Teaching Team and Interpersonal Skills via Design Projects: Transplanting an Industrial Team Model

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Abstract

Like most projects in the real world, undergraduate design projects are usually assigned as "Team" projects. In many such courses, little emphasis is put on teaching team and interpersonal concepts to maximize team success. The capstone Chemical Engineering design course at the University of Michigan is rated by student assessments and general consensus as the most difficult and intense course in the Chemical Engineering curriculum. Under the stress of successfully completing this course during what is, typically, the students last semester, group dynamics and interpersonal relationships can be strained to the limit**.** Recognizing this problem and the need to give graduating students insights into group dynamics and the interpersonal skills required for supervision, the author incorporated into the design course, concepts he helped developed for a implementing a team based compensation system in industry.

The program features lectures on team dynamics, given before teams are assigned. These explore such elements as working with people you don't "like", accessing and valuing individual skills, separating project issues from personal issues, structuring team work for inclusion and working through consensus. Suggested structures for initial meetings, which focus on team building, are presented. Design team membership is determined by the instructor by combing student-selected pairs to form the four member teams. Academic performance, prior work experience and overall diversity are considered, to the extent possible, in determining the teams. The first assignment for the each team is to develop and submit a set of Teams Rules which they will use to govern their decisions on team function and performance. These must be developed by consensus, signed and submitted for review. Simplistic or un-enforceable rules are rejected and required to be redrafted. Only after creation of governing rules are in place, does the group chose a coordinator. It is emphasized that there is no "BOSS", just an administrative coordinator to assure efficiency. During the course of the project, the supervisors will take action on interpersonal issues ONLY if all team members request it; If even one member does not agree to intervention, the students must resolve the issues themselves...just like in the "real" world. To facilitate participation and cooperation by all members of the team, two Peer Evaluations as submitted—one at mid term and the other at the end of the course. These evaluations are based on the ones developed for the industrial team assessments. The rules for utilizing these Evaluations are carefully reviewed prior to distribution of the forms. Each individual evaluates team performance, their own performance and the performance of each other member of their team. These scores are used as a guide by the project supervisors in allocating 10% of the total class grade that is based on individual participation and effectiveness. To date, the Peer Evaluations have been confidential but during the Fall 2004 term, a system will be implemented to give composited feedback to each team member on their performance. Students rate the team experience in the Process Design course one of their most valuable learning experiences.

INTRODUCTION:

The senior Chemical Engineering Design course at the University of Michigan is structured to simulate "real life" practice as much as possible. As would be true with any industrial design project, the course is team based, usually with four students to each team. The common practice had been to let students determine their own teams, with faculty assigning extra students who had not chosen teammates. The author's background in engineering management in the chemical industry led him to point out that this practice was in complete variance to industrial practice. Working with a self-selected group did not reflect the normal team experience in the nonacademic world.

More significantly, he found that, as with many team-based activities, it was assumed that the basis for good team dynamics and effective interpersonal relationships within a team were already known to students and/or would be intuitively be developed during the assigned projects. In reality, while most students had worked in teams during other courses, most have had little, if any, exposure to formal consideration of the basics of teamwork. Most had some "intuitive sense" of what worked and what didn't, but this was unfocused.

The importance of teamwork in today's work place is often not completely appreciated. It is an essential skill, on a par with technical skills. It is a major factor in compensation and advancement. Yet, while the importance of effective teamwork may be touched on in some courses, it is not often formally taught in any of them. This should be rectified if we are to produce graduates who can use their engineering skills to their true potential in the workplace.

Prior experience with researching and designing a team development model for an industrial workforce where results and compensation would depend on effective team skills, led the author to believe that this model could be effectively adapted to the U of M's senior chemical engineering design course with positive results. The industrial model consists of four distinct parts:

Teams Skills Training
Team Formation & Organization
Team & Individual Evaluation
Team and Individual Reward

The application of this model to student teams is discussed below.

TEAM SKILLS TRAINING

In many situations throughout life, there is a basic assumption that people inherently know the basics of teamwork. It is assumed that "on the job training" will allow any group of people to use intuitive skills to become an effective team. Even in team-centered activities, such as athletics and music, instruction tends to be on adherence to defined roles and other team concepts are just expected to develop naturally.

When these assumptions were examined in an industrial setting, they proved to be only marginally valid. In situations where self discovered keys to good teamwork DID develop, it was often at great expense of time and emotional energy and after a prolonged period of limited team effectiveness. Moreover, it was apparent that the most important keys to developing effective teams lay in the beginning, formative stages of the process, not after prolonged trial and error.

It is logical then that teaching team skills at the beginning of the process will result in better more effective teams than simply allowing them to self develop. This is true for two reasons:

1) Individuals learn effective team behaviors before they need to apply them
2) Team members have a more uniform understanding of what is expected of an individual within a team.

In the industrial team-based compensation model up to 40 hours of training over a 2-year period were dedicated to developing and reinforcing team skills. The first 8 hours of training were required at the formation stage of the teamwork groups. Obviously, this amount of time is not available in a single undergraduate design course. Yet the basics could be distilled into 1 1/2 to 3 hours of lecture, which highlight the basic concepts of teamwork and give student groups a foundation on which to build successful teams.

The author's teamwork lectures are based loosely on the concepts presented in "The Basic Principles of Team Work" [1] from the Zenger-Miller Series: Team Effectiveness. Lectures are divided into 6 parts: **Recognizable characteristics of good teams**

The Basic Principles of Teamwork
Requirements for an Effective team
Team Structure and Rules
Meeting and Schedules
Peer Evaluation

Recognizable Characteristics of Good Teams- This section of the lectures catalogs the students' observations and experiences. It emphasizes commonality of good team traits and spotlights student identified team characteristics that often are not noticed. It promotes "buy in" by showing that these experiences have merit and value.

The Basic Principles of Teamwork - These are the Zinger-Miller defined concepts shown in Figure I. These form the basic allowable behavior patterns within the student teams. It is their universal "Constitution" for team governance. Each principle is discussed. Why it is important? What situations might it cover? What are the alternatives and their outcomes?

Figure I

The Basic Principals of Teamwork

1. **Focus on the situation or issue, not the person**
2. **Maintain the self-confidence and self-esteem of others**
3. **Maintain constructive relationships**
4. **Take the initiative to make things better**
5. **Lead by example**

Requirements for an Effective Team- These are the actions, shown in Figure II, which enable effective team development. They are defined and discussed.

Figure II

Requirements for an Effective Team

1. **Defined Coordination-** SOMEONE IN CHARGE
Not a BOSS; A People Person
2. **Assessment of Strengths –** Assign work accordingly
3. **Agreement on the Problem: Agreement on Goals**
4. **Commitment to Goals**
5. **Frequent Reassessment & Adjustment**
6. **Communication, Communication, Communication**

Adapted from Zinger Miller

Team Structure and Rules- A team is “owned” by its members. But they do not operate in complete freedom. There are boundaries to their purpose and entitlement. There are external rules which apply. The group must formulate its own internal rules for governance and these must be ratified by all team members. These limitations and governing concepts are defined and discussed. The team must select and empower a member to focus and coordinate the actions of the group. Suggested criteria for this selection are discussed. The concept of consensus is explored.

Meetings and Schedules- Students often view meetings at their two extremes:

A “bunch” of people getting together to try to figure out how to do something
or A formal convening run strictly under Roberts rules of order.

In reality, neither model is effective in a design project. In class, the focus and structure of meetings is discussed. Sample agendas for the first 3 meetings on a design project are presented. These are show in Figure III. The use of schedules as tools for planning is explored. Critical path concepts are reviewed.

Peer Evaluation- Young engineers frequently are thrust into supervisory roles before they want them. Performance review is an important part of this role. Few students have a background in this area. Peer evaluation is an important learning tool to fill this void. In class, the nature and function of performance reviews is discussed. Constructive, future, directed evaluations are emphasized. Students are informed that they will be reviewing their peers as part of their grade for the design course. Honest evaluation within fixed guidelines is expected. The evaluation guidelines and forms are presented and discussed with the students. Peer Evaluations will be discussed in more detail later in this paper.

In the industrial setting of the model, the above subjects were presented over 8-12 hours of training time. Each concept was explained in detail. Exercises were used to emphasize and clarify each important point. Within the context of a design class, only 1 or 2 class periods can be dedicated to covering the material. In general however, the condensed version works at an acceptable level. Students are quicker to grasp the concept than most industrial workers, and are more willing to request clarification and contest points with which they don’t agree. This significantly compensates for the shortened time frame.

Figure III

Typical Schedules for first 3 Team Meetings

Meeting 1 (allow 2 hours)

1) Introductions, exchange information on availability
2) Group reading of the problem
3) Listing of ALL possible questions (1 List, copy to all)
4) Divide questions into categories
5) Divide up categories and assign research
6) Schedule next meeting

Meeting 2 (allow 2 hours minimum)

1) Distribute research results (1 copy to each member)
2) Review data versus the question list
3) Modify question list/assign additional research
4) Begin group development of a process concept (block diagram)
5) Review "deliverables" requirements
6) Groups assessment of team skills
7) Assign lead responsibility for specific portions of project
8) Select team coordinator
9) Schedule next meeting

Interim *Leaders develop tentative sched ules for their areas of responsibility*
Individual development review of the process concept

Meeting 3

1) Coordinate tentative schedules; assemble draft project schedule
2) Review individual process concept revisions; Revise concept design
3) Etc., etc

TEAM FORMATION & ORGANIZATION

Much has been written about team formation to maximize learning [2, 3]. The value of utilizing these principles early in the undergraduate experience is evident. Yet there is a certain "synthetic" nature to the team experience within these structured groups. In the non-student world, teams are formed based on skills and availability. A good manager normally tries to minimize the prior interpersonal conflict within a team, but for the most part, assignments are based on who has the necessary skills and the time. The ability to function cooperatively is, sometimes unjustifiably, assumed. Get along or get out is the choice. And most groups do work without extreme dysfunction, although sometimes at levels far below their potential.

Student about to leave the shelter of a university need experience working with teams not of their own choosing and not specifically formulated to insure maximum compatibility. It's usually easy to get along and be productive with your friends, but the real learning about teamwork lies when you must be productive with a group of people diverse in personalities, abilities and attitudes. Learning to work in teams, like technical learning is a progressive process building on each new experience. Early experiences may well work best with structured teams and the experiences then gradually transition to random assignment of teams at the senior level in an intense, creative, long-term project like those in a capstone design class. In our design class, our current practice is to allow students to voluntarily pair with each other and then the instructors form teams of four by matching the pairs. Some effort is made to avoid known conflicts and to assure some degree of equal academic abilities among the teams, but no more than an average "real world" supervisor would make. The "pairing" method is not the ideal simulation of the nonacademic workplace, but factors such as commonly available meeting times and sharing of rides to meetings, make it a expedient compromise.

Student teams are made to understand that they are self governing, independent entities. Within the framework of the course requirements and any governing university regulations, they are free to function according to their own rules. BUT the basic rules must be drafted, unanimously approved and submitted to the project supervisor for evaluation and approval. Such issues as communication, meetings, attendance and performance must be addressed. Figure IV shows the form used for this submission. One rule is required for all: An e-mail group must be created for communication and the project supervisor must be included in the group. All other rules are left to the group.

Typically, students address issues such as attendance and performance by imposing penalties. "Failure to make a scheduled meeting requires that you buy pizza for the group" is a frequent submission. "If you don't meet the deadline, you must do extra assignments" is another. The supervisor reviews these submissions and requires modification and resubmission where they are an inappropriate basis for effective performance. Punishment does not normally assure progress toward the desired result. A concept must be found which corrects the problem, but also assure progress toward the goal. Team rules are required to reflect appropriate methods of advancing the team result before they will be accepted. Good rules include concept such as: "If individuals consistently fail to meet deadline, a reassessment will be made of skills requirements and work distribution and appropriate adjustments made" and "Individuals who seem to feel undervalued will be given leadership roles in parts of the project that are recognized to be important to the end result". Once they are signed off by all team members and the

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Figure IV

Team Rules

Teams must have rules to function effectively. These serve as pre-agreement on how the team should act and touchstones to assure that individual actions are in accordance with that pre-agreement. Within the boundaries of the rules of the larger organization, teams are free to make their own rules and are free to change them. But both adoption and modification must be by unanimous mutual consent. Although compromise may be required of all, a team rule cannot be imposed on a team member who cannot accept it. As in most things in life, interpretation of a rule will be as important as the rule itself and problems must be resolved in the spirit of teamwork.

Please set down for the record your team rules for the following situations: One copy of the signed rules must go to each team member and one to your project supervisor.

1) **Communications Policy**: Given: *An official email group shall be established to include all team members and the project supervisor. It shall be the prim   ary address of all electronic communications.*   Other policies:

2) **Scheduling of Meetings**

3) **Attendance at meetings:** (allowance to be made for members out of town or ill)

4) **Assignment of work**

5) **Individual Failure to meet deadlines**

6) **Individual work not of required quality**

7) **Individuals who try to dominate the team**

8) **Individuals who feel left out or undervalued**

9) **Breakdowns in team dynamics**

10) **Other Rules**

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Signed by all team members

supervisor, everyone gets a copy of the rules and they become the basis for team actions. Rules can be changed during the course of the project, but only with unanimous vote of the group and permission of the instructor.

Instructors do not intervene in team disputes unless all members agree to seek consultation or if the dysfunction is so obvious that action must be taken to prevent complete failure in the team assignment. Counseling to individuals on handling team issues is always available, but no meetings on overall team problems are held with the supervisor unless all team members are present.

Teams select their own Coordinator to run the administrative aspects of the project. Experience indicates that students usually make a good choice for this position. They realize that it is not a popularity contest and that the Coordinator must be someone they can depend on even if they don't "like" them. And it is our experience that Coordinator's normally do a good job with this responsibility, although the position often brings a level of frustration well above that experienced by the other team members. As might be expected, supervisors usually see Coordinator's seeking advice much more often than they see other team members.

Project supervisors monitor team dynamics over the course of the term. Regular team progress meetings, technical advising sessions and review of the team email communications gives a good picture of the team situation. It is the authors experience that many teams go through three phases of team dynamics:

Phase I: Everything is "Wonderful"
Phase II: Problems
Phase III: Finding working relationships

The extent of each phase seems to be about 1/3 of the term and corresponds to three stages of student attitude toward the course:

Stage I- "Isn't this exciting to have a real problem"
Stage II- "Holy mackerel, this is a lot of work"
Stage III- "We have to buckle down and get this done"

Student teams in the senior chemical engineering design course at the University of Michigan have closely parallel development to engineering design teams in industry. Like industrial teams they are assembled with only partial regard to personal preferences. They both have defined goals and fixed boundaries, but the paths to reaching their objectives are of their own choosing. The design process inherently has benchmarks but no pre-established paths. Like their industrial counterparts student teams undergo a process of change and development over the course of the project. But both in industry and in academia, when this development can be guided and based on commonly shared basic principles of team behavior and operational rules that they have self-defined, the process is faster and usually smoother.

TEAM AND INDIVIDUAL EVALUATION

Objective evaluation of the work of others is an important element in the career of most engineering graduates. Whether in research, design engineering, production management or academia, engineering graduates eventually find themselves in a position where they are making personnel evaluations which affect the future of their organizations and their coworkers. With the widespread incorporation of the team concept in the workplace, the necessity to do these evaluations is likely to occur much earlier in a graduate's career.

With the exception of a few special cases, such as school grades, personnel evaluations have one primary purpose: future improvement of the individual. Rating and reward can be done without extensive thought about why and how performance ended up at an observed level. Nothing we do can affect the past. Blame cannot change a bad result. The only performance that can be altered is FUTURE performance. Evaluations can be used as an assessment of the past to define where improvement can be made and to give insights into how it can be accomplished. Evaluations are and should always be a constructive tool. They should be both given and received in that spirit.

Yet one of the greatest "fear factors" in any team based work group is evaluation.
Who will evaluate the team?
What standards will be used?
What about individual performance within a team? Is everyone automatically the same?
Who evaluates the individuals?
What is the purpose of the evaluation?

Peer assessments are particularly feared, as many people believe that friends will rate them well and "enemies" will rate them poorly. There is also a fear that a team member may attempt to make himself look better, by making everyone else look bad. Students also fear "betraying" a classmate by revealing their deficiencies to instructors. There is no question that some of these fears are grounded in occasional realities. But where peer reviews are grounded on fixed and universally understood criteria, the process is much less intimidating and much more effective.

The peer review system that the author developed for industrial work groups contains guidelines, which are equally valid for student teams. Figure V shows these guidelines. These are presented and reviewed as part of Team Skills Training. Further they are the cover sheets for every peer review form used in the senior chemical engineering design class.

Students are required to evaluate
1) Their Team
2) Themselves
3) All teammates

They are asked to be specific and avoid general comments.
Figure VI shows a review form. Note that there is no "check list" and only an over-all point system. A narrative is required in each area of evaluation. This is because in most teams and for most individuals there are important factors that would never be included

in any checklist and strengths or weaknesses that would never have the proper weight in a detailed point system. Summarizing a person's performance and contributions during a project is a very individualized evaluation. Trying to "hammer forge" individual contributions into a rigid evaluation system leads to distortion and extensive explanations of the true circumstances. In the form used, team members are given the freedom to present the picture exactly as they see it.

FIGURE V

Guidelines for Fair and Effective Peer Evaluation

1) Individuals must know in advance they will be evaluated and by whom

2) Individuals must be judged on their ability level for the period evaluated
   Students can not be held responsible for material not previously studied

3) Assessments must be based on result, not effort or good intentions
   But outside factors which interfered with positive results should be considered

4) Individuals must be evaluated based on performance in their specific assignments
   Lack of opportunity, importance or challenge is a management problem, not a performance issue

5) Statements must be honest and straightforward. Meanings must be unambiguous

6) Evaluations must be made on general patterns and not focus on isolated events
   Events with significant long term impact MAY be considered, however

7) Personal relationships and/or preferences have no part in objective evaluation

8) An evaluation should highlight strengths as well as weaknesses

9) Evaluations must be positive in tone, emphasizing development of the individual

FIGURE VI

Evaluation Form

Evaluation of ______________

Please give a narrative evaluation, consistent of the following categories:

Communication:

Technical Results:

Meeting Goals and Deadlines:

Teamwork:

OVERALL RATING __________
(1-10, 10 highest)

Comments:

In the senior chemical engineering design class, the students are asked to perform these evaluations twice: once at the time of their first formal Progress Report, about 40% into the term and again at the end of the course. Typically, because of mistrust of the system and the fact that they are just emerging from the "Wonderful" phase of team dynamics, the first evaluations give very high ratings to everyone, with few specific problems defined. Teams and everyone on them are generally rated 9 or 10 on the 10-point scale. These submissions are viewed by instructors as a "trial run" of the system and little meaning is attached to the results unless an extremely low evaluation is submitted.

By the final submission, teams have "matured" and do a much more realistic and effective job of evaluation. Over-all team scores generally range form 7 to 9 with some at 9.5 and only rarely a 10. Individual scores show much greater scatter than the first submissions. Outstanding individuals may still receive 10s even though the overall team score was significantly lower. Low performing individuals often receive scores in the 6-7.5 ranges, with truly dysfunctional members rating even lower. High and middle performing individuals almost always rate themselves lower than their teammates rate them. Low performing individual generally rate themselves about the same as their teammates rate them but there is more variance and some indication that they generally rate the overall team lower than others in that team. At this final stage almost all the students take the process seriously and make specific comments in line with the guidelines.

To date, all evaluations have been anonymous and not shared directly with anyone but the instructors. This is known to the students from the beginning. In the Fall 2004, the student evaluations will be condensed into a "Composite Peer Evaluation" which will be given to each individual student. This will be a labor-intensive activity for the instructors, but it is an important "next step" in implementing successful peer evaluations.

Ideally, peer evaluations should be given to each student, by his/her teammates and the results discussed. Experience in industry indicates that this process requires tremendous trust in the system, by both the evaluators and those evaluated. This trust normally builds only slowly over a period of years. Pilot programs are underway in the University of Michigan College of Engineering to introduce peer evaluation into earlier team based courses. Some of these have been attempted in the past, but current efforts are utilizing the positive approach using the same guidelines as presented for the design class. If these are successful, perhaps by the time students reach the senior level, they will have that trust in the system to allow effective face to face evaluation.

It might well, be asked, "If students only get a "valid" peer review at the end of a term, how can it be presented as a vehicle for improved performance? Why bother to do it." The answer to that is three-fold:

1) It teaches future engineers the basic skill of personnel evaluation

2) It provides input into individual performance within teams

3) When feedback proper mechanisms are in-place, it IS a source of development for the individual evaluated. The improvement in results may will not show up in the design class, but they can and should be used to improve results in the individual's professional career.

Of course peer evaluation is not the only evaluation of a team and individual's effectiveness. Throughout the course of the term, instructors and project supervisors are continually evaluating the "team component" of the project as well as the technical component. Just as in industry, the supervisors of student groups need to not only independently judge student performance, but also be able to judge the validity of the student peer reviews.

Implementation of the peer review process is easier with student teams than it is in industry. Class grades, while important, are a less serious element in life than income level. Members of students teams generally share more common traits than do the individuals in an industrial team even when that industrial team is technically based. Students. therefore, have a better understanding of the intent of the system and more inherent trust in it than is typical in industry. All the principle of the process developed for the industrial model applied directly to the student teams without modification.

TEAM AND INDIVIDUAL REWARD

In the industrial compensation system, the reward element was well defined. Various economic components were assigned weighted values. Percent attainment of goal was calculable in monetary units. This percent attainment was applied against a fixed pool of available of compensation monies to determine team payouts. Individual performance assessment factors were applied against the team payout to give individual compensation amounts.

With student teams, the reward system is not quite so straightforward. The project grade is earned by the whole team. The creative nature of the design process and the composition of the student teams do not lend themselves to easily quantifying the value of the various inputs. In the senior chemical engineering design course at the University of Michigan, the total grade associated with the team project is 70% of the final grade. 20 % of the final grad is based on individual assignments separate from the team and 10% of the course grade is reserved for "Supervisor's Evaluation". It is only in this component that an individual's contribution within a team can be rewarded.

The project supervisor uses several elements to evaluate this individual grade:

- Peer Evaluations
- Personal observations during team meetings over the course of the term

- Review of team e-mail communications
- Individual technical consultation on various aspects of the overall project

While the final result is extremely subjective, it is generally possible to get a clear picture of who shouldered a disproportionate amount of work, who held the team together during times of stress and who were low level contributors or disruptive forces in the team. Normally, an average contributor on an average team is assigned 7 out of 10 points. Stronger individuals on that team are then moved up in half point increments as appropriate, Weaker and disruptive individuals have their scores moved downward in a similar manner. Exceptional teams may start at an average value of 8 or even 9. Weaker teams sometimes start as low as 6.

Occasionally there is a student who makes a strong technical contribution but is a negative force on the team. In general, the team effect is penalized more than the technical effect is rewarded since in almost all cases, the overall result to the team is negative. Frequently students with modest technical ability will become a major force in team success by holding the team together and keeping things organized. Such students are always deemed positive contributors above the average level.

The “Supervisor’s Evaluation” is only able to shift a individual’s evaluation about a third of a grade point from overall team score. Clearly, this is an area where addition development is necessary as it is felt that this a separation of at least one full grade should be attainable within a team.

It is in the area of Reward that the industrial team model as currently utilized does not fit well into student design teams. Without economic values attached to specific portions of the project, it is difficult to properly value individual contributions. Kaufman et al [5] have looked at quantifying individual effort via peer rating. These seem to be an effective tool when applied to teams performing distinct multiple assignments. The situation becomes more complex when applied to a single longer-term design project. There is no ability to “start over and do better” at the start of a new problem. Results of individual contributions are cumulative and have long lasting effects. It is harder to give an overall evaluation of varying performance. Perhaps if Peer Review are introduced at a earlier stage of the curriculum so that they are better accepted and trusted, team evaluations can progress to the point where design teams can fairly and accurately assign credit proportionality to individual contributions within the team. For now that remains an item under development.

ACCEPTANCE AND SUCCESS OF THE MODEL

There are no quantitative data that verifies that the use of the industrial team model has had a positive effect on student performance. Some limited data does suggest that a more random team formation does not have a negative effect on the team experience.
In end-of-year course evaluations, student students are asked to rate the teamwork component of the course on a 1-5 scale for the questions:

1) I gained valuable experience working in teams in this course.

2) I increased my ability to work on a team with students who have diverse skills.

This data for the years from 2000 to 2004 indicates that students find the senior design course to rate well above the university average for similar team based courses. There was neither a noticeable increase in student ratings when teaching of team skills was introduced nor was there a drop in ratings when the move away from self selected teams was made. The existing data is affected to unknown degrees by variables such as class size, time of year and design problem difficulty and routine year-to-year variation in the actual scores is the norm. It is apparent, however, that none of the changes seemingly had major impact on the generally high level of positive reaction to the team concept as measured by student ratings

Comments from students, however, indicate that many felt that the lessons they learned in teamwork during the senior chemical engineering design course were as valuable as the technical concepts learned. This seems to be true without regard to the technical performance level of the team. Even individuals on relatively dysfunctional teams have commented that the experience will help them deal with difficult personnel issues later in their career.

What is definite is that after completing a team based design project under the model, students have been formally exposed to teamwork as more than an intuitive exercise. They have been introduced to the underlying basics of good teamwork and have had to develop team dynamics based on them. This should enable them to approach future team experiences with the understanding necessary for leadership.

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References:

1. “The Basic Principles of Teamwork” from the Team Effectiveness Series Zinger-Miller Inc, San Jose, CA, 1996

2. Felder, R.M. and R. Brent, *Cooperative Learning in Technical courses: Procedures, Pitfalls and Payoffs,* ERIC Document Reproduction Service, ED 377038, 1994

3. Haller, C.R., Gallagher, V.J., Weldon,T.L., Felder, R. M. “*Dynamics of Peer Education in Cooperative Learning Workgroups*”, J. Engr Education , 89 (3), p285-293, 2000