

Pima School: Expanding Excellence

Scottsdale School District's Pima school has a record of excellence that is maintainable and expandable into a K-8 school. If the faculty and staff is dispersed, one of the primary reasons for the school's excellence will be forfeited.

A unique advantage that is contributing greatly to Pima school being an excelling school is that its faculty and staff have been selected and managed to perform with close to ideal conative synergy. Conative traits determine the natural ways people act, react and interact. It is a major contributing factor in the success of enterprises of all types.

Conative synergy is a quantifiable asset

Conative synergy is defined by the leading authority on the conative faculty of the mind, Kathy Kolbe, as the natural balance of differing methods of conative problem solving. It is the combination of conative strengths among team members that enables them, when working as a team, to provide a predictable level of energy and goal achievement. Research shows that teams closest to 100% of conative synergy have the greatest probability of reaching their organizational goals.

(Click here for academic studies that show the [predictive validity of conative synergy](#).)

Kolbe has worked with universities, business leaders and educators around the world to determine the likelihood of success for groups of all sizes and with a diversity of goals. Last year, Kolbe tested the entire faculty and staff at Pima School and analyzed the conative traits among faculty and staff members.

Differences in Conative Synergy between Low and High Performing Teams

Failing teams consistently fall short in achieving goals -- regardless of incentives -- and are likely to have conative synergy in the **50% range and below**. They are constitutionally unable to achieve goals because the energy they expend either puts them at odds with one another or they become bogged down in inertia. Individual survival causes them to move away from team efforts, which limits their ability to improve the organization's performance.

Underperforming teams tend to have conative synergy between **60-69%**. They suffer from the inertia of too many members solving problems through replicated processes. Regardless of the effort made by the individuals on such teams, they will find it difficult to overcome that lack of sustainable synergy.

Average teams tend to have **70-79%** levels of conative synergy. Whether in business, government and education, they have difficulty improving in their results regardless of the amount of training they are provided.

Excelling teams usually have conative synergy in the **80-89%** range. They have a multiplier effect on the effort of individual members that results in achieving goals in an efficient and effective manner. Members of such teams thrive and seek to continue working in a team environment.

Highly excelling teams are likely to have conative synergy in the **90-99%** range. They set the standard that proves what is possible. They consistently achieve outstanding results. Team members thrive and are able to accomplish more than they would be able to either working independently or on less synergistic teams.

The principal of Pima school has carefully selected a team of educators and staff members. **Kolbe found that the Pima team has conative synergy of 95%.**

Pima school's conatively ideal team will continue to perform at a highly excelling level so long as the principal continues to manage its members so that they operate as a team with the freedom to function according to their conative strengths.

Consequences of dispersing vs. building on a team with high conative synergy

Individuals on the Pima team, if dispersed to large teams at other schools with lower conative synergy, will have little impact on improving the performance of those schools. In fact, in some cases, they would cause polarization of conative energies on other faculties, even decreasing the conative synergy on those teams. They would need to move as an intact team, with the same or similarly-minded leadership in order to transfer their excellence to another school facility.

It is not possible to slot an educator into a vacant position on a different team because of skills or years of experience and expect to improve the conative synergy that drives that school toward excellence. An analysis would need to be done of the faculty and staff at that school to determine the impact of conative synergy made by new team members.

If it is possible to keep the team at an excelling school such as Pima intact, and add new team members that maintain the high levels of conative synergy, then the school enrollment could be expanded while maintaining the levels of excellence. Adding the right mix of conative strengths to a team that is already at high levels of conative synergy is the most effective way of enlarging the number of students in the district who will perform at an excelling level, including converting it to a K-8 school.

Kathy Kolbe's recommendation to the Scottsdale School Board is to create a situation in which a greater percent of its students are taught in an environment in which they are likely to excel. That is highly likely to happen if Pima School becomes a K-8 school, serving a larger number of students than it does at this time. The school board will be able to use that achievement as the basis for other schools putting together teams with the conative synergy necessary to achieve the goal of school excellence.

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FORMING EFFECTIVE TEAMS IN A WORKPLACE ENVIRONMENT

by

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1 INTRODUCTION

1.1 Background

Facing intensified competition in a growing global market, manufacturing companies are reengineering their integrated production systems to achieve lean manufacturing (Askin and Huang [2000]). In recent years there appears to be a trend showing increasing popularity of cellular manufacturing, CM, and other team-related approaches in the workplace (Bailey [1997], Hut and Molleman [1998]) to achieve this goal. Substantial research has been performed to improve the grouping of machines and parts into cells as a result of this trend towards CM (see Burbidge [1975], King and Nakornchai [1982], Kusiak [1987], Askin and Vakharia [1990], Suresh [1991, 1992], and Singh [1993] for general reviews). However, until recently the human element in this area has been mostly ignored. Minimal research has been conducted regarding the selection of team members and subsequent training requirements. As is typical in the field of engineering, it is failure that has led to change. Manufacturing cells that have been formed solely on machine-part interaction have frequently shown limited benefits (see Carr, Groves [1998] for a list of examples). This failure has led researchers to search for other factors that impact the performance of the work cell, culminating in an increasing interest in the effects of personal skills and traits in the performance of teams.

The elements of effective team formation are not limited to personal skills and traits. Burbidge [1975] listed a set of dedicated workers as a key principle of cell autonomy (or

independence) that in turn is an essential aspect of successful cells in practice. In a survey of industry, Askin and Estrada [1998] found that training of workers was one of the top concerns when implementing cells. The conversion from traditional jobshop production to CM brings a new culture context to the worker team. In creating cells, workers with process oriented skills must be divided into part oriented teams and assigned to cells with heterogeneous processes. Worker training becomes an integral part of cellular team formation and success. In creating empowered teams, additional technical, teamwork, and administrative skills must be developed among the workforce. Cell productivity depends not only on the technical and administrative skills the workers possess but also the effective interaction among team members. This interaction and the related personality aspects are difficult to include in the aforementioned models due to the problems associated with quantifying their measures. Many systems exist that attempt to do so and we will evaluate the potential of several of these to be measured quantitatively as well as their demonstrated impact on productivity.

1.2 Problem Statement

Based on this need for effective interaction among team members, the purpose of this thesis is outlined as follows. Given an existing labor pool, it is desired to extract (a) one team or (b) multiple teams. It would be necessary to form a single team in a case such as creating a new manufacturing cell, undertaking a design project, creating a management or quality team, etc. Multiple team formation would be required if we were to shift from a non-cellular manufacturing environment to a cellular manufacturing environment. In this case we would need to determine which skilled individuals to place together in which cell. Multiple teams may be composed of the entire labor pool or just some of the labor pool. Skill requirements for the team may be identical or not. For example, if an entire segment of an organization were shifting to cellular manufacturing, the entire labor pool would need to be redistributed. However, if only a portion of the organization was being formed into a small number of teams, the entire labor pool would be considered but only a portion of it allocated. Depending on the nature of the work, cells could have the same makeup or vary from cell to cell.

We assume the labor pool itself is segregated into skill categories. Each member of the labor pool is assigned to one and only one skill category. The categories are defined according to the jobs or roles that need to be fulfilled on the team(s). For example, a team may require a milling machine operator, a turning machine operator, an inspector and an assembler. Each of these would become a skill category and any individuals belonging to the labor pool would have to be classified according to one of these skills. There are several assumptions made for this problem scenario. It is first assumed those skill categories and team skill requirements have been clearly defined to the satisfaction of management. This should be developed with due care as lack of appropriate skills will prevent a team from completing its job. The assignment of individuals to skill groups will have been performed as well. The case where an individual possesses more than one skill and so may choose which skill to fulfill is not considered here. It is also assumed that there exist sufficient individuals in the various skill categories to meet the requirements for the teams. That is, all team skill requirements will be met. It is expected that any deficiencies in requirement availability have been removed through

training and/or hiring as appropriate. Several papers (Ebeling and Lee [1994], Suer [1996], Min and Shin [1993], Askin and Huang [1997]) exist that have formulations for solving the training and related aspects of this problem. It is further assumed that all members of a skill category possess equal skill. While this may not be a realistic assumption in many situations, it is satisfactory for our purposes. Again, an approximation to this may be achieved through suitable training.

Finally, it is assumed that we have knowledge of the interpersonal mix required within a cell to promote effective team interaction. In order to utilize this knowledge, we assume that we have personality profiles of all potential team members being considered with which to measure the interpersonal mix against desired levels. The source of these tools for measuring effective team interaction is described in Section 3. This interpersonal mix will be the determining factor in deciding the construction of the team.

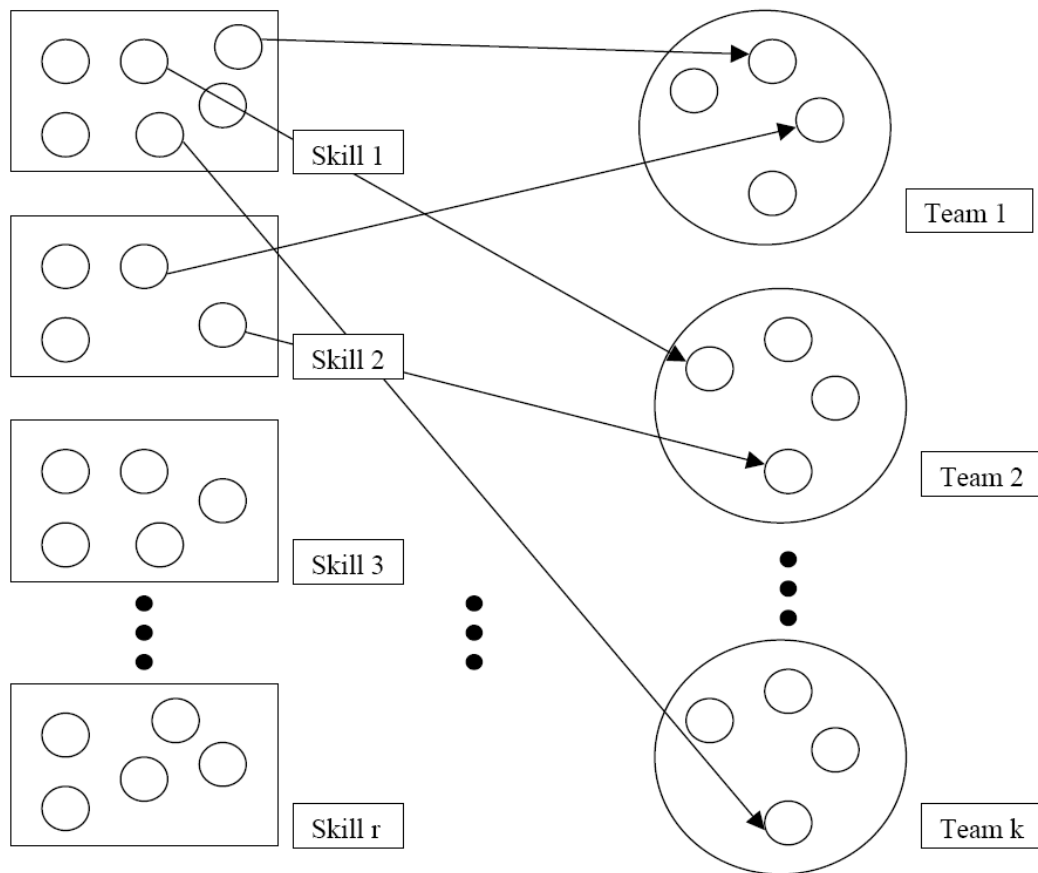


Figure 1 - Illustration of Problem Statement

Figure 1 illustrates the multiple team, partial labor pool, varying construction problem scenario. All individuals are classified into appropriate skill categories. The problem is then to assign individuals to the disparate teams in such a way that each team has a 'good'

Skill Categories Individual Assignments Team Skill

interpersonal construction. 'Good' interpersonal construction will be defined later in Section 3.

4 EXPERIMENTAL EVIDENCE

Prior to the inclusion of the Kolbe Concept® measures in a team selection model, it was deemed prudent to conduct an independent validation of the measures' effectiveness. Despite the quantity of data and analysis supporting its performance, our validation was necessary for completeness.

With the cooperation of Dr. Jeff Goldberg and his students we aimed to form synergistic teams in the SIE250/260 class and measure their effectiveness. This class was considered particularly suitable as it consists of over forty students and the class performs two projects during the course of the semester in groups of four. After approval was obtained from the University of Arizona's Human Subjects Committee (see Appendix A), the students were asked to complete the Kolbe A™ Index questionnaire. The completion of this and further participation were strictly voluntary. A sample of the consent form can be found in Appendix B. The results, in the form of individual MOs were recorded and used later to predict team performance. The students were only informed that I would form their teams as part of my research but were not given any information as to the nature of Kolbe Concept. It should be noted that the ability to balance the teams synergistically is limited by the make up of the class itself. For example, there are no implementer initiators in the class and a large number of fact finder initiators. Thus the best solution is constrained by these factors.

In the problem definition we assume distinct and defined skill groups. In approximation of these skill groups we segregated the class according to known grade point average (GPA). Where no GPA was available, transfer credits or other suitable measures were used to estimate their skill. The top 25% of GPAs in the class is considered skill group one, the second quarter is skill group two, the third quarter is skill group three and the last quarter is skill group four. To remove the bias of academic ability from the teams we placed one person from each skill group in each team. This constitutes choosing candidate team members from various skill groups into teams as in our problem description. Half of the class was formed with the intent to maximize effectiveness according to Kolbe team measures goal attainment, profitability, and viability. The other half of the class was placed into teams randomly with the same skill group requirements. The teams used in the final analysis are given below in Table 1. Teams 1 and 9 were formed randomly.

Team 1		Team 4		Team 9	
Student	MO	Student	MO	Student	MO
1A	8814	4A	7634	9A	7816
1B	7535	4B	7346	9B	7634
1C	8633	4C	7473	9C	7625
1D	5636	4D	5835	9D	7454
Team 10		Team 11		Team 13	
Student	MO	Student	MO	Student	MO
10A	3483	11A	6483	13A	6445
10B	5834	11B	7534	13B	7534
10C	7436	11C	7653	13C	8723
10D	8634	11D	7724	13D	8831

Table 1 - Project 1 Team Structures

Once the teams were formed, WAREwithal® software, kindly provided by Kolbe Corp, was used to predict the performance of the teams along the measures described above; viability, profitability and goal attainment. Any individual whose results indicated they were 'in transition' was excluded from the analysis. In order to prevent any unintentional bias, the instructor for the course, Jeff Goldberg, was neither informed which teams were formed by which method nor what the Kolbe Concept predicted their performance would be. The projects were graded by Dr. Goldberg and the results, in the form of project scores, provided for analysis.

On the advice of Kolbe Corp, teams whose scores were based on fewer than four members were excluded from analysis. The results of the remaining six teams are given below. Standard correlation was used.

Team	Actual Score	Viability	Profitability	Goal Attainment
1	90	71	98	35
2	95	82	98	60
3	92	66	98	23
4	90	85	100	65
5	85	53	33	79
6	90	67	88	40
Correlation		0.7117	0.8155	0.3571

Table 2 - Initial Validation Correlation Results

It is clear from table 2 that there is a positive correlation between the actual results and the Kolbe Concept's profitability measure and the joint measure, viability. It is also clear that there is a lesser correlation between the actual team scores and goal attainment. We see several possible explanations for this. First, as the term progressed it became clear that many of the previous GPAs were not representative of students' capabilities. This resulted in a number of teams not having equal skill levels, some had greater skill, some less. This affected the actual team results.

To correct this bias, with the aid of the instructor, the students were reassigned to the four skill groups. The class was again divided in two halves. This time, the Kolbe-based teams were formed using the heuristic provided in Section 6. The teams formed using this are given in Table 3.

Team 1					Team 4				
Student	MO	Viability	Profit.	Goal Attain.	Student	MO	Viability	Profit.	Goal Attain.
1A	3484	85	100	65	4A	7266	82	98	60
1B	8723				4B	6483			
1C	5636				4C	7724			
1D	7454				4D	7535			
Team 2					Team 5				
Student	MO	Viability	Profit.	Goal Attain.	Student	MO	Viability	Profit.	Goal Attain.
2A	7816	82	98	60	5A	7733	51	59	40
2B	8652				5B	5834			
2C	4375				5C	7534			
2D	7534				5D	8633			
Team 3					Team 6				
Student	MO	Viability	Profit.	Goal Attain.	Student	MO	Viability	Profit.	Goal Attain.
3A	8831	80	98	55	6A	7733	57	59	55
3B	4736				6B	7473			
3C	8623				6C	5835			
3D	6445				6D	7346			

Of the teams shown in Table 3, team 4 and team 6 were eliminated from the study due to the loss of one or more team members. The remaining four, along with randomly formed teams 7 and 8, performed as given under 'Actual Score' in Table 4.

Team	Actual Score	Viability	Profitability	Goal Attainment
1	92	85	100	65
2	95	82	98	60
3	90	80	98	55
5	85	51	59	40
7	88	55	78	25
8	95	82	98	60
Correlation		0.8181	0.8624	0.6033

Table 4 – Project Two Correlation Results

It can be seen by comparing the correlations from Table 2 and Table 4 that the predictions made using the Kolbe measures for project two were better on every criteria. The greatest increase in correlation occurs for Goal Attainment. This may be attributable to the additional input from the instructor on the skill levels of participants. This reflects the importance of the assumption that skills have previously been carefully assigned to individuals and shows the additional importance of management input in doing so.

To gain a further understanding of the Kolbe Concept, the behavior of individuals within teams was subjectively evaluated. From this evaluation we saw evidence of the predictive abilities of the Kolbe Concept with respect to particular individual and team behaviors, not simply overall team performance. For example, team 2's high-GPA person was determined to be an insistent Follow Through according to her MO. From this, we would expect to see her demonstrate patterning behavior, e.g. scheduling, planning, etc. In fact, after consulting with the professor, Dr. Goldberg, it was clear that she had initiated this type of behavior from the start. She had developed a plan and executed it according to schedule, leading the overall well-balanced group to a successful project submission. Two individuals on other teams were noted by Dr. Goldberg to have demonstrated particularly evident behaviors. When their MOs were referred to they proved to be insistent in these Action Modes®. On a team level, team 4 was heavily laden with Fact Finder with all team members in the preventative operating zone for Quick Start. The anticipated behavior for a group with this construction is that they would carry out excessive research and produce large volumes of work with very little ability to reach clear conclusions or make a decisive finish. According to the professor, this group indeed performed a very large amount of work on the project but only drew a single conclusion from the analysis they had performed.

Based on the positive correlations between the Kolbe Concept measures and actual team performance we submit that it would be an asset to include these in a team formation model.

8 CONCLUSIONS

Through the literature survey we identified the Kolbe Concept as a potential measurement tool for personality traits. It specifically measures the conative, or instinctual, tendencies of individuals. We found this to be a good candidate because it professed to be stable over time, easily measured and demonstrably linked to the productivity of the system. By carrying out experiments, we gathered evidence of this link and thus justified its inclusion in our model. However, we are not limiting this approach to one measurement system. There are other potential candidates to be investigated. For example, in our literature survey we identified 'The Big Five' personality dimensions. It's focus is the temperament element of individuals. This too may prove similarly successful in the prediction of team behavior upon further study. The basic premise of our research is not to promote a particular measurement tool but to demonstrate the possible effectiveness of forming teams with the consideration of personality traits. We have simply developed the heuristic using one measurement tool, the Kolbe Concept that appeared particularly promising.

The heuristic itself had both positive and negative performance characteristics. The average deviation from the lower bound was always less than 12% in our experiments. In itself this is a positive result. It has the potential to be improved with the addition of stronger lower bounds. As we would expect, the maximum deviations from the selected measures are higher but we still, on average, stay below 22%. It is also a positive that the 10% confidence intervals were narrow, indicating that the heuristic was consistent over the range of problems we considered.

There are some situations, however, where the heuristic has the possibility of performing poorly. For instance, if the pool of potential members is significantly greater than the required number of members, the calculated weights might not be a good indicator of potential problem areas. Concentrations in each operating zone/action mode combination may provide a better route. Another potential shortcoming is the method of team member selection. They are selected only considering one measure, Goal Attainment. This could lead to arbitrarily bad solutions with respect to Profitability. Consideration of a combined measure, such as Viability, for team member selection may prove a more robust choice.

For limited applications, the Balanced Placement Heuristic provides a means of incorporating interpersonal mix into the team formation process. It does this by combining a tested personality trait measurement tool, Kolbe Concept, with assignment techniques. This heuristic can be modified to expand its base of applications and to incorporate other performance-linked factors.

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TEACHING TEAMWORK SKILLS IN SOFTWARE ENGINEERING BASED ON AN UNDERSTANDING OF FACTORS AFFECTING GROUP PERFORMANCE

Robert Lingard¹ and Elizabeth Berry²

Abstract - *Being able to work effectively in teams is an important learning objective for software engineering students. Although many programs today make team projects fundamental elements of their curricula, few actually teach teamwork and communication skills directly.*

Consequently, students may gain experience working in teams but may not learn the skills necessary to perform effectively in a team environment. In previous studies it was shown that both team synergy and basic software engineering knowledge correlated significantly with team project success. This paper examines additional factors that have the potential to affect group performance. In particular, this study looks at gender, age, cultural diversity, previous work experience, and the degree to which work is equitably shared among team members as possible factors affecting success. Based on the results of this study, suggestions are made for both team formation and designing appropriate assignments to enhance the teamwork skills of students.

Index Terms - *Communication, group projects, software engineering, teamwork.*

INTRODUCTION

This paper summarizes the recent activities associated with attempts to improve group project experiences among software engineering students at CSU, Northridge. The study described draws on data collected over the last three years regarding team composition and team achievement for students in an introductory course in software engineering. In particular, this study looks at gender, age, cultural diversity, group viability, and previous work experience in the field of software engineering as potential factors influencing team achievement. Additionally, the degree to which work is equitably shared among team members is evaluated as a factor contributing to success. Some background and motivational material are provided along with a summary of previous results. The approach taken and the important results from the current effort are described. Based on the study results, some guidelines are outlined for team formation and suggestions are made for designing effective assignments to enhance the teamwork skills of students.

BACKGROUND AND MOTIVATION

It has long been recognized that engineering and computer science students need to learn communication and collaboration skills. In his 1992 article on "Educating a New Engineer," Peter Denning observed that employers felt that new hires did not know how to communicate and that they had insufficient experience and preparation for working as part of a team [1].

Unfortunately, as Simon McGinnes states in regard to teaching information technology, "the skills of communication and collaboration . . . have often been undervalued in computing courses." [2] "Computer science education too often focuses on individual contributions rather than on managed group efforts that depend on defined standards, methodologies, and software processes; however, such groups are the norm in the software industry," according to Hilburn and Bagert. [3]

Although many universities have recognized the need to assign group projects and have begun efforts to improve engineering and computer science curricula in this regard, students seldom receive any training on how to function collaboratively before such assignments are given, and little attention is given to how teams are formed. Consequently, teams often fail to function effectively. Students do not learn much from participating on dysfunctional teams and often develop negative views about the value of teamwork. [4]

Simply assigning more team projects is not sufficient in addressing the need for students to learn teamwork skills. In order for students to benefit from these team projects, efforts must be made to ensure that the teams are well formed and given the knowledge and tools necessary to operate effectively.

SUMMARY OF PREVIOUS RESULTS

A study conducted two years ago [5] compared team success with both team synergy, as measured by the Kolbe A™ Index [6], and basic software engineering knowledge, as measured by classroom tests. According to Kolbe, group synergy contributes positively toward group productivity. If true, this would suggest that forming groups to maximize synergy would result in groups that worked together more effectively and would, therefore, provide students with a more beneficial group experience.

The Kolbe A Index is an instrument that measures conation or a person's inherent talent or natural way of doing things and predicts what a person will or will not do, given the freedom to act. Whereas intelligence tests measure I.Q. and personality tests measure values and preferences, the Kolbe index measures the conative, the way people act while trying to achieve goals. It identifies four modes or striving instincts -- Fact Finder, Follow Thru, Quick Start, and Implementor -- each prompting people to act in a certain way.

The person who initiates in Fact Finder mode probes, asks questions, weighs pros and cons, and uses experience. This person collects data and establishes priorities before making a decision. The Follow Thru individual seeks structure and makes schedules. This person needs a sense of order and plans ahead. The Quick start individual innovates,

takes risks, improvises, and plays hunches. When asked to give a presentation, the Quick Start comfortably ad libs. The Implementor uses space and materials, builds, construct and uses hands-on equipment with ease. This person creates handcrafted models and insists on quality materials. Everyone has each of these abilities to some degree. However, people are most productive when they are able to utilize their strongest conative talents.

Figure 1 graphically depicts the degree to which each of these abilities is present. The four striving instincts are expressed through three possible operating zones, indicating how the individual will make use these talents.

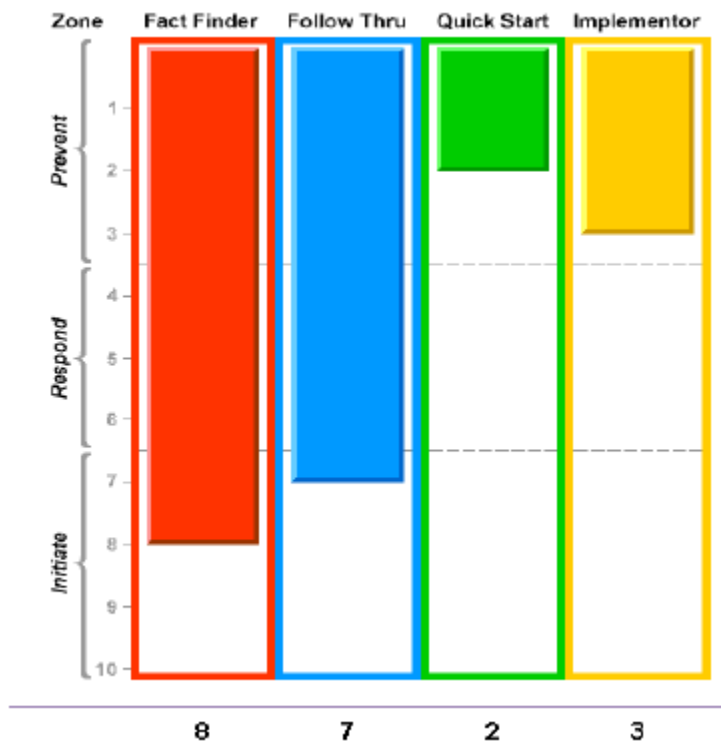


FIGURE 1
SAMPLE KOLBE RESULTS

A score of 7 to 10 in a given mode places the individual in the insistence or initiating zone. This indicates *how the person will act*. A score of 4 to 6 indicates the accommodating or responding zone or *how the person is willing to act*, and a score of 1 to 3 represents the prevention or resistance zone or *how the person won't act*. It doesn't mean people can't act in all of these ways; it just means that some won't come naturally.

According to Kolbe a productive team requires all of these talents, but they must be balanced with respect to the operating zones in order to maximize synergy. [7] Synergy is a productive balance of instincts within a team. It is derived from a mixture of complementary, conative talents. Ideal synergy involves not only the right mix of instincts to initiate solutions, but the same amount of energy to avoid problems as well. It was this measure of group synergy that was used in this study.

In the initial study the achievement of 23 teams in four classes over two semesters was analyzed. There were three important findings resulting from this study.

First, the results showed a correlation between the teams' ratings of their effectiveness and the scores on the projects. The correlation was statistically significant at the 0.025 level [$r(21) = 0.451, p < 0.025$]. This is consistent with other studies, such as one at Brigham Young University (BYU) described by Swan [4], which showed that team process effectiveness was the major factor accounting for the success of group projects. This suggests the importance of teaching group process skills as part of the regular curriculum.

The second finding was that there was a statistically significant correlation [$r(21) = 0.564, p < 0.005$] between Project Scores and the combined test scores of the team members. That is, teams made up of students who did well on the course exams also did well on the team projects. This suggests that to be fair to all students, teams should be balanced with respect to their cognitive abilities. In subsequent semesters, this was done by delaying team formation until after the first exam and using the exam results to balance the teams.

The third result was related to team synergy. Team synergy was calculated based on the "conative" assessments of all team members using the Kolbe A Index and project success was compared to team synergy. To do this each team member was assessed using the Kolbe instrument, and from that information a measure of group synergy was determined for each team. The synergy was expressed as a percentage where 100% indicated ideal synergy. According to Kolbe, ideal group synergy results when the sum of the members' instinctive energy is distributed so that 25 percent is initiating 50 percent is responding, and 25 percent is preventing. For the purposes of this analysis, group synergy was calculated as 100 percent minus the sum of the absolute values of the differences between the actual and ideal values in each of the three operating zones (initiate, respond, and prevent). Figure 2 depicts the synergy of one team in relation to the ideal. In this case the calculated synergy of the team would be 50% (100% - 6% - 25% - 19%).

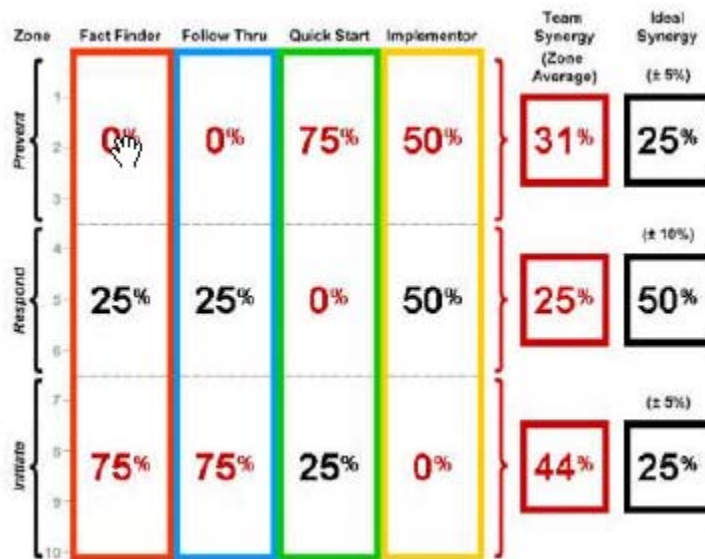


FIGURE 2
TEAM SYNERGY

One hypothesis of this experiment was that greater synergy would result in higher team scores. At first there seemed to be no correlation between team synergy and project success. However, the high correlation between Project Scores and the combined test scores of the team members might have been obscuring any effect of synergy on group achievement. If only the population of teams without exceptional high or low test scores was considered, in particular, only those teams within two standard deviations of the mean, there was a significant correlation between group synergy and project scores [$r(19) = 0.380, p < 0.05$]. With these more cognitively balanced teams there was also a high correlation between each team's rating of its own effectiveness and team synergy [$r(19) = 0.478, p < 0.025$]. This suggests that there may be a significant correlation between group synergy and project performance.

The current study examines this further.

CURRENT STUDY RESULTS

One purpose of the current study was to reexamine some of the same factors previously analyzed. This analysis included the data collected over a two year period. In all, 181 students comprising 39 teams were analyzed. Most of the conclusions from the original study were reinforced. The data are shown in Table I. The table is sorted by project score.

In the current study the correlation between project scores and combined test scores of team members was even more significant [$r(37) = 0.549, p < 0.0005$]. Similarly, the correlation between teams' self rating of effectiveness and project scores also showed a greater significance [$r(37) = 0.472, p < 0.005$]. In evaluating the relationship between project scores and group synergy the Kolbe measure of *viability* was used. *Viability* is a complex metric developed by Kolbe analysts to measure how closely the combination of Kolbe scores for a group match those of an ideally synergistic team. The study results

show that this measure of synergy correlates significantly with project scores [$r(37) = 0.3247, p < 0.025$].

TABLE I
STUDY RESULTS

Team Name	Project Score	Exam Scores	Effective-ness	Viability
F98-C	95.5%	85.3%	4	57.0%
S00-4	91.5%	87.0%	4.5	84.0%
F98-5	90.5%	81.8%	4.5	96.0%
F98-F	90.5%	85.6%	4	31.0%
F98-E	90.0%	78.2%	3	98.0%
F99-A	90.0%	85.4%	4	98.0%
F99-C	89.3%	77.8%	3.75	67.0%
S99-2	88.0%	87.8%	4.25	76.0%
S00-1	88.0%	87.1%	4.25	48.0%
S99-E	86.5%	78.9%	4.2	34.0%
S99-D	85.5%	78.6%	4.4	96.0%
S00-7	85.5%	76.3%	3.8	76.0%
F99-1	85.3%	79.3%	4	98.0%
S00-6	85.0%	81.0%	4.5	37.0%
S99-5	84.0%	84.3%	3.8	91.0%
F99-3	84.0%	80.9%	4.5	98.0%
S00-2	83.5%	78.4%	4.25	71.0%
F99-2	82.7%	81.8%	4	34.0%
S99-3	82.5%	83.3%	4	91.0%
F99-B	82.0%	77.1%	3.8	86.0%
F98-B	81.5%	77.8%	3	48.0%
S99-A	81.0%	75.1%	4.4	91.0%
S99-B	80.5%	74.9%	2.33	98.0%
F98-A	80.0%	81.7%	4.5	98.0%
S99-4	79.5%	79.2%	3.6	31.0%
F98-2	79.0%	72.9%	4	98.0%
F99-D	78.7%	81.1%	4.8	98.0%
F98-4	78.5%	77.7%	2.75	29.0%
S99-1	78.0%	76.5%	4	92.0%
F99-E	78.0%	79.4%	4.8	86.0%
F99-F	76.0%	80.6%	4.25	0.0%
S99-7	75.0%	81.1%	4	91.0%
S00-3	74.0%	72.0%	2.6	31.0%
F98-D	73.5%	76.8%	3.33	98.0%
S99-C	73.5%	77.9%	3.5	86.0%
S99-6	72.5%	79.6%	3.5	0.0%
F98-1	71.0%	81.0%	3.67	57.0%
S00-5	67.0%	76.3%	2.5	29.0%
F98-3	66.0%	76.1%	2.33	0.0%

ADDITIONAL STUDY RESULTS

An additional objective of the current study was to examine a number of factors potentially influencing team success that had not been previously analyzed. In the survey given at the end of the semester to all students in the course, information is gathered as to their age, gender, native language, and work experience. It is natural to ask whether any of these factors affect group performance.

With respect to age it is interesting to note the wide range of ages among the students. The average age for a team ranged from 21.3 to 38 years. The somewhat surprising result was that there was no significant correlation between average group age and project scores. One might have thought that older, more mature students would have had more experience working in groups and, therefore, that older groups would have done better. This study showed no evidence that such was the case.

Among the students in these classes 25.8% were women. This is consistent with the overall percentage of women majoring in computer science at CSU Northridge. Among the teams studied the percentage of women on a team ranged from 0% to 60%. However, no significant correlation was found between the percentage of women on a team and the project score for that team.

A third factor analyzed was the cultural diversity on a team. In the survey students were asked to specify their native language. For each team a diversity number was calculated by determining the number of different languages spoken and dividing that number by the size of the team. For example, for a team of five with three different native languages among the members, the diversity value would be 60%. It is interesting to note that as many as 17 different languages have been identified as native within a typical class of 30 students. It was thought that such a high level of language diversity might have contributed negatively toward project success. However, analysis of the data showed no significant differences in project scores based on the degree of team cultural diversity. It might be that since all teams were diverse, all teams were affected to a similar degree. Seventy-nine percent of the teams included three or more different native languages, and all teams included at least two. Because cultural diversity is still a likely issue with respect to group performance, this subject will be dealt with in the later section on teaching strategies.

This study also tried to determine whether there was bias that favored predominately English speaking teams.

The percentage of native English speaking team members ranged from 0% to 80%, but there was no significant correlation between the teams' English speaking ability and their team scores. In fact, although not significant, the correlation was negative.

The last factor of this type analyzed was relevant work experience. Students were asked whether they were currently working in a computer related field. Again, it was thought that relevant work experience might contribute toward project success. Twenty-eight percent of the students indicated that they were currently working in a computer related

job. The percentage of such experienced students on a team ranged from 0% to 75%. Surprisingly, there was no significant correlation between work experience as measured here and team performance even though work experience did correlate significantly with test scores.

ANALYSIS OF GROUP PARTICIPATION

One part of the survey given to students at the end of the semester asks them to evaluate the other members of their team. In particular, one question asks them to rate each team member's contribution to the team project as a percentage of the total effort. That is, they are to give each team member, including themselves, a value from 0% to 100% such that the sum of such numbers is 100%. If a student felt that all members of the team contributed equally, a value of 20% might be given to each person on a five person team.

A measure of equality of participation was calculated as minus the variance of the average scores of the individuals on a team. That is, the scores each team member received from the other members of the team were averaged and the variance among these average scores was calculated. Since the greater the variance the more unequal was the participation among team members, the variance was negated to serve as a measure of equality of participation.

This measure of participation correlates significantly with project scores [$r(37) = 0.3276$, $p < 0.025$]. Additionally, this measure correlates even more significantly with the teams' self ratings of their effectiveness [$r(37) = 0.4691$, $p < 0.005$]. This last results probably reflects the fact that team members see a relationship between team ineffectiveness and a lack of participation by one or more team members. Overall, these results suggest that team success might be increased if better participation among the team members could be achieved. The next section discusses teaching strategies to encourage greater participation by all team members during group assignments.

The somewhat related factor of group size was also analyzed in this study. Although most teams in this study consisted of five members, there were some three, four, and six member teams. Analysis of the data shows a significant negative correlation between team size and project scores [$r(37) = -0.3435$, $p < 0.025$] indicating that smaller teams do better. This may be due to the difficulties in coordinating group activities among the various group members. Some techniques for teaching groups to deal with such issues are discussed in the following section.

TEACHING STRATEGIES

In most courses in which group projects are required, students receive little, if any, guidance on how to be an effective team member. It seems evident that students need instruction in group process as well as how to interact effectively with members of their own team. The fact that the groups are composed of students from varying backgrounds and ethnicities makes it imperative that time be spent in helping students understand the importance of the social domain of group process. In our previous study [8] we suggested a number of exercises to promote understanding of the group process, but it is also important for students to establish comfortable relationships with others in the group.

During the beginning stages of the group projects, students benefit from activities which increase the ease with which they interact with each other.

Throughout the semester students should have opportunities to analyze and discuss the group process as they are experiencing it. Following are activities which can easily be incorporated into a class in which a group project is required. The exercises below suggest activities that may be useful in addressing some of the specific problems uncovered by the current study. Further research is needed to assess the effectiveness of these techniques.

Sharing Commonalities

This activity should be used early in the semester, shortly after the groups have been formed. Instruct students that they will be meeting with their project teams and that each group is to come up with three things they all have in common. Explain that each thing they find in common must be specific rather than general. For example, it could not be, "We all have brothers and sisters;" however, it could be, "We all have two brothers and one sister." It could not be, "We all drive cars." It could be, "We all drive red Mazdas." Have each group choose a recorder and spokesperson. Allow the groups about 15 minutes to come up with their lists. Walk around the class and help any groups who are having difficulty by brainstorming ideas. At the end of the allotted time, have a spokesperson from each group share the group's list with the class.

This activity is a good way to get students talking to each other and asking questions they normally wouldn't ask. It helps in establishing cohesiveness in the group and serves to promote participation.

Team Retreat

In this activity, adapted from Silberman [9], the instructor provides each team with a stack of index cards (different sizes in each stack are best). Challenge each team to be as effective a group as possible by constructing a three-dimensional model of a "Team Retreat," a place where they could go to study, work on their project or just relax. They may use only the index cards, but folding and tearing the cards are permitted; no other supplies can be used for the construction. Encourage teams to plan their retreat before they begin to construct it. Provide marking pens so that teams can draw on the cards and decorate the team retreat as they see fit. Allow at least fifteen minutes for the construction. Do not rush or pressure the teams. Each group should have a successful experience. When the constructions are finished, invite the class to walk around the room and view their classmates' projects. Reconvene the teams and ask them to reflect on the experience by responding to this question: What were some helpful and not so helpful actions we did as a team and individually when working together? Summarize the comments and emphasize the need for helpful actions when working as a team.

Team Meeting Reports

Requiring teams to produce written meeting reports can be helpful, not only for organizing and planning team activities, but also for improving team member participation. In the software engineering class of this study, teams were required to produce such reports when working on major projects.

For each meeting one team member assumed the role of moderator and another served as recorder. It was a requirement of the course that each member of the team serve as the moderator at least once and also as the recorder once. This helped to insure participation in meetings by all team members. As Bean points out, a dominant individual in the role of moderator has to be quiet in order to get the team's help, and a quiet person in that role must practice speaking up. [10] This encourages individuals to improve their teamwork skills. Also, the meeting report form required that all members present at the meeting be listed by name. Although attendance at team meetings was not considered in determining course grades, the fact that their presence was being documented encouraged individual participation in team efforts.

The “Mine/Ours” Strategy

Another strategy used to encourage greater participation on group projects is what we called the “mine/ours” technique. This technique is applicable to a wide range of exercises. In the software design project, one of the required team tasks was to produce a high level design diagram for the system to be built. Without specific guidance teams often just assign this task to one team member. The others merely serve as reviewers of the diagram produced. Too often the reviewers are content to accept what has been produced without really learning how to produce such a diagram themselves.

Furthermore, the diagrams produced are of lower quality if they have not had the benefit of a true collaborative effort. With the “mine/ours” strategy, each student is asked to independently produce a version of the required diagram as a homework assignment. Then, in a team meeting, the individual diagrams are compared and discussed, and the team produces a consensus diagram. Each team must submit not only their consensus diagram, but also the individual diagrams of each of the team members. This approach insures that each team member participates in this part of the project. This technique, which is a variation of Bean's “Evidence-Finding Strategy” [9], is applicable for any task where a team consensus is desired and where a good result depends on team members being individually well prepared before the collaboration begins.

Hypothetical Situation

Since it is difficult to devise projects in a classroom setting that match many real world situations, it is sometimes useful to have teams work on hypothetical problems. For example, one of the important activities in software engineering is risk analysis. However, many of the risks present in real projects never appear in classroom projects. In a real project, employee turnover could be an important issue, but in the classroom, except for the case of an occasional student dropping a class in mid semester, this is not a serious project risk. The team can be given this as a hypothetical problem for their project, however, and asked to develop plans for risk mitigation, monitoring, and

management. This activity can be combined with the “mine/ours” strategy described above by asking individuals to independently produce lists of project risks for a hypothetical situation, have teams arrive at a consensus prioritized list of risks, and then assign the team the task of developing a risk management plan for the highest priority risk

Role Playing

Teamwork skills and team member participation can often be enhanced through role playing. One way to do this is by selecting an existing team, or by selecting any group of students in the classroom, and assigning specific hypothetical roles to each. The selected group would then hold a simulated meeting in front of the class in which they attempt to solve some project related problem. The problem might relate to a real situation facing the team or it might be a hypothetical problem of the nature discussed in the section above. For example, in the case of the problem of employee turnover posed above, each member of the group might be asked to play the role of an individual from a different organization in a hypothetical company. One student might play the role of a software project manager, one might represent the human resources department, and another might assume the role of a software developer. These students are then asked to conduct a simulated meeting to discuss the issue at hand. Role playing gives students an opportunity to interact with other team members in ways that would be unlikely in normal classroom project work and provides them another opportunity to improve their group communication skills.

SUMMARY AND CONCLUSIONS

This study reinforces the findings of the original effort regarding the significant correlation between team project success and both team synergy and team perceptions of their own effectiveness. The Kolbe A Index can be useful in forming synergistic teams since it provides an indication of people’s problem solving styles. It has long been recognized that both cognitive and affective factors contribute to team productivity. The Kolbe A Index, however, provides new insights into how groups function. According to Hoffman, "this approach offers a fresh, 'third way' of measuring and optimizing individual employee and team achievement." [11]. Although it is rarely possible to form ideal teams, it is helpful for students to understand the significance of team composition, and it is important that they receive the necessary instruction and assistance for dealing with any resulting problems relating to team dynamics.

The current study also reconfirmed the finding that team achievement correlates with knowledge of the course material as indicated by scores on exams. To the greatest extent possible, teams should be formed to equally distribute the software engineering knowledge and abilities present in the class among the teams. This helps to ensure fairness and minimizes the likelihood of having ineffective teams.

An important new finding of the current study is that team success is affected by the degree to which there is equal participation by all team members. Consequently, efforts to improve the participation by individuals toward accomplishing team goals can be beneficial.

In order for students to gain the maximum benefit from team experiences, it is important for them to be members of effective teams. Instructors can help insure that this happens by taking care to form teams that are most likely to be effective and by devising exercises that both help teams understand the group process and encourage individual participation in team efforts.

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