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 that 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.

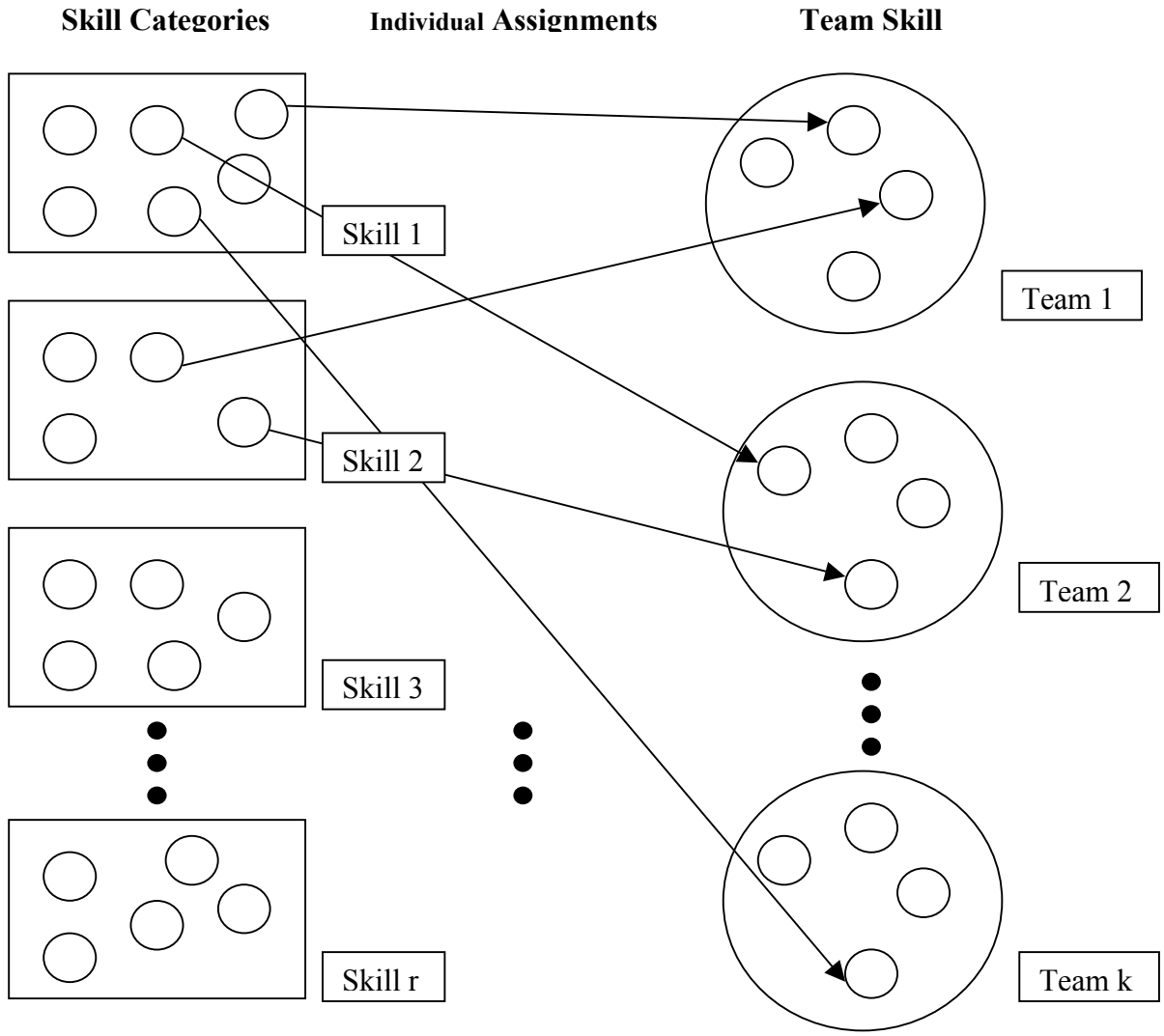

Figure 1 - Illustration of Problem Statement

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'

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				**Goal**	**Team 4**				**Goal**
Student	**MO**	**Viability**	**Profit.**	**Attain.**	**Student**	**MO**	**Viability**	**Profit.**	**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				**Goal**	**Team 5**				**Goal**
Student	**MO**	**Viability**	**Profit.**	**Attain.**	**Student**	**MO**	**Viability**	**Profit.**	**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				**Goal**	**Team 6**				**Goal**
Student	**MO**	**Viability**	**Profit.**	**Attain.**	**Student**	**MO**	**Viability**	**Profit.**	**Attain.**
3A	8831	80	98	55	6A	7733	57	59	55
3B	4736				6B	7473			
3C	8623				6C	5835			
3D	6445				6D	7346			

Table 3 - Project 2 Teams and Predictive Scores

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.