Evaluation of the IEEE Transactions on Engineering Management article," Comparison of Manufacturing Performance of Three Team Structures in Semiconductor Plants"

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INDIVIDUAL RESEARCH PAPER

Diane E. Bailey, "***Comparison of Manufacturing Performance of Three Team Structure in Semiconductor Plants***", IEEE Transactions on Engineering Management, Vol. 45, No. 1, February 1998

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1. Abstract/Summary

The concepts studied in this research paper are to examine and compare three kinds of improvement-team programs. These improvement-team programs are continuous improvement team (CIT), quality circle (QC), and self-directed work team (SDWT). Each team is various in level of autonomy, training, and task content which lead to different level of decision-making power, skill attainment, and skill use permitted with program. The author used the cognitive model of participation to describe the way to increase the productivity. They have chosen eight semiconductor manufacturing site as samples. The measurements that the author used to measure the performance output are qualitative data and quantitative data. Quantitative analysis of performance showed the contrast result with the assumption that SWDT should perform most productive. Qualitative analysis of performance showed the result that the poor implementation and failure to integrate production program with engineering department hindered the success of program and the quantitative performance. The author commended in the last past that some features, such as voluntary versus mandatory participation and temporary versus permanent team duration also limited this study. Furthermore, they cannot determine if the nature of membership is driving the results more than autonomy, training, and task variables.

2. Methodology

The research design of the paper began with the analysis of variance (ANOVA) to prove the hypothesis of cognitive model. The ANOVA can describe the trend of variable factors vary, and p value in the ANOVA method, which can decide the reliability of the result. The lower p value, the higher chance to reject the assumption. According to the hypothesis of the cognitive model, if we increase the level of autonomy, extended training, and task content. That will generate a better performance. The researcher had chosen samples from eight semiconductor fabs in seven firms. There was only one firm, which being assigned two improvement team programs. The data could be categorized into qualitative data and quantitative data. The quantitative data was collected at the work group level via production records within six months. The data covered one to three months, and included the number of wafers processed per month, work schedules, headcount, scrapped wafer counts, cycle time information, equipment utility and availability, and other information specific to product and processes. Those quantitative data provided performance variables, direct labor productivity, indirect productivity, and scrap percentage. The researcher collected the qualitative data via interview, and self-report measures. The survey of qualitative data makes use of the instrument for measuring organizational effectiveness at work group level [1]. The data from the questionnaire were measured on five-point Likert-type scales[2], which used to measure attitude more reliably. Those qualitative data provided information about statistical results, which indicated the level of autonomy, training, modified task content of each program.

3. The contributions of the paper to the literature

The contributions of this paper to the literature are that the improvement of team performance, such as CIT, QC, and SWDT, need more than one bullet magic, increasing the autonomy, training, and task content. The implementation, especially in QC's and SWDT's, is a crucial point that can decide success and failure of programs. According to the qualitative results and the discussion and conclusion part, the analysis shows the incur problem as below:

PROBLEM THAT HAVE BE FOUND IN EACH SITE	CIT	QC	SWDT
System controller.		x	x
Motivation		x	x
Information infrastructure/training.			x
Misperception of the role and Changing role.			x
Complex task and the nature of low-level workers			x
The assignment of team roles regardless to existing status.	x		
Reward system.		x	
Mismatch in project selection			x
Career insecurity			x

1) **The system controller, which is a pre-requirement of QC's and SDWT's, was not effective because of the reluctant to evaluate their peer.**
2) **The infrastructure need was inadequate. The lack of computer hardware and specific software was a good example. That lead to the inefficient decision-making system, such as database, and tracking system. Furthermore, the requirements of training to use the related software were missing.**
3) **The misperception of each one's role generated the problem of co-operation.**

Furthermore, this research raised an important question about improvement-team program that " Is it suitable to use participation scheme in semiconductor industry with low-level workers. A factor that should be strongly considered is the assignment of team role regarding to the existing status structure.

According to the result from the table, we can find out that QC's and SDWT's need more attention from the top-level and middle-level managers. Supporting is very important to SDWT to become an effective team or mature team, which will say in another part.

4. What have the other researchers found that are related to this research?

There are many researches that studied about the improvement team of manufacturing. There is no specific topic research paper that match to the research paper perfectly. The research papers that I will introduce have some important aspects relating to the research of Diane Bailey. I found that crucial aspects related to improvement-team are roadblocks to productivity improvement, human resource problems, training and skill workers, implementation's process and implementation's time.

1. The three of five crucial roadblocks to productivity improvement in the semiconductor industry [3] are 1) Equipment Reliability/ Maintenance Practice that included time in preventive and maintenance. This roadblock can affect the setup and recovery the machine to continue working. Furthermore it should be weight highest in the quantitative analysis. 2) Insufficient Planning & Modeling Systems. This roadblock, including the manufacturing information system, can increase or decrease the time in problem solving obviously. 3) Lack of Training Personnel. If the operators are not able to run their equipment or fail to recognize the damaged product and so on, These will cause the equipment to face considerable amount of downtime. Three crucial roadblocks should effect the weight of quantitative data differently.

2. Many researches indicate that the crucial factor of improvement team is human resource. Gersick [4] remind us that there is no simple, linear growth pattern, and that level of team maturity varies as members change, tasks, change, etc. One of the problems in changing organization structure is maverick [5], which is defined by the author about voluntary and mandatory participation. In my opinion, maverick will affect the result and the cross-training data immensely, so the author should include this topic in the research. Appleyard [6] have picked up the human resource in semiconductor as a project. She discussed that statistic process control (SPC) activities exhibited a great degree of variation in human resources practice. She introduced characteristics of teams in skill and work tasks analysis. The characteristics of teams, table is shown in appendix A. In [11], Jumbi Edulbehram and Dan Rascher described they find that successful systems not only include a seamless interplay of internal resources, but also encourage the identification and incorporation of appropriate external knowledge and know-how. Furthermore they separated the workers into three categories, operators, technicians, and engineers, to analyze the improvement team performance. The different types of training, OJT (on-job-training) and classroom training, were provided to each kind of workers in various level. Those became the correlation between different types of training and the performance metrics, which is different from Bailey's paper.

3. In the "Building a self-direct work team", Wellins [7] suggested five issues that should be consider to develop an effective SDWT's. He also suggested the six-step process to help companies get started in creating a successful SDWT's implementation. One issue that the paper did not identify as an important factor is the reward system. Many organizations that use SDWT's implement various types of "gain-sharing" or team bonus schemes, along with skill-based compensation plans. Such compensation schemes rewarded team members in three areas, job depth, job breadth, and vertical skills. This system will automatically generate

self-motivation and the enthusiasm to train and improve skill continuously. One important step that he suggested is the continually evaluate the progress of the SDWT's, especially the initial stage. Team implementation can always benefit from critical and continual adjustment and improvement. The inadequate reward system and evaluation will lead to inappropriate feedback and response. Allander [8] found out that the implementation path to SDWT's will be take from two to five years to become a mature SDWT. Allander's research contrasted with the method that Bailey used in her research. She set up the program and evaluated the program in the nascent stage. The initial stage of SDWT's will generate the problems about adapting each one's role, co-operation, leadership's changing role, perception of the improvement team, and communication between members and external resource. Those problems are eventually crucial to the success of the improvement of productivity and performance, as the other variables, increasing autonomy, training, and task content.

4. In the "A Methodology for Team Effectiveness Research", Aken [9] introduced another way to measure the team performance. He suggested that different team types may represent different species of teams having unique design and management requirement, so the study need to understand what relationships between team variables hold at specific levels of analysis (i.e., individual, group, organizational). He used the Within and Between Analysis (WABA) to evaluate the factors that effect the various types of work teams. Aken's method can tell that whether there are other relative factors that effect the different types of work-team performance.

5. Strengths and weaknesses of the paper.

The research paper's concept contained the idea about 1) cognitive model of participation 2) precondition of the model 3) the hypothesis 4) the analysis of quality and quantity performance. Actually, this research paper only emphasized three primitive factors that effected the performance of three types of improvement teams. There are derivative factors that directly effect to two of three types of improvement teams immensely, especially SDWT's, in order to increasing those three factors, which are autonomy, training, and task content. The qualitative data and quantitative data had been collected from eight sites of semiconductor industry. The data had been analyzed by ANOVA to verify the confidence of the data. The qualitative result of self-report measurement data was ensured to be representative of each program by using five-point Likert-type scales. The lack of effective linking between the qualitative data and quantitative data lead to inaccurate quantitative results. The strengths and weaknesses of the paper describe below:

Strengths

- **In this research paper, the researcher made use of ANOVA to verify that the data can represent the samples. That the researcher had chosen the samples from many sites in different firms provided the broadly base of information.**

Weaknesses

-The paper failed to cover the other factors that effect immensely to two of three programs, such as the reward system, evaluation, communication, and voluntary or mandatory participation. Rather, the author just analyzed them as a survey and conclusion.

-The maturity's time of each program is different, so it is inaccurate to measure the outcome that some of the improvement teams are mature, and some are not. For example, the CIT program had implemented first. The CIT's team probably changed to be matured before the QC's and SDWT's teams, and the matured CIT could perform more efficient and productive than the QC's and SDWT's teams, which were immature yet.

-The paths of implementing each team's program are differently. Especially, the implementation of SDWT's program is more sophisticated to implement successfully. The QC's and SDWT's program could change the structure of organization, so those need more attention from the executive. The more autonomy that team gains, the higher degree of training, understanding the changed role, the expectation of team, and accountability of the members is needed. The more training that team gains, the higher degree of evaluation, feed back, and investment is needed. The more tasks content that team gains, the higher level of communication system, the clarification of each one's responsibility, and so on is needed. But, the research did not take those variables into account.

-The result from the qualitative data did not clearly connect to the quantitative result. Qualitative result is crucial in the SDWT's program, because this program related directly to the changing of organization behavior. The lack of effect of qualitative data to the quantitative data provided the illustration of SDWT performance's outcome. For example, the bad information system could seriously affect the time in problem solving and the time in preventive-maintenance, especially in the SDWT's fab that wanted to improve to real-time production system. The lack of supporting from engineering could affect the task-training data.

6. The conclusion of this research paper

Three kinds of the improvement teams need attention and support to be efficient improvement teams. The SDWT's is more sophisticated to implement, especially in the human resource factor. SDWT's is most similar to the team in the matrix organization. According to the cognitive model of participation, the SDWT's should gain the most effective performance, but the obstacle in human resource affect the performance, for example, the disillusionment among operators toward the program and the lack of engineering support. The most questionable comment that the researcher introduced is 'Are the participation schemes appropriate among low level workers?', because the SDWT's is directly linked to the training and skill of participators. The researcher also suggested that the time frame of survey and gathering data is in nascent stage, so the QC's and SDWT's were probably immature yet, which leaded to poorer performance than CIT's. The researcher also commented the limitation of the study that some aspects of human resource factors had not been measured, for example, the mandatory and volunteer of participation.

7. Additional Reference

In my opinion, the paper's reference was insufficient. The lack of time frame's analysis leaded to possibly unmatched between hypothesis and the result. Montebello and Buzzotta [10] introduced the time frame to approach the mature improvement, and the obstacle along the way to becoming the efficient team. He suggested not only the way to design and organize

teams, but also the team development behavior, four stages of typical team-development process and the relationship between team behavior and the process of team development. In design and organize team process, five characteristics that must be identified in any job are task identity, task significance, autonomy, feedback, and skill variety. Trainers and human resource department professionals can accelerate the often slow and cumbersome process of developing teamwork. The four developmental progressions are cautious affiliation, competitiveness, harmonious cohesiveness, and collaborative teamwork. The implication is that groups must develop through this predetermined sequence if they are to mature into fully effective teams. Each stage is describe below:

Stage 1: Cautious affiliation. In this stage, the participators concern about collective and individual ability. They are very enthusiasm to accomplish the tasks ahead.

Stage 2: Competitiveness. In this stage, the team's member realized the gap between their expectation and their abilities. They can not accomplish the task as they expect. That generated a lot of blaming, defensiveness, and test confrontations. Subgroups may form, with factions competing for influence.

Stage 3: Harmonious cohesiveness. In the end of this stage, the members discovered that they feel like the team as an entity, the members as individuals, their social encounters, and the sense of belonging they are beginning to feel.

Stage 4: Collaborative teamwork. During this stage, a group of individuals becomes a truly collaborative team. Structured processes and procedures emerge to allocate resources, resolve personal conflicts, deal with the larger organization, give warranted positive feedback, and discipline members for unacceptable behavior.

After defining the stage of team progression, they suggested the 'Dimension Model of Teamwork Patterns', which contained a behavioral model consisting of two dimensions -- getting thing done and building strong relationships. It defines four distinct patterns of teamwork that correspond to four stages of the team development: authoritarian (storming), reactive (forming), casual (norming), and true teamwork (performing), which are shown in Figure 1[10].

FIGURE 1
Dimensional Model of Teamwork Patterns

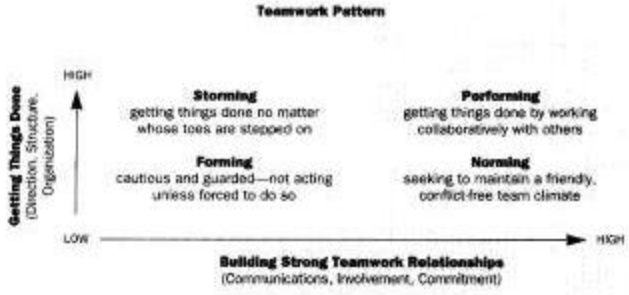

Figure 2[10][1] describes the characteristics of the four stages, sorted into quadrants. Each quadrant includes the representative behaviors of the corresponding developmental stage: Quadrant 1, Authoritarian (corresponds to Stage 2 in the old model) Quadrant 2,

[1] Please see Appendix B

Reactive (the old model's Stage 1); Quadrant 3, Casual (the old model's Stage 3); and Quadrant 4, True Teamwork (the old model's Stage 4).

FIGURE 2
Relationship Between Team-Development Behavior and the Four-Stage Model

QUADRANT 1—Authoritarian (Stage 2)
- high structure and direction—low involvement
- gets things done without regard for the needs of team members
- dominated by one or two team members
- overstructured, with tight control
- impatient with lack of progress
- overly competitive and confrontative
- self-serving—"look out for yourself"
- one-way communication
- people become testy, blameful, and overzealous
- frustration, anger, and resistance to goals
- defensiveness, competition, and choosing sides
- subgroup polarization and infighting.

QUADRANT 2—Reactive (Stage 1)
- low structure—low involvement
- doesn't act unless forced to
- impersonal, watchful, guarded, and cautious
- tentative attachment to the team
- members cautiously explore boundaries of acceptable individual and team behavior
- tendency to avoid others—to be "loners"
- very little real communication
- tentative attachment to the team
- suspicion, fear, and anxiety about the task ahead
- some anxiety about why they are there, who others are there, who'll lead the group, and what they'll do.

QUADRANT 4—True Teamwork (Stage 4)
- high structure and direction—high involvement
- gets things done by working collaboratively with each other
- agreement on who they are, what they're doing, and where they are going
- team has clarified relationships and performance expectations
- participation by all team members in achieving challenging goals
- cooperative and productive climate
- open, direct, relevant, and businesslike communications
- ability to prevent or work through team issues.

QUADRANT 3—Casual (Stage 3)
- low structure—high involvement
- seeks to build a friendly and social team climate
- high concern for the needs of team members
- unfocused, irrelevant, overly friendly communications
- informal information exchanges and social encounters
- feelings of mutual trust, respect, and harmony
- avoidance of conflict
- focus on harmony and conformity
- competitive relationships become cooperative
- sense of team cohesion and close attachment to the team.

Based on the model of teamwork patterns, Psychological Associates developed an assessment process to measure team patterns. The process relates to important operations such as decision making, goal setting, and resolving conflict. Furthermore, we can identify the degree of team's maturity, which provided the efficiency comparison.

8. Future work

In my opinion, the research should start from 'Within and Between Analysis' that can help the researcher to identify the related factors that effect the performance of different types of improvement teams. When the level of autonomy, training, and task content is increased, there are other factors that should be concurrently increased, especially in SDWT program. I thought there are some secondary factors that should be measured along with the primary factors, autonomy, training, and task content. For example, if we input the high level of task content, we should adjust or measure the secondary factors, such as the efficiency of communication system, and the clarification of each one's responsibility. Both, primary and secondary factors, effecting the performance of improvement team in positive or negative, are also depended on the correlation between them. After that, we should measure the weight of each quantitative data. According to 'the crucial roadblock to productivity in the semiconductor industry', each of quantitative in the study should be weight differently. For example, time in meeting and time in preventive maintenance should be weight differently, because time in preventive and maintenance can affect the setup time; consequently, seriously affect the productivity. Finally, we must use the qualitative data, survey, and observation to identify the stage of progression and the team development behavior. That will show the status of the team in each program being mature or immature. I thought the time phase

analysis, the stage of progression and team development behavior, is one of the crucial point that will tell us whether the team is in the process of adaptation and whether the researchers should finally analysis and make conclusion. Alternatively, we can compare each team of different program within the same stage and recommend the problems that obstruct the approach to the final stage of maturity of the team.

9. Reference

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Appendix A

Characteristics of teams.

			Team	
		QIT (n=11 Fabs)	SDWT (n=6 Fabs)	CFT [2] (n=11 Fabs)
1) # of Meetings/Week Max		3	7	2
Min		0.25	0.5	0.25
Avg		1.0	1.9	0.8
2) Voluntary Membership? Yes		8	2	7
No		3	4	4
3) Single Project Only? Yes		3	1	5
No		8	5	6
4) Who Decides on Team's Projects?				
Total no. of fabs answering "Managers"		2	1	2
Total no. of fabs answering "Joint"		6	3	6
Total no. of fabs answering "Team"		3	2	3
5) Who Authorizes Team's Expenditures?				(n=10)
Total no. of fabs answering "Managers"		6	3	8
Total no. of fabs answering "Joint"		3	2	1
Total no. of fabs answering "Team"		1	0	1
Total no. of fabs answering "Other"		1	1	0
6) Are Managers or Supervisors Members?				
Yes		9	4	10
No		2	2	1

[2] Cross Function Team.

Appendix B

Relationship Between Team-Development Behavior and the Four-Stage Model.

QUADRANT 1--Authoritarian (Stage 2)
*** high structure and direction--low involvement**
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