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Research Paper

R-9: Involving Suppliers in Product Development in the United States and Japan: Evidence for Set-based Concurrent Engineering

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1. PURPOSE

The purpose of this paper is to evaluate the findings, the methodology, the strengths and weaknesses and references of the research paper entitled "Involving Suppliers in Product Development in the United States and Japan: Evidence for Set-based Concurrent Engineering" by Liker, Sobek, Ward, and Cristiano and to determine what contribution is makes to engineering management literature and how it relates to other publications in this field.

2. SYNOPSIS OF CONCEPTS

2.1. Assumptions

2.1.1. Concurrent Engineering has a positive impact on development time, product cost and product quality.

Liker et al cite both practical and theoretical basis that concurrent engineering, or more generally the concurrent performance of multiple tasks and multiple resources, results in reduced product development time, product cost and product quality. This is supported by many researchers, including [2, 3, 5, 7, 8, 11 and 12].

2.1.2. Despite the potential of concurrent engineering, U.S. companies have difficulty achieving truly concurrent design.

The authors do not cite references to corroborate this statement, but it is supported by [2, 6 and 8]. Many of the problems associated with concurrent engineering adoption in U.S. firms has been attributed to the lack of cross-functional team structures in U.S. companies. This further supports the notion cited in the next assumption.

2.1.3. Much management research in Concurrent Engineering has focused on organizational and communication aspects of CE.

Virtually all the research I uncovered regarding problems in adoption of concurrent engineering and best practices centered around organization and communication. For example, [5, 6, 7, 10] exclusively dealt with organization issues in effective CE implementation. They demonstrated results that CE and product development were demonostratably improved when cross functional teams and co-location were utilized. However, Liker et al argue that in the automotive industry, these approaches have become so commonly adopted as to no longer offer a competitive advantage. This is supported by [3], wherein Kim B. Clark shows great improvements by U.S. automakers with respect to use of cross functional teams, co-location and Quality Function Deployment (QFD). Even still, effective adoption of CE is still a problem to be solved.

2.1.4. Differences in Japanese and U.S. automakers form a sufficient basis for the deduction of information based on these differences

One might wonder why a study was conducted on two distinct groups on the correlation between a newly defined technique (set-based CE), and effective implementation of CE. Liker et al argue that Japanese companies have been shown [2, 7, 9] to be more effective at CE. Therefore, it set-based CE can be shown to correlate higher among those who have demonstrated more effective CE, then it can be conjectured that set-based CE results in more effective CE and product development.

As will be discussed later, this is a very broad assumption to be made, since there are many other differences between U.S. and Japanese automakers.

2.2. Basic Premises of the Paper...

2.2.1. Full implementation of CE requires a 'revolution' in the underlying paradigm of design, not simply organization and communications aspects.

This is a very important point not only in the paper (its fundamental premise), but as a contribution to overall product development and CE as well. Kim Clark, who authored [1, 2, 3] has discussed the value of design process as an effective means of facilitating CE. He has focused on product architecture, and specifically modular product architecture as a means of fostering CE practices. Pine [11] also discusses the effectiveness of product modularity on concurrent design by independent teams, even at different points in the design, manufacture, delivery chain. As we will discuss in the section regarding other research, there is another body of related research which deals more with differences in Japanese and U.S. design styles.

However, as mentioned, virtually every other researcher of CE has focused on organizational related issues such as cross functional teaming, co-location and QFD.

Here, Liker et al demonstrate through case studies and empirical survey that the design process, and specifically how much ambiguity is tolerated when providing requirements to suppliers, and how broadly the suppliers independently explore the design space, evaluating alternative solutions that integrate well with other dependent product components and design decisions.

2.2.2. Truly effective CE requires a change from 'point-based' design paradigms, to 'set-based' paradigms.

Two terms were introduced in this paper: point-based and set-based CE approaches. The concept is that traditional design commences with convergence on a single design solution. As other factors and functions are brought to bear on the design, the design changes by a progression from one point to another. Given that a fundamental demand which CE imposes is that of the necessity for early and high "bandwidth" communication, such point changes in the design process are expensive in communication and force behaviors to "freeze" incomplete solutions, or delay communication.

Set based solutions propose to generate a set of design alternatives. The entire design process is therefore based on assuming work that supports the entire set. As the design progresses, the set of solutions is narrowed to the point of convergence. Any solution which supports the set will support the assumptions that other design teams are operating on.

3. METHODOLOGY EMPLOYED

3.1. "Triangulation" method of using hybrid methods

Based on recommendations in the literature to use 'triangulation' or the application of more than one technique or investigator in the application of studies [4], Liker et al applied three basic techniques. First, to determine a set of hypotheses, they relied on case studies inductively, and deductively through logical implications of set-based concurrent engineering theory.

They then conducted a survey in 1993 of 92 Japanese and 119 US auto parts suppliers. The sample space received a questionnaire which was supplementary to a survey which was conducted in the previous year regarding broader issue than just set-based issues.

Survey measures were unique to this survey (this is discussed below regarding 'weaknesses') and were extracted from the case studies.

3.2. Assumptions

3.2.1. Japanese vs. US automakers

The purpose of surveying and comparing Japanese and US parts suppliers and automakers was that Japanese automakers have been considered to be more effective in CE [28, 4]. Their relationships with their parts suppliers are generally longer-term, and different in process. Therefore, such distinctions can serve to show sensitivities of survey variables to certain design practices unique to US or Japanese companies. Furthermore, if greater use of set-based techniques can be attributed to those companies considered more effective at Concurrent Engineering, then set-based approaches may be considered potentially attributable.

3.2.2. Parts Suppliers and automakers to isolate communication.

The basis of surveying parts supplies and their automaking customers is simply to more effectively isolate points of communication in the design process. The interface between supplier and automaker is rather well defined, and the requirements need to be communicated rather 'cleanly' and formally. Furthermore, state-of-the-art automotive design and manufacture requires that these two entities operate concurrently. This relationship provides the opportunity to analyze the content and timing of the requirement setting and changing process in order to gain more insight into the possible use of set-based approaches and their effectiveness.

4. CONTRIBUTIONS TO LITERATURE

This paper sought to analyze aspects of product design which affect concurrent engineering performance. Specifically, a technique introduced in this paper as "set-based" concurrent engineering was presented in which rather than demanding more from communication mechanisms and organization to support product changes, or process aspects such as early product freeze, instead, as functions involved in the design concurrently operate on a broader 'set' of design alternatives which have been brainstormed or otherwise created early in the design process. Extending the research in CE to design approaches and introducing the concept of 'set-based' concurrent engineering is a significant contribution to the literature.

Secondly, this paper demonstrates that many organizational aspects of CE such as co-location, cross-functional teams, etc. have already been adopted so broadly in the auto industry as to no longer serve a competitive advantage. This proposes that more design process oriented aspects such as set-based CE potentially serve as the next competitive opportunity.

Lastly, the authors suggest ways in which the CE process may be extended by developing new tools which leverage set-based approaches. The argue that there are two future directions needed for research on set-based CE. The first is the development of tools which can communicate sets of design alternatives and deal with incomplete and ambiguous design information. The second is to conduct further empirical research on set-based design, to develop a set of 'standardized measures' and to accrue data from which more definite and broader conclusions can be gained.

5. COMPARISON WITH OTHER RESEARCH PAPERS

5.1. Similar Findings

5.1.1. General observations about related research

There are several areas on which this paper touches which form the basis for other research. They are:

- Concurrent Engineering
- Supplier Involvement in Product Development
- Automotive Product Development

5.1.2. Findings which support the paper's research

[6] indicated that there was a great increase in US Supplier involvement in the design of their customer's products, not just the manufacture. 38% in the 1998 survey indicated that the supplier did most of the design and the customer "filled in the details", while in 16% of the cases, the supplier did all of the design and in 12% of the cases the design was equally distributed. Only in 5% of the cases did the customer assume full design responsibility. However, between 1988 and 1984 there was also a 24% increase in the number of relationships in which there were visits at least every 2 months (from 50% to 74% of respondents), and a14% increase (from 22% to 36%) in those who visited at lease every 2 weeks.

5.1.3. Findings which extend the paper's research

In [8], Imai et al analyze learning patterns in Japanese companies. However, in this paper, they also analyze the entire design process. They divide the process into three basic phases: variety amplification, variety reduction, and learning. What is interesting is that the "variety amplification" they describe is set-based. That is, it is the process of generating many design alternatives early in the design process. They describe that Japanese companies, more than U.S. companies, perform more variety amplification, and carry these "sets" of alternatives longer in the design process, being more willing to deal with design ambiguity among design team members. They also indicate that the long term relationships between suppliers and companies supports this ambiguity. These findings, though published in 1983, directly address and support the set-based concept.

5.1.4. Findings which refute the paper's research

I could find nothing which directly refuted direct findings of this research.

5.2. Other References Which Were not Included

Liker et al did not address product attributes or process attributes which may effect (i.e. encourage or discourage) set-based approaches. For example, [Abernathy, Reinerston and others] discussed that concurrent development can occur more effectively when interfaces are cleanly defined through product architecture in which the components designed by concurrently operating teams are 'loosely' coupled in the dependencies, functional communication and therefore, their interdependent risk. [Pine and Abernathy] also discuss that modular design architecture results in the ability to more quickly generate multiple alternatives. While Liker et al indicate that spending more time early in the design process to generate more alternatives positively affects concurrency, they offer no product architecture or process solutions for more effectively doing so.

6. STRENGTHS & WEAKNESSES

6.1. Strengths

6.1.1. Explores a New Aspect of What Affects Concurrent Engineering Effectiveness

6.1.2. Very effective Sample Space

6.1.3. Methodology Very robust, even in light of such a novel area of research

6.1.4. Hypotheses Are Sufficiently Broad

6.2. Weaknesses

6.2.1. Measures of "set-basedness" has no historical basis, or were they significantly correlated (prove)

No standard measures of set-based design or CE existed, according to the authors. Since "set-based" was unique terminology introduced in the paper, equivalent concepts would have to be identified in the literature. As mentioned in the previous section, while design reuse and related areas introduce similar concepts, I found none sufficiently similar to this context which had established measures which could be used.

The authors derived the measures based on case studies which had given them clues regarding the concept of set-basedness.

6.2.2. "Self-fulfilling Prophecies"

The survey conducted used measures based on case studies which had indicated the potential presence of what was labeled set-based techniques. However, these case studies were of a sample space which was nearly equivalent to that of the sample space used in the survey presented in this paper.

6.2.3. Performance related outcomes of the use of set-based approaches were not considered due to sample space diversity.

A fundamental question in determining the effectiveness of set-based techniques is the impact of these on overall product development performance. Measures such as product quality, time to market, or cost have been cited [Measuring Development Performance in the Electronics Industry]. However, due to the diversity of the sample space, wherein suppliers manufacturing parts ranging from mufflers to doors, wheels and door handles, etc. were included, such performance measures, as stated by the authors, could not accurately be applied. This is a significant weakness in my mind, since not only was the relationship between set-based techniques and product development performance or product performance not analyzed, but neither was the relationship between set-based technique usage and concurrent engineering effectiveness. [5, 19, 23] have studied the relationship between concurrent engineering practice and product development performance.

The assumption in this paper was that there was a positive correlation between the number of years of experience with CE, and the adoption and practice of set-based approaches. If we wish to determine the effect of set-based practices on product development performance, we would presume then that 1) companies get better at product development the longer they apply CE and 2) set-based approaches positively affect product development performance. These assumptions may not be true, since they were not tested.

6.2.4. *Did not Include Some Factors in the Model*

[Hull] included the Newness of the design as an independent variable. How new the design is may impact how the supplier and the customer may communicate about the design.

7. IDENTIFICATION OF RELATED FUTURE RESEARCH

Much additional work could be performed in the area of defining better metrics for measuring "set basedness". Furthermore, extending the research to consider the effect of set-based CE on overall product performance would be significant. Additionally, there are potential applications of set-based CE to foster design reuse and thereby improve productivity and quality in subsequent generations of systems, such as that described in [1].

8. REFERENCES

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