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Strategies for Successful Interdisciplinary Projects: A California State Polytechnic University, Pomona, Perspective*

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An innovative interdisciplinary capstone activity is described that integrates theoretical and experiential education in preparing undergraduate students for engineering, science, and business careers. The model uses real projects funded by corporations. The success of the program is in part attributable to the effective use of team building training as well as peer-based and team-based performance reviews. Team building introduces participants to a strategy to increase group cohesiveness and productivity. This training involves the completion, interpretation and discussion of the Myers Briggs Type Indicator (MBTI). The effective use of peer-and team-based performance reviews reinforces the techniques presented during team building. The criteria for client, project and team selection are summarized. A MBTI analysis of a set of teams, and the rationale for peer and team-based performance reviews are included.

INTRODUCTION

THE CAL POLY Pomona Engineering Interdisciplinary Clinic (EIC) was established in order to provide an innovative capstone activity that integrates theoretical and experiential education in preparing students for engineering, science and business careers. During the past nine years EIC has developed and refined a pedagogical model that utilizes interdisciplinary mentor/student teams to undertake funded projects. The keys to the successful implementation of this model has necessitated that careful attention be given to clients, projects, mentors and student participants.

CLIENTS

The identification of supportive clients has been critical. This occurs as a result of a marketing approach that communicates the character of a successful organization and the benefits achieved by client participants. In addition to providing project funding, clients must be willing to work with EIC and its mentor/student teams in establishing clearly defined deliverables for a doable project. These clients must also identify a technical liaison who willingly interacts with the EIC teams and facilitates their access to the client's experience with relevant technology. The clients must also be willing to communicate a genuine interest in both the project and the team and to provide feedback about the teams' performance.

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PROJECTS

The selection of specific projects has also been a demanding aspect of the EIC model. Historically, many EIC projects follow a research, design, build, test and document scenario. In addition to addressing the constraints of time and personnel, the EIC has used other criteria to facilitate project identification. The projects must be identified but not on the client's critical path. In order to allow sufficient EIC team input the project target should have established requirements but not detailed specifications. Once preliminary ideas have been proposed by a client, EIC has discovered that the authoring of a project prospectus gives assurance to clients and breaks the ice for the faculty/student team who will challenge the project.

FACULTY AND STUDENT SELECTION

Central to the success of EIC is the identification of faculty mentors and students to create high-performance teams. Teams are small groups of people who have complementary skills, who work together to achieve a common goal for which they are collectively responsible [6].

The benefits of teams [5] include, but are not limited to, the following:

1. Create higher-quality solutions than most individuals working alone.
2. Provide an opportunity for more individuals to develop and utilize leadership skills and fulfill personal needs.
3. Serve as a vehicle for organizational development efforts.

In EIC, the aim is to have high performing teams, which have the following key characteristics [6]:

strong core values;
general sense of purpose which translates into specific performance objectives;
the right mix of skills (technical, problem-solving and interpersonal);
creativity.

In order to set the stage for the development of high-performance teams, it is imperative to address the issues of personnel selection. This is a challenge to EIC because at the beginning of a typical academic year seven faculty mentors and 50 student engineers, scientists or specialists must be identified.

Research on selecting for teams is relatively new; however, it appears that technical skills as well as interpersonal and self-management skills are important for successful teams. Ideally, team composition should be diverse. Studies demonstrate that diversity of experience is positively correlated to performance [1, 14]. In addition, diverse teams had more synergy, that is they were able to produce outcomes greater than the sum of the individuals in the group. Research on group processes and project planning has indicated that groups will develop project plans that are superior to the plans developed by the best member [8].

The EIC has therefore been challenged to develop a screening process in order to assure the identification of high performance teams. Teamwork and leadership experience have been used to evaluate candidates and to potentially identify teams who have a higher probability of being successful. The EIC has also found that a willingness to be committed, hard working and to work collaboratively are more important student characteristics than mere brilliance.

Table 1 reflects the broad range of disciplines in EIC for the 1998–99 Year. You will note that each team has at least three disciplines.

The diversity within EIC is also reflected by a broad range of team, leadership and work experience. For the 1998–99 year 85% of the EIC student participants had significant team experience, e.g. sport team, US Navy and construction crew. For this same year 75% had leadership experience, e.g. coach, department manager and library supervisor.

Table 1

Team	Disciplines
#1	CHE,ECE,ECET,PHY
#2	ARO,CHE,ME
#3	ME,CHE,ECET,CE
#4	ARO,IE,ECE,PHY,MAT,MET
#5	IBM,CIS,MKT
#6	CS,ECE,MAT
#7	ECE,CS,CIS,CIS

Table 2

Team	Avg. GPA	Std. Dev. GPA	Avg. GWT	Std. Dev. GWT
#1	3.29	0.29	7.50	2.07
#2	3.29	0.46	8.71	1.50
#3	3.27	0.43	9.25	1.39
#4	3.47	0.24	8.43	1.51
#5	3.36	0.36	8.20	1.48
#6	3.37	0.30	7.50	1.22
#7	3.40	0.24	8.00	1.67

Work experience is typical (83%) for Cal Poly Pomona students. This may range from machine operator to cashier to technician to automotive mechanic.

In industry, there are numerous benefits to complex selection systems consisting of interviews, tests and reference checks. The major benefit, which also applies to EIC, is the increased likelihood of choosing applicants who are skilled and motivated to perform well. In order to determine a student's technical, interpersonal and self-management skills, extensive information is obtained from applicants to EIC. Students complete a lengthy selection process which consists of an application form, two letters of reference, and interviews by the EIC director, as well as faculty mentors. Student performance information such as GPA, and GWT (graduate writing test) scores are obtained. Student involvement in extracurricular activities is also viewed as important.

The demonstrated academic achievement of EIC students is reflected by high average overall GPAs and average GWT scores for the 1998–99 teams. The relatively small standard deviations indicate that EIC teams are composed of individuals who are fairly complimentary.

In spite of the best efforts at selecting team members with the right mix of technical and interpersonal skills, the disadvantages of teams still must be addressed. Teams take significant effort to implement and manage. They also require more time for the decision-making process. However, in EIC, we have found that the team approach is worth the additional effort.

The identification of the team faculty mentor is important. Faculty mentors encourage students to have high performance expectations and reinforce the importance of working in a team-oriented manner. In addition, EIC faculty mentors understand the relevant technology and if necessary facilitate some technology training. They may also need to assist the student team in project planning, organization, and client communication.

TEAM LEADER

Once an EIC faculty/student team has been identified attention is focused on the selection of the team leader. According to [3] the team leader serves as the center of communications and

monitor total system productivity. Their major responsibilities are to establish and communicate clear objectives for the team, carefully plan and guide initial meetings and activities of the team, encourage a high level of interaction among team members and facilitate early development of team norms and responsibilities. Most often the EIC team leader is a student but in some cases this role may be assumed by the faculty mentor. This leader faces significant challenges. The most important challenge is maintaining the focus of the students on the agreed upon project deliverables throughout the period of the project.

The team leader's success is due in part to the person's ability to effectively choose the appropriate management style for the team. Typically leadership style is autocratic, participative or laissez-faire.

Autocratic leadership style is directive and controlling. The leader organizes work relationships and establishes clear patterns of getting things done, *with little input* from the team members. Generally this results in a restrictive work environment which can create high levels of tension and conflict, as well as reduced motivation. It is important to note, that for some teams, an autocratic style can work if the leader reduces the amount of control used to influence the team. Participative leadership style is collaborative and responsive; team members have a high degree of influence over work relationships and task accomplishment. The leader exhibits less direct supervision, but retains final authority and responsibility. Finally, laissez-faire leadership is leading by not really leading; in other words, the leader does not fulfill the implied obligations and responsibilities of the position. Of the three types, the most successful leaders use the participative style, but are willing to become more autocratic if the situation warrants.

TEAM BUILDING TRAINING

To provide the faculty mentor and team members with the tools for creating a successful team, the EIC provides team building training at the beginning of the project process. The EIC team building is a group intervention consisting of a series of activities designed to help members examine how a group functions and how it may function better. The EIC team building training consists of exercises in communication, conflict management and consensus decision making. This training also involves the completion and analysis of the Myers Briggs Type Indicator. All team building training takes place during an intensive one-day session. This time spent working closely together as well as opportunities for socializing provides the foundation for the teams' focused work effort during the months to come.

Team building also occurs as a result of regular team meetings. Teams schedule weekly meetings during which progress is reported and action items are identified. These meetings also serve to provide the faculty advisor the opportunity to offer technical support and most important, mentoring. This mentoring takes the form of modeling professional behavior, and encouraging students to do one's best for the good of the team.

One way to assess interpersonal style diversity is the Myers-Briggs Type Indicator (MBTI). Major corporations administer nearly 40 percent of the three million MBTI assessments that are completed yearly, for team building and management development [10]. The MBTI has been used in research relating psychological type to managerial behaviors such as decision making (Nutt, 1990):

conflict resolution [9];
leadership [12];
managerial effectiveness [4].

The MBTI reports key preferences along four scales:

extraversion (E) introversion (I);
sensing (S) intuition (N);
thinking (T) feeling (F);
judgment (J) perception (P).

Scores are typically reported in two ways: type, which consists of the highest score along each scale, or style which is the highest score of two scales. Frequently in business settings the focus is on problem solving style, which reflects the way a person obtains and processes information.

Table 3

MBTI Type		Problem-Solving Style	
ESTJ	14	ST	
ISTJ	13	ST	
ESTP	2	ST	29
ENTJ	4	NT	
INTJ	3	NT	
ENTP	2	NT	9
INFJ	2	NF	
INFP	1	NF	
ENFP	1	NF	4
ISFP	1	SF	
ISFJ	1	SF	2
			44

Table 4

Team	Problem-Solving Style			
	ST	NT	NF	SF
#1	6	1	1	0
#2	3	3	0	1
#3	4	1	0	0
#4	2	1	1	0
#5	6	0	0	1
#6	2	1	2	1
#7	5	2	1	0

Tables 3 and 4 summarizes the MBTI types for the 1998–99 EIC students and teams.

These results indicate that EIC is composed mostly of students who show a ST orientation. This suggests that they would prefer to work in an environment that requires them to perform real-time technical problem solving. Generally, the problem solving style of the ST is systematic and prefers quantitative measures. There are also a significant number of EIC students with an NT orientation. These are the students who are interested in future-time technical problem solving. They also like to deal with future possibilities. Within six of the seven groups there is a mix of the different problem-solving styles. This reflects the balance of problem-solving approaches that is needed for the successful completion of EIC projects.

PERFORMANCE REVIEWS

EIC is unique in that team building occurs also by continuous improvement, where members meet periodically to monitor group and peer development and accomplishments. This monitoring process is by peer and team reviews (also known as 360-degree feedback), which happens twice during the year.

Peer review is 'fair, accurate, credible and more comprehensive' (13). This process is also appropriate for developing personnel and facilitating making needed changes to optimize performance (2). Continuous improvement develops the faculty mentor's and student's sense of responsibility to the team.

To encourage honest evaluations, faculty/student team members confidentially evaluate each other during this phase. Therefore all students are evaluated individually by their mentor and each peer within their group. The individual reviews for each person on a six member team would include 5 peer reviews and a faculty mentor review for each student. The evaluations are summarized, weighted (60% student peer and 40% mentor) and reported to each student during a one-on-one meeting with the advisor. At this time if there are areas of development for a team member, the advisor conveys this to the student in a way as not to create defensiveness, but facilitate behavior change.

The individual performance review first lists results achieved. The form then addresses the two major areas of feedback: interpersonal, which consists of strong communication skills and supportive behaviors, and rational, which consists of analysis, idea generation and problem-solving skills. The form used in EIC identifies student performance in four areas:

resourcefulness;
quality of results;
contribution to the team;
quality of communication.

These four factors have been shown to be crucial to the success of project planning efforts [7]. A 1–6 scale is used with 1 interpreted as needs significant improvement and 6 understood as highly effective. Each evaluation for each category requires a comment that identifies why the rating is high or what one must do to improve.

The EIC also utilizes team performance reviews which are developed collaboratively with the EIC director. These reviews focus on the following areas: planning, implementation of project plan, attainment of project goals, documentation and demonstration of technology to the client, communication with client and expectations met. Specific suggestions for improvement must be written by each evaluator for each area. The forms are completed by the team as a group, the faculty mentor, the clinic director and the client. A composite evaluation is prepared by the director and communicated to the team as a whole.

CONCLUSIONS

During the past nine years the Cal Poly Pomona Engineering Interdisciplinary clinic has successfully challenged 52 projects for 17 different clients. All projects have been successful because they have resulted in a positive learning experience for both faculty and student participants. EIC clients are also very positive about this partnership. Not only does the client benefit from technology development but they are linked to well-trained professionals. EIC students are competent with both project planning and interdisciplinary plan implementation. They develop a unique understanding of clients and the importance of effective client- and team-based communication. Furthermore, the EIC capstone experience has been successful because it promotes student teams to come together, to have fun, to establish a sense of project ownership and to do their best to be successful.

A successful Engineering Interdisciplinary Clinic model has been developed at Cal Poly Pomona. This model focuses on effective project selection and involvement by the client liaison. However, the success achieved by EIC is in part attributable to care taken in identifying student and faculty participants. This selection process attempts to balance the technical with interpersonal competence required by the team. This model creates through training and promotes by faculty mentoring, a work environment that is team based. Furthermore, it monitors team and individual performance through a comprehensive performance review process. The end result is a comprehensive learning experience that provides students with the opportunity to practice their technical skills while developing their interpersonal skills.

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