simultaneously fulfilling the ABET Criteria and meeting the goals of the ASCE BOK? The answers to these questions lie in conducting an assessment on a much greater and more diverse sample, to measure the skill set that is crucial for the Engineer of 2020 and “successful intelligence”.

Bibliography


**Appendix A: Individual and Group Questions**

**Individual Question 1:**

Please answer the following questions to the best of your ability. Your answers are confidential; they will in no way affect your standing at Tufts University.

1. You have just arrived in a foreign country as part of your post-college backpacking adventure. While you were traveling (and without access to news media), there was a travel warning issued by the U.S. Bureau of Consular Affairs to defer from traveling to this country due to terrorist attacks. Your short-term visa allowed you to gain entry into the country, but in the chaotic airport, your backpack was stolen, leaving you without a phone, friend, valid travel documentation, or money. The U.S. Embassy’s ability to provide emergency assistance to U.S. citizens is extremely limited, particularly for people outside the capital. What do you do?

**Individual Question 2:**
2. After graduating from Tufts, you landed a great job working as a structural engineer. During your first week, a project manager asks you to supervise the restoration and rehabilitation of the Longfellow Bridge. You would like to demonstrate your engineering ability, but you do not have previous fieldwork experience and you are not entirely confident in the amount of information you actually retained from your classes. While on site, you notice that the contractor is not meeting the safety requirements.

You would like to inform the contractor that you are new on the job and that it would be extremely helpful if the workers could explain each step in the process so you can learn and verify that it is the correct procedure. However, in expressing your uncertainty, you realize that you may lose a certain amount of respect, which you are afraid could lessen your authority and may result in the contractors ignoring your safety requests.

How can you make sure the job is being completed properly, while maintaining your authority to enforce the safety requirements?

Group Question A:

A half-acre lot was recently purchased in Roxbury, MA and you were put in charge of development. Unfortunately, you realized that after taxes and unpredicted fees were deducted, your project account is nearly depleted. Although complicated, you take on the challenge of developing the land. Before making any decisions, you may want to consider some of the following information. Refer to Figure 1 for further information.

- The lot lies adjacent to Ellis Elementary School (K-5) that has a school bus drop-off area currently located close to a busy intersection.
- The lot is surrounded by buildings on three sides, one of which is the school. The fourth side boundary is a high-vehicle-volume street.
- On the other side of the street is a river that shows signs of being heavily contaminated by mercury.
- The underground gas and sewer utilities traverse through the middle of the lot and the soil surrounding the pipes is primarily earth “fill” that does not have significant bearing strength.

Because this piece of land has been empty for several years, members of the neighborhood have used it for multiple purposes. During the day, Mr. Johnson and Mr. Smith, both of whom are elderly, usually set up their card or chess table. At night, a large teenage group declared it to be their “hang-out” and most people are too afraid to object to this claim or even walk by the lot after dark.

It is your job to most effectively develop the land. Consider all the possible impacts of your solution and the steps that must be taken in strategic execution.

Group Question B:
Unexpectedly, the nearby town of Somerford, MA underwent a tremendous escalation in population growth this summer. The biggest problem the town is facing is accommodating the large number of elementary school students, since the existing school facilities are now clearly insufficient for the incoming class. As Director of the Town Planning Committee, you are responsible for solving this dilemma.

Background information: Even before the drastic increase in population, Somerford was a highly developed town, which, of course, complicates matters. Furthermore, the town is currently over budget, and with town elections coming up, you’d like to appease all parties. You may want to consider the following information, which was gathered during a preliminary land investigation. Refer to Figure 1a.

Area 1: Wetlands hosting several endangered plant species.
Area 2: Water treatment facility location. Contaminated water flows into building. *Note: When surveyors were examining the land, they noticed an interesting water leakage, which appeared to be polluted. When water treatment specialists were sent out to investigate, they noticed that there is one area where the sewer pipes merge with clean water outflow pipes, post treatment.
Area 3: Power Plant facility. Power lines running to and from buildings. Also near a natural gas compressor station with highly pressurized gas lines running below ground from the station.
Area 4: Commuter Railway station.
Area 5: Within 1 mile of Somerford Maximum Security Correctional Facility, also known as Alcatraz of the East Coast.

It is your job to effectively solve this predicament brought on by the unforeseen increase in population.

Appendix B: Rubric Development

Question 1-Analytical
Analytical Ability: When a person analyzes, evaluates, compares or contrasts Problems

1  a  Need to find belongings 1
   b  Need to obtain MONEY 1
   c  Need to find some sort of ID 1
2  Contacts must be made
   a  Contact airport security, police, local authorities 1
   b  Contact Embassy (Capitol is acceptable) 1
   c  Call family to alert them/ emergency contact 1
3  Address immediate danger
   a  Find a safe location (airport/ friend/ safer country) 1
4  Acknowledge communication barrier
   a  Find another American, person in same situation, local friend 1
5  You need to think about long term consequences
   a  How to eventually get home 1
   b  What to do if you can't get home- youth hostel, local friend 1
6  a  Calling home to ask what to do 0
Question 1- Practical

Practical Ability: When a person puts into practice, applies, or uses what he or she has learned

1. Belongings/ Proof of ID/ Money/ Backpack
   a. Go to security for help
   b. Have your parents wire $/ somehow cover expenses
   c. Have your transportation documents/form of ID faxed
   d. Spread your belongings so you are not carrying everything together/ money in pockets
   e. Find bank (Specify info you will give them, i.e. SS#, Acct password)
      Or ask what information you need to provide them with
      Go to Bank without specific info or plan = 0
   f. Have Embassy re-issue travel documents/ VISA
   g. Ask Americans from your flight to lend you money
   h. Have parents send money (WIRING = OK)
   i. "Go to" or "Make my way to" Embassy

2. Contact/ Go to Embassy
   a. Have airport security, police, or someone in airport help you
   b. Contact parents (Either call collect, payphone, borrow phone at airport)
      and have them contact Embassy
   c. Contact Embassy yourself by borrowing phone
   d. Use money to call/get to/ use at Embassy
   e. Go to Embassy and give them specific info (i.e. SS #, Travel Docs)
   f. "Contact" or "Try to call" or "Go to" Embassy without specifying how

3. Address Immediate Safety
   a. Stay in airport or find nearby safe shelter
   b. Make sure family and friends are informed of what is going on AND ask
      them to book flight or make calls
      * Calling home to ask what to do = 0
   c. Contact local friends
   d. Give itinerary ahead of time

4. Deal with Language Barrier/ Find people to communicate with
   a. Call local friend or emergency contact person
   b. Find other English speaking travelers, people from your flight,
      people in same situation

5. Do something that addresses long term (safety)
   a. Go to youth hostel
   b. Find feasible mode of transportation
   c. Find your way to a safer country
   d. Find food
   e. Use money to stay in motel
   f. Keep going on trip

Question 1-Creative

Creative Ability: Used when a person creates, invents, or discovers

1. Find Money/ ID/ Backpack/ Belongings
   a: Money
      go to bank without specifying plan of action or information
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>go to bank with information prepared</td>
<td>1</td>
</tr>
<tr>
<td>Have parents wire money to you</td>
<td>1</td>
</tr>
<tr>
<td>Borrow from Americans, people in the same situation, or sympathetic people</td>
<td>1</td>
</tr>
<tr>
<td>Carry extra money in pockets</td>
<td>1</td>
</tr>
<tr>
<td>b: ID</td>
<td></td>
</tr>
<tr>
<td>Go to security</td>
<td>0</td>
</tr>
<tr>
<td>Other method or attaining your ID or proving ID</td>
<td>1</td>
</tr>
<tr>
<td>c: Backpack or belongings</td>
<td></td>
</tr>
<tr>
<td>Go to security</td>
<td>0</td>
</tr>
<tr>
<td>spread belongings so you are not carrying everything together</td>
<td>1</td>
</tr>
<tr>
<td>2 Contact Embassy</td>
<td></td>
</tr>
<tr>
<td>a Call them yourself or “Go to Embassy”</td>
<td>0</td>
</tr>
<tr>
<td>b Find someone to direct you to Embassy/ Borrow phone/ payphone</td>
<td>0</td>
</tr>
<tr>
<td>c Go first to airport security or local police to connect you to Embassy</td>
<td>1</td>
</tr>
<tr>
<td>d Call parents to call Embassy</td>
<td>1</td>
</tr>
<tr>
<td>e Go to Embassy with specific information prepared</td>
<td>1</td>
</tr>
<tr>
<td>f Attempt to bribe Embassy?</td>
<td>1</td>
</tr>
<tr>
<td>3 Immediate safety</td>
<td></td>
</tr>
<tr>
<td>a stay in airport</td>
<td>0</td>
</tr>
<tr>
<td>b Inform family of friends that you are in danger</td>
<td>0</td>
</tr>
<tr>
<td>* Calling parents for info/ asking what to do = 0</td>
<td></td>
</tr>
<tr>
<td>c travel to Embassy with specified mode of transportation</td>
<td>1</td>
</tr>
<tr>
<td>d Get food and/or place to sleep</td>
<td>1</td>
</tr>
<tr>
<td>e Get to another country or safer place</td>
<td>1</td>
</tr>
<tr>
<td>f Give itinerary to family before leaving</td>
<td>1</td>
</tr>
<tr>
<td>4 Deal with language/ Communication barrier</td>
<td></td>
</tr>
<tr>
<td>a Not dealt with</td>
<td>0</td>
</tr>
<tr>
<td>b Find other Americans</td>
<td>1</td>
</tr>
<tr>
<td>c Find other people who speak same language/in same situation</td>
<td>1</td>
</tr>
<tr>
<td>d Find local friends</td>
<td>1</td>
</tr>
<tr>
<td>5 Long term planning</td>
<td></td>
</tr>
<tr>
<td>a Try to fly home</td>
<td>0</td>
</tr>
<tr>
<td>b Continue on trip</td>
<td>1</td>
</tr>
<tr>
<td>c Stay with local friends</td>
<td>1</td>
</tr>
<tr>
<td>d Settle in country and find a job</td>
<td>1</td>
</tr>
<tr>
<td>e Go to youth hostel</td>
<td>1</td>
</tr>
<tr>
<td>f Tell airline that you lost your ticket and try to get return flight</td>
<td>1</td>
</tr>
<tr>
<td>g Get money and check into a motel</td>
<td>1</td>
</tr>
<tr>
<td>h Use terrorism to get home</td>
<td>1</td>
</tr>
</tbody>
</table>

Question 2-Analytical
Analytical Ability: When a person analyzes, evaluates, compares or contrasts

1 Need to deal with job site hierarchy-
   Talk to Contractor, Foreman in specific manner
   Ask boss/higher level engineer/safety codes to back you up
2. Need to make sure safety requirements are met and job is done right. 
   Remind, tell, enforce safety, express concerns

3. Need to learn/figure out what is going on.
   Observe, ask workers/contractor to explain steps

4. Deal with inexperience/gender issues.
   Explicitly address difficulty with being "new" or "novice"

5. Think ahead to long term. How might this affect your position at work?
   This may require getting a higher level engineer involved

Note: Getting Boss involved may count for both 1 and 5 if you are asking for support and covering yourself at your job in long run

Question 2- Practical

1. Deal with job-site hierarchy
   a. Talk or question contractor or foreman without being afraid to lose respect
   b. Express concerns informally or in private
   c. Recognize that it is ultimately someone else's responsibility
   d. Maintain authority by backing yourself up with building codes/reference material/more experienced engineer
   e. Ask in manner that allows you to avoid embarrassment
   f. Be grateful to contractor; establish positive relationship

2. Enforce job site safety
   a. Report them or Threaten to or do tell owner/boss
   b. Question/remind/firmly let them know they must to follow safety rules
      Recognize that they are not following requirements
   c. Bring higher-level engineer
   d. Remove safety from your responsibility

3. Learn about what is going on
   a. Have workers explain
   b. Research ahead of time
   c. Observe (not really learning)
   e. Call your project manager to ask about what SHOULD be happening
   f. Have resources on site

4. Do something to address inexperience
   a. Explain that you are new and would appreciate cooperation
   b. Act like you know what is going on and/or you are just checking them
   c. Recognize that you are inexperienced, but continue to ask questions anyway
   d. Say you have or describe your previous work experience
   e. Make your own calculations to show contractor where he errs
   f. Ask boss what to do/to come out to site

5. Does solution take long term into account
   a. Keep boss informed of what is going on so it won't come as a surprise
      and you are covering yourself

Creative Ability: Used when a person creates, invents, or discovers
1 Job site hierarchy
   a talk to foreman 0
   b Tell them you just want to be "extra safe" 1
   c talk to foreman privately/ informally 1
   d Ask in a way that avoids embarrassment 1
   e Establish good relationship/ Act grateful 1
   f Maintain authority by backing yourself up with references, building codes, more experienced engineer 1
   g talk to contractor "on the record" or "off the record" 1
   h Sacrifice respect now to get respect later 1

2 Enforce job site safety
   a reminding/asking contractor/workers about safety 0
   b Remind them/ Firmly tell them they MUST follow safety rules 0
   c Threaten to tell owner/boss or fire contractor/ Report 1
   d See if contractor has his own safety inspector 1
   e Make contractor realize that he is not following requirements as
   f Take a chance on what you know- Make contractor follow your requirements

3 Learn about what is going on
   a Have workers or contractor explain to you 0
   b Bring reference materials or learn about job ahead of time 1
   c Make your own calculations and compare 1
   d Research ahead of time/ Call your boss to check 1
   e Learn by taking a chance (pretending you know) and seeing
      if they say anything

4 Do something to address inexperience
   a Tell them that you are new 0
   b Don't explain or feel as though it is an issue 0
   c Tell them your qualifications/ other pertinent experience 1
      "At Tufts…"
   d Act like you know or like you are just checking them 1

5 Solution with long term in mind
   a Tell your boss before making any calls 1
   b Keep boss informed of all things 1

Group Question A
Analytical

1 money/ property issue in development 1
   (Method of building/ Repaying through making money commercially)
2 Safety of kids
   (Fenced in areas, playgrounds, parks)
3 Limited space/ driver issues/ roadways, lights
   (Access ways/ Parking lots)
4 Environmentally sound
   "Eco-friendly" areas, recycled materials)
5 soil strength-Cannot build big buildings
Light-weight, constructible solution  
6 Dangerous teenager hangout  
Create some type of diversion for teen gatherings/ bball courts  
7 Political issues  
Attempt to appease all parties: school kids, older people, teenagers

Practical

1 Is the development feasible?  1  
2 Is it monetarily feasible?  1  
3 Is it safe for kids?  1  
4 Is it accessible?  1  
5 Is it environmentally sound?  1  
6 Building restrictions- Can it be supported by soil?  1  
7 Does it maintain the positive aspects of what was already there?  1 
Chess players..

Creative

1 Development  
Playground/park = 0  
Giant chessboard = 1  
Commercial building (small food stand) = 1  
2 Monetary issues  
Plan on paying with the revenue brought in by establishment = 0  
Sell part of land = 0  
Get town to pay for it/ tax write-off = 1  
3 Way of enforcing safety  
Install fencing = 1  
4 Accessibility/ space limitation issue  
Provide parking/ bicycle space = 1  
5 Environmentally sound  
Provide "eco-friendly" space = 1  
Come up with plan that will avoid (or fix) water contamination problem = 1  
6 Building Restrictions satisfied  
Take zoning into account = 1  
7 Preserve positive aspects of existing land  
Ways of keeping the chess table there = 1

Group Question B

Analytical

1 There is a problem with not having sufficient facilities for students  
(Address issue by thinking of ways of having more schools available)  1  
2 Budget issues/ Political issues  
(Expresses expense concern, appeasing all parties)  1  
3 Wetlands- endangered species  
(Realize that wetlands should be preserved if possible)  1  
4 Water treatment facility  
(Realize that the facility should be fixed)  1  
5 Power plant may be an issue  
(This may be dangerous within school vicinity)  1
6 Commuter rail station
   (Building near the rail station may be very loud)
7 Prison nearby - may be dangerous
   (School children should be kept away from this area if possible)

Practical
1 Way to provide education to so many students
2 Town is over budget/ You still need to appease all parties
   Consider cost issues
3 Wetlands - endangered species
4 Address water treatment facility
5 Avoid power plant facility
6 Commuter rail station
7 Prison - utilize inmates/ move them

Creative
1 Way of providing education to high number of students
   Bus kids to another nearby town or community = 0
   Build another school = 0
   Joint program/ vocational school = 0
   Find teachers within community = 1
   Break into smaller schools = 1
   Encourage boarding school = 1
   Shifting schedules = 1
   Using existing facilities = 1
2 Budget Issues
   Save money = 0
   Money from school events = 1
   Perform cost/benefit analyses
   Talk to community members for input = 1
3 Wetland/ Endangered species
   Do something to preserve = 1
4 Water Treatment facility
   Fix piping = 1
5 Power plant
6 Commuter rail
   Sound proof = 1
7 Prison
   Use inmates to do work = 1
### Appendix C: Statistical Analyses

#### Interrater Reliability: Correlation

<table>
<thead>
<tr>
<th></th>
<th>Analytical</th>
<th>Practical</th>
<th>Creative</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Q1, Q1P, Q1C</td>
<td>Q2, Q2P, Q2C</td>
<td></td>
</tr>
<tr>
<td>Correl</td>
<td>0.948</td>
<td>0.922</td>
<td>0.964</td>
</tr>
<tr>
<td>Average</td>
<td>3.1</td>
<td>91</td>
<td>3.0</td>
</tr>
<tr>
<td>Variance</td>
<td>2.2</td>
<td>91</td>
<td>0.7</td>
</tr>
<tr>
<td>St. Dev</td>
<td>1.5</td>
<td>44</td>
<td>1.4</td>
</tr>
<tr>
<td>Standard Error of mean</td>
<td>0.3</td>
<td>0.97</td>
<td>0.422</td>
</tr>
<tr>
<td>St. Error of Diff</td>
<td>0.14</td>
<td>0.09</td>
<td>0.257</td>
</tr>
<tr>
<td>t-value</td>
<td>0.222</td>
<td>0.161</td>
<td>0.108</td>
</tr>
<tr>
<td>P value</td>
<td>0.826</td>
<td>0.873</td>
<td>0.599</td>
</tr>
</tbody>
</table>

#### Validation

Comparison of Q1 and Q2

<table>
<thead>
<tr>
<th></th>
<th>Analytical</th>
<th>Practical</th>
<th>Creative</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Q1A, Q1P, Q1C</td>
<td>Q2A, Q2P, Q2C</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>3.1</td>
<td>91</td>
<td>3.0</td>
</tr>
<tr>
<td>Variance</td>
<td>2.2</td>
<td>91</td>
<td>0.7</td>
</tr>
<tr>
<td>St. Dev</td>
<td>1.5</td>
<td>44</td>
<td>1.4</td>
</tr>
<tr>
<td>Standard Error of mean</td>
<td>0.3</td>
<td>0.97</td>
<td>0.422</td>
</tr>
<tr>
<td>St. Error of Diff</td>
<td>0.14</td>
<td>0.09</td>
<td>0.257</td>
</tr>
<tr>
<td>t-value</td>
<td>0.222</td>
<td>0.161</td>
<td>0.108</td>
</tr>
<tr>
<td>P value</td>
<td>0.826</td>
<td>0.873</td>
<td>0.599</td>
</tr>
</tbody>
</table>