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Author(s): D. Wahlstrom

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Abstract: Critique of the IEEE Transactions on Engineering Management article, "The Influence of Process Concurrency on Project Outcomes in Product Development: An Empirical Study of Cross-Functional Teams."

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D. Wahlstrom

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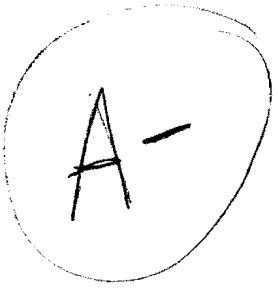
Individual Research Paper

Critical Evaluation of R-6 Paper



To; Dr. Kocaoglu
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By: Dan Wahlstrom

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General Concepts

This paper is a critical review of a case study on Concurrent Engineering (CE) [3]. The case study defines CE as a fundamentally new way of looking at how products - as well as their enabling technologies, manufacturing, testing, and support services are conceived, specified, and developed. The basic factors of CE are defined to include: common goals, complete visibility of design parameters, mutual consideration of all downstream decisions, overlapping problem solving, collaboration to resolve conflicts, teamwork and continuous improvement. From this point on, the case study will be known as the "Paper". The Paper looks at four areas of CE in terms of process concurrency and its impact on the success of New Product Development (NPD) projects. The four areas are two way communication, overlapping problem solving, readiness to make decisions based on uncertain and ambiguous information, and readiness to release uncertain and ambiguous information. The Paper separates the behaviors and processes on a team level from the behaviors and processes of the organization. The organization includes information technologies, reward systems, organizational structure and culture. The objectives of the Paper are to:

1. Model and operationalize team level behavior and processes that determine the degree of concurrence in the CE process.
2. Test how identified team level behaviors and processes contribute to the outcomes of product development projects.

The model suggests a positive relationship between project inputs and outputs;

Inputs

- Two way communication
- Overlapping problem solving
- Readiness to make decisions based on uncertain and ambiguous information
- Readiness to release uncertain and ambiguous information

Outputs

- Team satisfaction
- Project cost and schedule
- Product cost and quality

The Paper states that most of past research has focused on the enablers of CE such as tools, methods, information technologies, organizational cultures, reward systems, physical locations and culture. In doing so, an important segment of research has been left ignored. This segment deals with the reasons for investing in the enablers in the first place. These reasons are to achieve effective and efficient team level attitudes, processes and behaviors. Therefore, the focus of the Paper is to investigate the "black box" of CE, principally the project teamwork and its attitudes, processes, behaviors and what affect they have on project outcome [3].

Methodology

The research for the Paper used data in part from a larger global study prepared by the Intelligent Manufacturing Systems (IMS), a international collaboration between industry and academics. The companies studied were geographically located around the world in fourteen different countries. The following criteria were used to identify appropriate company characteristics for use in the Paper:

- The project duration was less than two years.
- The project was recently completed within one year.
- Project team members included representatives from manufacturing and engineering/Research & Development (R&D).
- A project leader was used in a formal sense.
- For geographically distributed projects, representatives from manufacturing and engineering/R&D were uncollocated.

The data collection involved a questionnaire survey given to project leaders and to representatives from manufacturing and engineering/R&D. The participants were asked to base their replies on a single CE project they had been involved with. The answers were measured according to two variables:

1. Degree of Concurrency in the CE Process
2. Project Outcomes

The degree of concurrency measures used a combination of straightforward questions and open-ended qualitative questions. The qualitative questions asked respondents to describe situations in which they had to use or release uncertain or ambiguous information. The format of open-ended questions were used in order to elicit a less judgmental response. Degree of Project outcome measures focused on assessing the relative success of CE projects in terms of project efficiency and effectiveness, as well as team satisfaction. Whereas efficiency is defined as meeting a budget and schedule, and effectiveness is defined as meeting product quality and functionality.

Only a brief synopsis of the data analysis is offered due to my own deficiencies in statistics. Note: This approach was agreed upon between Dr. Kocaoglu and myself in class. Two levels of aggregation were applied to the data. The data from team leaders and representatives from manufacturing and R&D/engineering was tested for consistency and reliability. In addition, measurement analysis was performed on the entire survey.

Contributions and Comparisons

The positive effects of two-way and overlapping communication on project outcome are supported by three actual working cases. First, Honeywell Avionics Systems Division recently took top prize in a nationwide contest for applying concurrent engineering practices. The contest sponsored by "Machine Design" magazine and

Structural Dynamics Research Corporation rewarded firms for most successfully implementing concurrent engineering and automation tools. Honeywell stated that "included in its CE arsenal besides advanced CAD tools and close customers collaboration was extensive cooperation among internal teams handling tasks such as process improvement and information technology" [1]. Second, Pratt & Whittney Canada Inc. recently won a Computerworld Smithsonian Award for reducing product lead times and operating a paperless manufacturing plant. Pratt & Whittney "compressed the development time by overlapping the design and manufacturing phases, stating that input from maintenance and manufacturing engineers resulted in better designs, avoiding conflicts that crop up later in the cycle which are more expensive and difficult to resolve" [6]. Third, Rockwell International Space Systems Division employed a process called Design for Competitiveness to reduce the development and products costs of the Space Station Docking Module. This technique used cross functional teams in an intensive three day session. It improved the "two-way and overlapping communication because all members were present together at the same time. One of the real secrets of reduction cost is being able the have the people who know the most about it involved from the start" [4].

The Paper points out that CE involves an integrated type problem solving approach requiring heightened two-way communication. "The nature of integrated problem solving and two-way communication requires a effective coordinator or champion who strives for grip consensus, encourages risk taking, and closes the loop by ensuring action items are resolved quickly". Since much of this activity occurs during the design, the design engineer often becomes the project leader. The role and authority of the design engineer has expanded "they must be able to speak the language of the downstream people". This places many downstream process individuals in a position of providing input into the design process which increases company morale and team satisfaction [2].

The Paper also relates the CE flow of information to that of theories from Information Processing Theory (IPT). IPT describes the nature of how information is communicated, transferred and translated between individuals and systems. A major challenge of creating effective and efficient teamwork is "persuading team members to work together as an actual team and not just an information exchange group". To do this requires investing the team with key deliverables and the authority to obtain the necessary resources. "A barrier to integration of concurrent engineering is poor communication between team members which translates into the need for effective communication and real-time feedback as critical aspects of any design project" [8].

At my own work, we use a process called Value Analysis (VA) to reduce cost without compromising quality of products and machine assemblies. VA employs a method of systematically analyzing the primary and secondary functions of products. By identifying the primary functions, one may look to cut costs on secondary functions, as they don't add value to the end product. This methodology utilizes cross-functional teams, gathered together in intensified week long sessions to focus on a particular high cost design or warranty area. The benefits of this intensive atmosphere is direct two-way communication and overlapping problem solving involving representatives from engineering, purchasing, manufacturing, sales, service and assembly. It also minimizes the uncertainty and ambiguity of information because all the necessary parties are present in the decision making process.

Strengths and Weaknesses

A strength of the Paper in terms of concept is the newness it brings to current research on CE. It is stated that the majority of the past research on has focused on the enablers known as tools, methods, information technologies, organizational structures, reward system, physical systems and culture. This paper differs from other researcher's work in that it deals primarily with teamwork attitudes, processes and behaviors as opposed to CE enablers.

Several weaknesses in terms of concepts is the lack of consideration given to interdependencies of information technology and physical locations to team level behaviors.

- CE information enablers may increase the effectiveness of two-way communication and overlapping problem solving. They may also decrease the level of uncertainty and ambiguity in design information. For example, if manufacturing had access to electronic drawings and e-mail on the shop floor, problems might be resolved easier more efficiently. " In order to make CE projects successful, information needs to be shared - Product Data Management software heightens information sharing capabilities; If necessary, users can even share incomplete information" [5].

- The closeness and physical proximity of team members employees may also increase the effectiveness of two-way communication and overlapping problem solving. I find it easier to communicate to shop floor employees and resolve problems when meetings are face to face. One such CE implementation strategy is to "locate team members in close proximity. This arrangement promotes communication on an informal basis and fosters group spirit" [9].

A strength in terms of methods is that the sample size is taken from a broad set of industries thus minimizing some potential bias due to the variation in CE implementation and experience. Also, use of a diverse international sample may minimize extraneous effects due to culture, and organizational structures.

A weakness in terms of methods is that the paper does not mention the possible influence of the company size on teamwork behaviors. Smaller companies may be much better at providing an environment that encourages closer collaboration and cooperation. This may not be just physical dimensions, but positive personal relationships among engineering and manufacturing individuals may improve the willingness to deal with uncertainties. Likes and dislikes may affect the degree of two-way communication and team satisfaction.

The strengths in terms of results are reflected by the qualitative data on the degree of Concurrency in the CE process. The original construct on the degree on concurrency of the CE process and project outcomes are supported by positive correlation's between:

- Two-way communication and both team process satisfaction and product effectiveness

- Overlapping problem solving and product effectiveness

- The use and release of uncertain and incomplete information was found to be significant in discriminating between successful and unsuccessful projects.
- Uncertain and ambiguous information resulted in ineffective team behaviors.

A weakness in terms of results is that no suggestions are given as how to improve two-way and overlapping communication. By combining the results of this paper with suggestions for improvement, this paper would offer a powerful analysis tool of process concurrency as well as a justification and suggestion tool to improve areas within an organizational system.

Conclusions

The Paper discusses the results in terms of theoretical and practical implications, then generalizes the results to apply to all "technology-intensive manufacturing companies".

Theoretical

The authors considered it important to breakdown the CE process into attitudes and behaviors as they related to team performance, communication and information exchanges. The conclusions of the paper from a theoretical standpoint are as follows:

1. The attitudes and behaviors of CE team members concerning uncertain and incomplete information and their affect on project outcome is confirmed and supported by their literature search on decision making theory.
2. The use of uncertain and incomplete information had a negative impact on team satisfaction.
3. Positive relationship between team member interdependence and team performance.
4. Positive relationship between two-way communication and team satisfaction.

Practical

The paper suggests that the findings may be used as benchmark tool for assessing an organization's success in achieving concurrency in the NPD process. The authors stipulate that top managers and projects leaders should be aware, "CE will not guarantee success in NPD, yet not using a CE process could ensure failure". The conclusions from a practical standpoint are as follows:

1. CE has a positive affect on achieving project budget goals and does this without the detrimental affects on quality, cost or schedule.
2. Results establish a moderate relationship between team members satisfaction and the requirement to tolerate ambiguous and uncertain information. This is especially important in the downstream manufacturing process in that release of this information could threaten initial team satisfaction. This negative impact may be avoided by increasing the level of two way communication between upstream and downstream members.

General

The authors justify generalizing the results because of the wide cross section of industries studied. They used a broad set of technological based companies and thus claim it is relevant to extrapolate the findings to most manufacturing companies of a similar nature. They state that the only problem with this assumption is the use a non-random set of companies, but feel the accusation is countered by the wide range of concepts studied relating the performance and CE practices [3].

Future Work

The National Research Council has identified organizational and communication effectiveness as two broad areas for future research in the design process. Organizational issues are concerns with design planning, organizing and managing the concurrent engineering process. Communication issues involve the internal and external facilitation ;and control on information transfer in design projects. They state while much work had been done in the fields of organizational study, very little has focused on the design process [7]. Two projects that they have identified are:

1. Create and evaluate useful models on how information is and should be exchanged and used in a concurrent engineering process.
2. Understanding of how multi-disciplinary teams work in order to improve their performance.

Personally, CE is a relatively new field of study for me and one that is very interesting. As a design engineer in a small manufacturing company, I have witnessed various design process in action. We currently have a new product development project that is scheduled to begin early 1997. Through my reading for this project, I have become exposed to a number of successes stories involving using CE in the design process. My own future research is to develop a CE implementation strategy for use in our company's new development project.

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