

AC 2007-939: ASSIGNING CIVIL ENGINEERING STUDENTS TO CAPSTONE COURSE TEAMS

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Assigning Civil Engineering Students to Capstone Course Teams

Abstract

Assigning students to teams for project courses that systematically accounts for balance and diversity affects the functioning and success of the teams. This paper presents an implementation of a goal programming model for grouping senior civil engineering students into a semester-long capstone design project course. Student attributes consisting of overall GPA, grades in prior selected coursework, cooperative work experience, skills with relevant computing software, and Jung-Typology (J-T) or Myers-Briggs Type Indicators (MBTI) were all considered in the allocation of students to project work groups.

Student team assignment is achieved through goal programming to create balanced teams using a program entitled Balanced Student Assignment Team Macro (BSTAM) implemented with Microsoft Excel® spreadsheets. The method has been used by the Krannert Graduate School of Management at Purdue University over the past six years for assignment of individuals to teams in the Professional Masters Program, encompassing the Master of Business Administration (MBA), Master of Science in Industrial Administration (MSIA), and Master of Science in Human Resource Management (MSHRM) programs.

One especially positive outcome of using the BSTAM method is that the course instructors have a much better understanding of the attributes of each class. The course instructor's work with an MBTI expert in the Center for Career Opportunities at Purdue University who suggests criteria for use with the MBTI data, reviews the MBTI data for the teams assembled by the program, and provides a debriefing session to the class on attributes of the various MBTI types. Most importantly, guidelines are presented to the faculty and students for understanding and working with individuals in the teams as the semester progresses.

The authors have now successfully used this assignment method three spring offerings of this course. With experience, the input data are refined to more closely achieve the desired goals. Students are told about the process when the assignments to the teams are announced. They generally appreciate the considerations in making the assignments and do not argue for changes. While performance of the teams in the past two years has been quite good, there is still a spread in quality of the final design products among teams.

This paper provides some background on the course and the need for using a system for assignment of individuals to teams. It shares the knowledge gained in choosing the data to be used and in setting criteria and penalty functions for the various items. The Excel-based software is available for use by others.

Experiences and tools used to evaluate team and individual performances are described. While improvements can always be made, this system allows for forming reasonably balanced teams based on criteria important to functioning in the course.

Key Words: academic performance, capstone design, goal programming, personality types, spreadsheet macro, team formation

Introduction

Instructors have students work in teams in their courses to enhance learning and accomplish course objectives. The teams may last only for an assignment or project, or last for the entire semester or longer. Frequently, the students are allowed to self-select their teammates and in other instances, assignment of individuals to teams is done by the instructor using some heuristic. It is not a simple matter to include more than a few attributes in making the assignment of individuals to teams, especially for a large number of students. The three credit hour senior design course in Civil Engineering at Purdue University (CE498) focuses on providing an integrated, realistic capstone design experience covering the multifaceted aspects of a real-world engineering project (e.g., technical, legal, environmental, ethical, etc.) in a fashion which addresses (as much as possible) all major aspects of the civil engineering profession. The course is taught every semester with enrollments ranging from 50 to 100 students. Teams of 5 or 6 students each are formed and work together for the entire semester and all teams work on the same project. The author has been the lead instructor for the course each spring semester since 2001. The project is typically a building, bridge, or highway relocation that is in the process of being designed and constructed by professional firms. The typical estimated total cost of these facilities is in the range of \$5M to \$15M. The Design-Build (D-B) approach is taken with each of the student teams acting as a D-B firm competing for the project. For realism, the course starts out by asking the teams to form a firm and respond to a Request for Qualifications (RFQ). Within two weeks, a Request for Proposals (RFP) is issued and it, along with Addenda, controls the remaining portion of the course. More information on the history of this course was provided by Drnevich (2001, 2005)^{1,2}.

Balanced Student Team Assignment Macro (BSTAM)

The software used to facilitate the student team assignment (BSTAM) was developed by John Norris (Norris (2007)³) originally as part of an independent study as an MBA student with classmate Ali Jalal in 2001. The goal of the independent study was to make an easy-to-use, efficient tool for automating the cumbersome process of assigning incoming MBA students to teams each year. The solution is a Microsoft Excel Workbook which allows an administrator to set the target levels for each attribute desired per team (e.g. at least 1 person with co-op experience per 5 person team), whether a penalty should be assigned if the team has more or less than the goal and how many penalty points to penalize teams in violation of the goal. This is referred to as “goal programming” in Operations Research or mathematical programming. The objective function is the squared deviations from the target level multiplied (or weighted) by the penalty points and then summed across all groups. To summarize, the objective function is the sum of the weighted squared deviations from the target level of each attribute per group. The software and formulation have been in use since 2001 at the Purdue MBA program for which the software was written. It has been used at two other top MBA programs as well. The formulation of assigning balanced teams is similar to the Design of Balanced Teams (DBT) (Desrosiers et al., 2005)⁴ with the difference being that the BSTAM formulation asks the user to specify whether to penalize teams that are either above or below the target level whereas the DBT model uses

deviations (greater than or less than) from the centroid, essentially the middle point for all values. The BSTAM software can do this by writing the same constraint twice, first goal for penalizing below the target and a second goal for penalizing above the target. These two formulations are essentially similar since penalizing team levels above or below a target value will tend to bring the teams close to the average or target value essentially accomplishing the same objective.

Current techniques for solving binary variables and a quadratic objective function create difficult problems in optimization, as pointed out in the literature (Bhadury et al., 2000)⁵. The BSTAM source code is written in Visual Basic for Applications within Microsoft Excel, commonly referred to as macros. The macro utilized is essentially a swapping algorithm that continues to loop until a specified number of loops pass without any improvement in the objective function. The idea of using a heuristic such as swapping students between groups has also been utilized before (Reeves and Hickman, 1992)⁶. The swapping heuristic does allow lateral or non-improving moves, that is, if swapping two people neither increases nor decreases the objective function the swap is permitted. This is in an attempt to prevent getting stuck at a local optimum. The immediate concern is that cycling could begin to occur, so the software needs to create a “tabu list” of moves that are not to be repeated. For more information on the topic of “tabu search”, see Glover and Laguna, (1997)⁷. In an analysis of published heuristics, Weitz and Lakshminarayanan, (1997)⁸, concluded a “that an adaptation of a pair-wise exchange procedure drawn from the final exam scheduling literature outperforms a more sophisticated graph theoretic approach which has previously been shown to be a top performer for VLSI design.”

The criteria used for balancing teams, is left to the administrator or course instructor. Criteria that immediately come to mind includes: prior class performance (measured by GPA), completion and performance of relevant courses, and applicable experience and computer skills. Behavioral measures popular for use include the Myers-Briggs Type Indicator (MBTI)¹. An approach for how to model the MBTI results for teams is proposed by Chen and Lin, (2004)⁹, who provide a matrix of values comparing the 16 personality types quantifying which types were more likely to work well together. Another behavioral measure often considered is the Big 5 Personality Measures (Goldberg)¹⁰, consisting of: conscientiousness, extroversion, agreeableness, neuroticism (emotional stability) and intellect (openness to experience).

The weighting of goals is also highly subjective. A systematic approach for determining relative weights can be done through the use of the Saaty’s Analytic Hierarchy Process (AHP). This technique has been used in similar applications and involves $n(n-1)/2$ pair wise comparisons of all attributes considered important for controlling in the model (Zakarian and Kusiak, 1990)¹¹. The referenced paper also highlights techniques for generating similar quality results using fewer comparisons, when the number of unique pair wise comparisons would be too great to enumerate. The referenced paper’s implementation of AHP is in an industry setting, but provides insights into how AHP could be used to address the student assignment problem.

Selection of data to use in establishing teams

At the outset, persons who obtain data for use in forming teams must be sensitive to and comply with the Family Educational Rights and Privacy Act (FERPA), a Federal law that protects the privacy of student education records. (www.ed.gov/policy/gen/guid/fpco/ferpa/index.html) The law applies to all schools that receive funds under an applicable program of the U.S. Department of Education.

One of the features of BSTAM is that the data is stored in a separate Excel workbook from the source code. This was designed to facilitate easier updating of the source code without the risk of releasing confidential student data. The source code serves as an Excel Add-in, however it was determined that keeping the file in an Excel workbook format was more accessible for non technical users. Hence, the data workbook can remain under the control of individuals who have a right to access and use the data.

The key to assignment of persons to teams is to make use of only the data that is relevant to forming competent teams where each team has sufficient knowledge, skill, and attitudes to successfully address the project. Some requirements are preset in that only civil engineering students registered in their final semester before graduation are allowed to enroll in the course. The first author, in conjunction with colleagues who have co-taught the course over the past six years, selected the following data to consider for each person in the course:

- Cumulative GPA (students assigned to quintiles),
- Prior course performance (letter grade) in a number of key prerequisite engineering classes (e.g. construction, environmental, geotechnical, materials, structural, transportation, systems, etc.),
- Work experiences (Co-Op., internships, etc.),
- Computing skills (AutoCAD, Excel, MathCAD, etc.), and
- Personality Type (Jung Typology (JT) or Myers-Briggs Type Indicators (MBTI)).

Data from the first three items may be available from student records based on grades in relevant courses. In addition to these sources, on the first day of class, students are asked to complete a web-based questionnaire that allows them to characterize their work experiences and computing skills in greater detail than would be represented by a letter grade in a course, identifying a co-op experience or a computing course. Frequently, computing skills are gained early in their academic programs and some diminish through nonuse over the intervening years. There is some question about the accuracy of self-reported skills, especially computing skills. In the questionnaire, for each major software type, e.g. AutoCAD, OtherCAD, MathCAD, Excel, Word, etc., students must select one of four possibilities: 1) Expert, 2) Capable User, 3) Little Knowledge, and 4) Never Used. While no hard data are available, it is the impression of the author from observing performance of students in this class that students tend to overstate their capabilities especially in some of the more popular software such as Excel and Word, but for some of the more infrequently used software such as AutoCAD, they tend to understate their capabilities. It appears students rate self assessment of skills on familiarity and frequency of use.

Personality Type is most easily obtained by asking the students to compete the Jung Typology test on line (Jung Typology Test (1998)¹²). This test is provided by Humanmetrics free of charge. It consists of 72 questions with Yes or No answers. Once all questions have been completed, the test taker selects the “Score It” button and a summary of the test results is provided that includes the four letter indicators along with the strength of each of the four preferences. The students use copy and paste commands to insert their personal results into an e-mail message to the instructor who integrates them into the database. (See Appendix A. for a Summary of the Jung Typology Classifications and a summary of how the personality types in CE 498 changed over three years. Detailed analysis of this data is beyond the scope of this paper but the changes in personality types can help explain why each class has a different character. Of particular note are major changes from predominantly Introversion (I-scores) to Extroversion (E-scores) and from Perceiving (P-scores) to Judging (J-scores)).

Details of data preparation for use with BSTAM

Data for each student must be contained in a single worksheet tab where there is a header row with column titles followed by one row for each student. The first three columns typically contain a unique student identifying number in the first column followed by first and last name. The remaining columns then contain the relevant data for each student. The data sheet used in forming teams for the senior design course uses 50 to 60 columns (Excel has a limit of 256 columns). However, data in all of these columns need not be used in executing BSTAM. There will be many cells for which there is no information, especially for grades in elective courses. This does not present a problem for use of BSTAM. BSTAM is made up of two Excel workbooks; a source-code file (Codefile.xls) and a file with all the data and settings (Datafile.xls). The data are pasted into the “Add Data” tab in the Datafile.xls. Codefile.xls is loaded and displays explanations for all of the tabs of the template sheet (these are available on the BSTAM webpage <http://web.ics.purdue.edu/~norrisjb/bstam/bstam.htm>). A pop-up menu (See Figure 1.) is then chosen in which the user specifies the number of teams to be formed, the maximum number of individuals per team and the minimum number of individuals per team. The pop-up menu allows for selecting which macros are to be invoked. The first macro to be used transfers the data from the “AddData” to the “AllData” tab, which checks the data and registers it for use in the optimization routines. The separate “AddData” and “AllData” tabs allow for appending new data to the existing data (i.e. if a new student is added). The BSTAM software was originally designed to help assist the MBA program build teams during the summer when it is typical to see shuffling of enrollment that continues until the day of orientation.

The most important tab in the Datafile.xls is the “ValueList” tab. Table 1 provides a view of this sheet with only a few of the 60 columns displayed. The list in the first column describes the information needed in each row.

The “Title of Attribute” can be any unique descriptive title as shown in Table 1. The “Target Number per group” in the second row is the number of students with a given attribute that is desired in each group. The columns in the third row can only contain “<” or “>” and indicate that penalty should be applied if the number selected for the group is greater than or less than the target number per group.

Group Assignment

Clear 'AddData' Random Data Reset Old Runs Close Form

Set Up Instructions
 Paste Data into 'AddData' Worksheet. First 3 columns are reserved for ID#, First, & Last (or other). No empty rows between students. First Row must contain column headers. Data starts in row 2.

The 'ValueList' worksheet stores settings on # of Groups, size of groups and attributes you wish to group on. Please click 'Set Goals' to your right to guide you through this process.

Data Import Options (Import data from 'AddData' to 'AllData')

Clear Data from 'AllData' Worksheet and start over with data from 'AddData'.

Add Data: Will import unique data from 'AddData' into 'AllData' & keep current students intact.

Ignore 'AddData' worksheet and leave 'AllData' worksheet as is.

Current Team Assignment Options (Columns B & C in 'Students' Worksheet)

Clear current team assignments, clear locked groups and clear no shows. (Clear Columns B & C).

Clear current team assignments but keep locked groups and keep no shows. (Clear Column B only)

Leave groups as is, just continue optimizing. (Leave Columns B & C as is).

Set Goals

Minimum Group Size:

Maximum Group Size:

Number of Groups:

Fill in the information above and then click this button.

Optional Output

Display Calculation Sheet

Display Macro Output Sheet

Time Limit: Enter a time limit to run. (HH:MM:SS) 01:00:00 for one hour, 00:15:00 for fifteen minutes.

Performance Time Limit:

 Writes group assignments to 'Groups' worksheet. If you manually alter group assignments, then click this to update the 'Groups' worksheet.

Figure 1. Pop-Up menu associated with the Codefile.xls workbook for setting parameters and invoking macros.

The “Penalty Points” in the next row are relative numbers that allow weighting of one parameter compared to others. For example, 150 Penalty Points were applied to the “Class 440 took class”, a much larger number than nearly all the other Penalty Points shown to put emphasis on having at least one student who took the class on every team.

Table 1. Sampling of Information Used in the “ValueList” Tab of the Datafile.xls.

	GPA lowest	GPA low	GPA middle	GPA high	GPA highest	Class 164 a	Class 164 b	Class 440 took class	autocad ex	autocad ex or cu	%E hi	%E med
Title of Attribute:												
Target Number per group:	1	1	1	1	1	1	2	1	1	4	1	1
Penalize if < or > than:	>	>	>	>	>	<	>	>	>	<	>	>
Penalty Points:	100	60	40	60	200	40	20	150	75	40	70	40
ColumnName	GPA	GPA	GPA	GPA	GPA	164	164	440	autocad	autocad	%E	%E
Value to search for	<2.605	<2.86	<3.08	<3.38	<=4.0	a	b	a	ex	ex	>=75	<76
	>=0.0	>=2.605	>=2.86	>=3.08	>=3.38			b		cu		>=35
							c					

The “ColumnName” row identifies which column in the “AllData” worksheet is to be used for this item. Note that it is possible to have multiple columns in the “ValueList” worksheet make use of data in the same column of the “AllData” sheet. The values in the “ColumnName” row must match on column in the first row of “AllData” worksheet exactly or an error will be displayed. BSTAM does contain a user interface for setting these up, however once a user becomes comfortable with the software they will probably find it easier and faster to manipulate the values directly on this worksheet.

The “Value to search for” information may occupy as many consecutive rows as needed below the “ColumnName” row. The example in Table 1 just makes use of three rows. The program is not case sensitive and will match values regardless of upper case or lower case.

Logic for GPA Columns – In Table 1, five columns are devoted to optimizing teams based on GPA. The goal is to have a reasonable distribution of student GPAs on every team without having two or more students with high or low GPAs on any one team. To establish these criteria, the GPAs for the class were sorted from highest to lowest. Since the team size was five (or six) persons, the GPAs for the highest, high, middle, low, and lowest quintiles was determined using the original data. The values for this example are 3.38, 3.08, 2.86, 2.605, and 0. (In practice students entering this class almost always have a GPA greater than 2.0, but using the 0 will not affect the values.) Setting the Penalty Point for the lowest and highest GPAs to larger values will help ensure that teams will have students with both a lowest and a highest GPA, but not more than one in each category.

Use of these criteria for GPA generally produces teams having an average GPA within 0.15 (on a 4-point scale) of the average GPA for the entire class. Statistical analysis using Levene’s Homogeneity of Variance (Levene, 1960)¹³ was used to determine that the variance among GPA across groups was not statistically different.

Logic for selection of students for teams with desired grades in a selected course – Columns labeled “Class 164 a” and “Class 164 b” (Graphics For Civil Engineering And Construction) in Table 1 illustrates the procedure for obtaining teams where every team has at least one student who has completed course 164 with a grade of A and that each team should not have more than two students with a grade of B. Criteria like these have to be decided by observing the number of students and the grade distributions in each course under consideration. It turns out that similar criteria will apply to nearly all of the required courses in the program, but special criteria will have to be applied to elective courses, especially those with small enrollments. For example only about 10 students took the CE 440 (hydrology) course and had grades of A, B, or C. It was considered important background for this project, so an effort was made to spread these 10 students out over the teams with no team having more than one student who took and passed 440 with a C or better grade.

Similar logic to the above is used for distributing individuals with computing skills among the teams. The “grades” for these cases are the self-reported skills where “ex” = Expert, “cu” = Capable User, “lk” = Little Knowledge, and “nu” = Never Used. The logic in Table 1 aspires to

have an expert in AutoCAD and no more than four credible users on each team. Again, the target numbers and logic depend on the distribution of information available for the given item.

Logic of Jung Typology Scores - J-T test results produce a four letter type indicator and a number indicating the strength of preference for that letter as described in Appendix 1. The example in Table A.2 in Appendix A shows the results for just one of the letters, “E”, for which the strength of preference can range from 1 to 100, with a person scoring a 100 indicating extreme extroverted characteristics. The “E” scores were sorted from high to low and the values for the upper and middle thirds were determined to be 70 and 40, respectively. The goal was to have teams with no more than one member having high strength preferences in extraversion and no more than one member having medium preferences in extraversion. This process can be used for the other seven letters; however it may not be necessary to consider all eight letter types, especially if the number of students is very small for some type preferences. (The distribution in this course for the past two years was unusual for engineering students in that about two-thirds of the class indicated extroversion preferences. However, they were typical of engineering students in that less than 10 percent of the class indicated “P” (Perceiving) tendencies and the strength of preference for these was weak. Hence, criteria for distributing the “P” types were not used.) The BSTAM was used initially in spring 2005 with 97 students divided into 16 teams. It was used again with refined criteria in spring 2006 with 78 students divided into 15 teams. The criteria were further refined and BSTAM was used to distribute 74 students into 14 teams in Spring 2007.

Evaluating BSTAM results

Once the information in the “ValueList” tab is complete, the Excel file containing BSTAM macros (Codefile.xls) is loaded, the desired options are selected, and the macro is invoked by selecting the Run Optimizer button. The program usually takes less than a minute to form the teams for the number of teams (14 to 16), total number of students (70 to 100), and the number of criteria (50 to 60) used in this course. Results are tabulated in the “Groups” tab on the Datafile.xls workbook along with all of the corresponding data provided in the “AllData” tab. Hence it is easy to scan the teams for situations where the desired criteria are not met. A more systematic review of the efficiency of the optimization is provided in a separate “Calculations” tab. For situations where desired goals are not met, it is usually sufficient to change the Penalty Points for that item and run the optimization again.

Team announcement process

The formation of teams is done at the second meeting of class in the semester. Data gathering on the students from historical records is begun several weeks before class begins and is facilitated by personnel in the Undergraduate Office who obtain the data from queries to the database. Information on the personality type and self-reported work and software skills are obtained through an on-line assignment that is completed in class on the first day of class. Students are asked to bring a copy of their personality test results with them to the next class.

The instructor assembles the data into the Datafile.xls workbook and BSTAM is used to determine the team assignments. While the program takes less than a minute to run, the process of assembling the data and determining the necessary team criteria can take a few hours.

The assignment of individuals to teams is announced at the beginning of the second class period. A preface to the announcement provides the general criteria for assigning individuals to teams. (See bullet point list of items provided earlier.) As student names are displayed, they are asked to move to locations in the room reserved for their team. Once all teams are announced, the members of each team introduce themselves to each other. This is followed by a presentation by our local expert on personality test interpretation who skillfully presents an overview of what the test results tend to indicate. In the process of the presentation, people in the groups get an opportunity to understand some of the personality indicators of themselves and their teammates and more importantly how to more effectively interact with these individuals. This process can be an excellent way to initiate the team experience for the semester.

Assessment of team performance

An experiment of MBA students that split students into randomized and balanced groups concluded that balanced groups spread work more evenly (Donohue and Fox (1993))¹⁴. An earlier study by Muller (1989)¹⁵ concluded "that balanced groups have a modest advantage over groups that are formed randomly" (page 631) and "balanced groups felt slightly more satisfied with their group" (page 631), but also raised some concerns about inequity among balanced teams providing "some tentative evidence that the more experienced students in balanced groups are less satisfied with their group and feel less challenged" (page 631) which may "suggest only tentatively that the more experienced members of a balanced group feel their performance and learning in the project are compromised or watered down by the weaker members" (page 629). As Muller (1989, p. 631)¹⁵ points out, the instructor (or administrator) needs to make a judgment call on how much effort is warranted to potentially increase harmony, learning and satisfaction.

Some of these concerns about team member inequity can be addressed by making teams create a contract or "Signatory Code" (Bailey et al. (2005))¹⁶ where team members agree in advance what each student must do to receive credit for the team component of the coursework. The teams in that article were balanced for language skills and gender, but admittedly the focus of that article is not on the technique for assigning students to teams.

Several methods are used to assess team performance in this senior design course. The first is to have the teaching assistants have short informal meetings with each team every week as part of the "office" component of the course. Potential problems can be shared with the course instructor who can take steps to address an issue. Occasionally, the expert from the Center for Career Opportunities is consulted for additional insight based on the mix of personality types in the given team.

Early in the semester, each team provides a written report and makes a presentation on their proposed conceptual design and the results of their alternatives analysis. The presentations before the instructional staff and students invited from other courses (but not students on

competing teams) can indicate problems in team chemistry and functioning to observant instructors.

Very shortly after the first report and presentations are completed, every student is asked to complete a peer evaluation questionnaire as shown in Figure 2. The student evaluates himself/herself and every person on his team concerning their performance as outlined in Figure 2. The questionnaire is conducted online and results are held in strict confidence. The numerical evaluation ratings for each individual in a team are averaged and the average of the ratings for all team members is established. If all persons on the team were perceived themselves and their peers to be rated “Excellent” or “Very Good”, the average peer evaluation score would be unity. On the other hand, if one or more persons on the team were perceived to have performances in the “Good”, “Fair”, or “Poor” categories the average peer evaluation score will be less than unity. These evaluation scores are then used to adjust the grade applied to the written report for the team to establish the report grade for the individual. The process is to multiply the report grade by the individual’s average evaluation score divided by the team average evaluation score to obtain the report grade for the individual. The net result is a reduction in the report grade for the individual or individuals whose average is lower than the team average and an increase in the report grade for others whose average is higher than the team average score. In most instances with well-functioning teams, adjustments are equal to one. On some teams, if only one person slightly downgrades a teammate, the impact is minimal on the adjustment. However, if two or three persons on a team consistently down grade a teammate, the adjustment can be dramatic. This peer evaluation has been in use every spring semester for five years and there is more than one instance where the team report grade was say a 90% and one, under-contributing member had his report grade adjust to 60% or lower. Doing this evaluation early in the semester serves as a “wake up call” for the individual and is usually sufficient to get that person engaged with his/her team. The course instructor carefully monitors the situation and usually meets with the individuals and/or team as appropriate to assist the reunification process.

At mid term, students are invited to complete an anonymous survey on their experiences in various aspects of the course which includes: speakers, lectures, assignments, presentations, reports, and the peer evaluations. The overwhelming majority of the students are pleased that the peer evaluation was conducted and endorsed having it conducted again at the end of the semester.

At the end of the semester, a second peer and course survey are conducted along with the standard course evaluations mandated by the university. While no randomized control groups were used for comparison, fewer issues of team performance or discontent have been observed in recent years where the Myers-Briggs Type Indicator was used in the team formation process. Prior to that only overall grade point average, grades in selected courses, and computer skills were used to form the teams. The clear advantage of BSTAM is that many more factors can be systematically considered as compared to forming the teams by manual methods. Given the observed success with use of BSTAM, we do not intend to use randomly generated teams for comparing team performance.

CE 498 PEER EVALUATION

Request for Proposals – Phase 1

(Due before 5:00pm on Friday, March 2, 2007. Do on-line by going to course website)

FIRM No. _____, FIRM NAME _____, YOUR NAME _____

Evaluate the performance of the members of your firm, based on the following criteria:

- 1) Attendance at meetings including timely arrival and departure
- 2) Participation in gathering information, the development of solutions, products, and deliverables
- 3) Quality of work products generated

Assign a grade to each member of your firm from the scale below. A grade adjustment factor for the RFP, Phase 1 grades will be applied based on weighting factors given in parentheses shown below. Although the values for *E* and *VG* are identical, please assign whichever you think better describes your colleague's performance. There is space to write comments. Your comments are very valuable, and are required when you evaluate someone's performance as *G* or lower. Be sure to evaluate yourself in the first row.

Evaluations done by each individual will be kept confidential. Please do not share your evaluations with anyone else.

Letter Grades for peer evaluation

- E* = Excellent (1)
- VG* = Very Good (1)
- G* = Good (0.8)
- F* = Fair (0.6)
- P* = Poor (0.2)

Member Name	Letter Grade	Comments
Person doing evaluation		

Figure 2. Peer Evaluation Questionnaire

Summary

This paper presents a method for assigning individuals to teams that optimizes academic performance, practice experience, software skills, and personality characteristics based on criteria established by the instructor. The process is done in an Excel spreadsheet using the software Balanced Student Team Assignment Macro (BSTAM) developed by the co-author. The software is available free of charge and downloadable from an internet site (see references). The paper describes the software, and with examples, explains how to use it. Effective team functioning can be enhanced by the process used to announce the team assignments. When students learn of the procedures used, they readily accept their assigned teammates. There is some discussion on assessing team performance and there is a description of the tools used in this capstone senior design course to evaluate individual performance in the teams. Surveys conducted at mid-term and at the end of the semester indicate that students are generally satisfied with their teams and with the survey and evaluation methods used in this course.

Conclusions

The Balanced Student Team Assignment Macro (BSTAM) is an easy-to-use tool for creating balanced and diverse teams. It allows for including far more attributes than could be handled by simple heuristics or manual procedures, which were used previous to the availability of BSTAM. Overall, the authors' experience that team assignment based on attributes as used herein provides reasonably well functioning teams and provides information the instructor can use to address individual and team issues that may arise during the course.

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End note

- i. MBTI, Myers-Briggs, and Myers-Briggs Type Indicator are registered trademarks or trademarks of the Myers-Briggs Type Indicator Trust in the United States and other countries.

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Appendix A. Summary of the Jung Typology Classification (From <http://www.humanmetrics.com/cgi-win/JungType.htm>)

According to Jung's typology all people can be classified using three criteria. These criteria are:

- **Extraversion - Introversion**
- **Sensing - Intuition**
- **Thinking - Feeling**

Isabel Briggs-Myers added fourth criterion:

- **Judging - Perceiving**

The first criterion defines the source and direction of energy expression for a person. The extrovert has a source and direction of energy expression mainly in the external world while the introvert has a source of energy mainly in the internal world.

The second criterion defines the method of information perception by a person. Sensing means that a person believes mainly information he receives directly from the external world. Intuition means that a person believes mainly information he receives from the internal or imaginative world.

The third criterion defines how the person processes information. Thinking means that a person makes a decision mainly through logic. Feeling means that, as a rule, he makes a decision based on emotion.

The fourth criterion defines how a person implements the information he has processed. Judging means that a person organizes all his life events and acts strictly according to his plans. Perceiving means that he is inclined to improvise and seek alternatives.

The different combinations of the criteria determine a type. There are sixteen types. Every type has a name (or formula) according to the combination of criteria. For example:

ISTJ

Introvert Sensing Thinking Judging or

ENFP

Extrovert INtuitive Feeling Perceiving

For a certain person a type formula and quantitative measure of expression of each criterion (strength of the preference) can be determined using the Type inventory. Then the corresponding type description can be represented. So, by activating the Jung Typology Test and answering the inventory questions you will discover your type formula, strength of the preferences and type description. It may help you to identify your general life style and your style in certain fields of activity (business, love, education, communications, conflicts).

A summary of personality types by year in CE 498 Senior Design is provided in Table A1 and Table A2 provides a summary of the changes in the eight indicators over three years (spring semesters only).

Table A1. Summary of personality types by year in CE 498 Senior Design

Year	2005		2006		2007	
	Count	Percent	Count	Percent	Count	Percent
ISTJ	14	18.9%	2	2.8%	6	8.5%
ISTP	5	6.8%	2	2.8%	0	0.0%
ISFJ	6	8.1%	2	2.8%	1	1.4%
ISFP	2	2.7%	0	0.0%	1	1.4%
INTJ	7	9.5%	6	8.3%	9	12.7%
INTP	9	12.2%	0	0.0%	3	4.2%
INFJ	1	1.4%	5	6.9%	1	1.4%
INFP	5	6.8%	1	1.4%	1	1.4%
ESTJ	5	6.8%	15	20.8%	11	15.5%
ESTP	5	6.8%	2	2.8%	1	1.4%
ESFJ	3	4.1%	14	19.4%	8	11.3%
ESFP	1	1.4%	3	4.2%	1	1.4%
ENTJ	5	6.8%	10	13.9%	20	28.2%
ENTP	2	2.7%	2	2.8%	0	0.0%
ENFJ	2	2.7%	7	9.7%	7	9.9%
ENFP	2	2.7%	1	1.4%	1	1.4%
Total	74	100.0%	72	100.0%	71	100.0%

Table A2. Summary of changes in personality indicators over three years in CE 498 Senior Design

Year	2005		2006		2007	
	Count	Percent	Count	Percent	Count	Percent
I	56	62%	18	25%	22	31%
E	34	38%	54	75%	49	69%
	90	100%	72	100%	71	100%
S	45	54%	40	56%	29	41%
N	38	46%	32	44%	42	59%
	83	100%	72	100%	71	100%
T	61	69%	39	54%	50	70%
F	27	31%	33	46%	21	30%
	88	100%	72	100%	71	100%
J	47	58%	61	85%	63	89%
P	34	42%	11	15%	8	11%
	81	100%	72	100%	71	100%

Note: Unequal totals are due to both no response (2005) and students having a neutral score on a particular construct.