Product Specification Management in Collaborative NPD: An Investigation of Problems and Good Practices in Electronics Industry

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Abstract

Client-supplier collaboration has been an imperative approach to new product development (NPD), in which a good product specification management system and practice is crucial to the assurance of product quality. This study investigates product specification management in client-supplier collaborative NPD. Based on the interviews and survey study, 12 problems and 13 good practices of product specification management are identified. It also compares the importance and degree of the implementation of the product specification practices in Hong Kong electronics industry. The results suggest that more intensive practices should be implemented for better product specification management.

Key Words: Product Specification, Client-Supplier Collaboration, New Product Development, Hong Kong Electronics Industry

1. Introduction

The role of supplier involvement in new product development (NPD) has been escalating (LaBahn and Krapfel, 2000; Primo and Amundson, 2002; Ragatz *et al.*, 2002; Wynstra *et al.*, 2001). In the past decades, there has been substantial research on the various aspects of the management of the collaborative NPD between clients (buyers) and suppliers (Araujo *et al.*, 1999; Chung and Kim, 2003; Petersen *et al.*, 2005; Sobrero and Roberts, 2001; Walter, 2003; Wynstra and Pierick, 2000). However, in spite of the importance of the collaboration, product specification management has not been well studied.

A product specification is a written description of a product that is generated beforehand to guide the development of a product (Smith and Reinertsen, 1991). In other words, product specifications direct NPD processes and determine the quality of products to be developed, which play a crucial role in the success of NPD. However, research on product speci-

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fication management in client-supplier collaborative NPD has been limited. Karlsson *et al.* (1998) explored product specification management in collaborative NPD and they revealed that suppliers are facing a number of problems in product specification development. The research suggests that the problems need to be tackled for improving product specification development, and in turn NPD performance. This paper tries to provide an deeper understanding of product specification management in collaborative NPD by empirically investigating the problems encountered in the specification development process in electronics industry as well as identifying good practices for tackling the problems. This paper has six sections. After the introduction, current literature on product specification management is reviewed in the second section. The third section discusses the research methodology. Section four and five report the findings of the interview and survey studies about the problems and good practices of product specification management. The last section presents discussion, conclusion and suggestions for future research.

2. Previous Research on Product Specifications

The role of product specifications in NPD has been recognized (Smith and Rhodes, 1992). Ulrich and Eppinger (2000) argued that product specifications are precise descriptions of what a product has to do and they represent a clear agreement on which a company will attempt to satisfy clients' requirements. Smith and Reinertsen (1991) stated that product specifications are critical in the product development process. A poor specification can delay the execution of development, and lead to increased development cycle and poor product quality. Basically, a product specification is a central element of NPD (Nellore *et al.*, 1999). Acknowledging its importance, several authors have contributed to the understanding of product specification management. Ulrich and Eppinger (2000) presented basic steps to guides the development of product specifications. Smith and Reinertsen (1991) proposed several techniques to help companies develop a product specification that enables speedy product development process. Nellore *et al.* (1999) investigated the product specification development process in automotive and aircraft industries.

In recent decades, client-supplier collaborative NPD has become a crucial strategy of NPD. The collaboration is definitely not a simple task. Clients and suppliers are facing challenges and problems in pursuing the success of the collaboration (Wognum *et al.*, 2002). Karlsson *et al.* (1998) explored product specification management in the collaboration. They found 12 problems in the product specification development process. The most common problems include: frequent changes of product specifications, misinterpretation of specifications, and overspecification. Karlsson *et al.* (1998) also proposed five factors that may contribute to the success of product specification development, including role of suppliers, technical content,

changes, cost, and participation.

As a matter of fact, there have been very limited studies on product specification management in the collaboration. Karlsson *et al.* (1998) pioneered the research and their findings about the problems of specification management suggest an important fact that product specification development is complicated and challenging in the collaboration. However, as Karlsson *et al.* (1998)'s research was based on survey data collected in automotive industry, the findings may not be applicable to other manufacturing industries due to the differences in product natures, manufacturing process complexity, and supplier involvement, etc. Moreover, although the authors presented five success factors of product specification development, the empirical support of the factors was not reported. Considering the limitations of the research, this study attempts to empirically investigate the problems of product specification management in electronics industry, which is a very important industry in Hong Kong and worldwide, and identify good practices to help companies improve their product specification management.

3. Research Methodology

Two research approaches were adopted to investigate the product specification management problems and good practices in collaborative NPD from suppliers' perspective. We first conducted in-depth interviews with industrial practitioners to investigate the product specification management problems and the corresponding practices to tackle the problems. Questionnaire survey was subsequently conducted to further validate the interview findings statistically. The details of the two research approaches are discussed in the following sections:

3.1 Interviews

Four industrial practitioners of Hong Kong electronics industry participated in the interview study. As shown in Table 1, the practitioners were experienced that they had at least five years working experience in electronics industry. Moreover, they all participated in NPD projects in collaboration with their clients, implying that they are knowledgeable about the product specification management processes of their companies.

In the interviews, the practitioners were asked to list and describe the problems encountered in product specification management processes. Moreover, they were also requested to report their current practices or suggestions for solving or preventing the problems. To ensure the reliability of the data collection, we transcribed the interviews and sent the interview reports to the interviewees for review. They all acknowledged the correctness of the reports, which ensures the reliability of the interview data.

Table 1. Interviews profiles

	Working experience in the company (yrs)	Products developed	Department	Position
Interviewee 1	11	Home Electronic Appliances	Engineering	Assistant Engineering Manager
Interviewee 2	7	Electronic parts	Engineering	Senior Engineer
Interviewee 3	5	Technological Electronic Products	R&D	Application Engineer
Interviewee 4	9	IC Chips	Quality Assurance	Senior Engineer

3.2 Questionnaire Survey

Followed by the interview study, a questionnaire survey was conducted to further validate the interview findings about product specification management problems, as well as the good practices in terms of the extent of implementation and importance of the practices. Part-time Master of Science students in the Department of Manufacturing Engineering and Engineering Management of City University of Hong Kong constitute the target sample primarily because the vast majority of them were working in manufacturing industries. We selected the respondents based on three criteria. First, the respondents must be working in companies which develop electronics products. Second, they must be working in the departments which involve in NPD, e.g. design, and engineering. Third, they must have at least two years of working experience in their companies in a bid to ensure that they have a good understanding of the product specification development processes. Finally, 101 questionnaires were collected and used for data analysis. The profiles of the respondents are shown in Table 2.

Table 2. Survey respondents' profiles

Department	Percentage (%)
Manufacturing/ Production	36
R&D/ Product Development/ Product Design	26
Quality Assurance/ Control	18
Marketing/ Sales	10
Purchasing	6
Other	4
Position	**Percentage (%)**
Upper management	14
Middle management	6
Engineer	69
Other	11
Working experience in the company	**Percentage (%)**
2-3 years	48
4-5 years	24
6-7 years	7
8-9 years	6
10 years or above	15

4. Interview Results and Analysis

4.1 Problems of Product Specification Management

In the interviews with the industrial practitioners, numerous problems in product specification management were reported. The details of the problems are discussed as follows:

1. Over specification – Clients may develop specifications that are too strict, e.g. too narrow tolerances, thereby leading to high manufacturing costs.
2. Wrong specification – Clients sometimes develop wrong specifications of which the requirements are either in conflict or incorrect. It could take substantial time for clients and suppliers to deal with the problems, especially when the problems are discovered in the later stages of product development, which may incur a great deal of additional cost for redesign and rework.
3. Missing specification – A complex electronics product has complicated engineering design and may involve over thousands of components. It is not uncommon that some important information is missing, which necessitates interactions between collaborating parties for clarifications.
4. Misinterpretations of specifications – Misinterpretations of specification can be induced in different ways. First, sometimes clients inform suppliers the modifications of specifications verbally but not in black and white. Verbal communications may not be clear and precise, which bring about misinterpretations of specifications. Second, the misinterpretations may be provoked by language barriers. In the global manufacturing environment, clients and suppliers from different countries collaborate to develop new products. Product specifications may be developed in different languages. Incorrect translations of specifications could induce serious misunderstanding. Even though collaborating parties use the same language, they may interpret a technical word in different ways because of the difference in cultural or educational backgrounds, which could also lead to the problem.
5. Specifications are too general – The specifications provided by clients may be too general and vague. Suppliers need to spend substantial time to communicate with clients to understand their requirements.
6. Insufficient standardization – Clients often neglect the importance of standardization. They may require non-standardized parts or components which necessitate high manufacturing or procurement costs.
7. Insufficient cost optimization – Clients tend to have less concern about cost optimization of product design. They may propose design that needs complicated manufacturing processes, therefore leading to long development time and high manufacturing costs.
8. Frequent changes of external environments – In the dynamic external environment, it is evitable to change product specifications during product development so as to meet al-

tering environments such as technology development, etc. In volatile product development the number of such changes is significant.

9. Frequent changes of client requirements – Clients are becoming more demanding and they tend change product design at the expense of their suppliers. The changes could be disastrous especially when suppliers have established specific production lines.
10. Specifications are not well discussed at early stages – It is common that only few staff of collaborating parties participate in the discussion of product specification development conducted at the early stage of product development. Without the involvement of all relevant departments, product specifications cannot be fully reviewed and discussed. Consequently, they may fail to notice some important issues in early stages. After the relevant departments discover a problem, the specification need to be modified and the time and effort spent on the development processed would be wasted.
11. Clients do not listen enough to the opinion/views of suppliers – Clients sometimes ignore the suggestions of suppliers. As a manufacturer of products, suppliers are more familiar with the technical issues of products. Suppliers' intentions to revise specifications for product improvement, however, are often underestimated.
12. Clients do not give reasons for changing specifications – Clients may propose specification changes without giving reasons. Suppliers, seeking to comply with client requirements, always need to make the changes blindly. In this situation, the expertise of suppliers is not utilized, and consequently re-design and re-work may be induced. As a manufacturer of products, suppliers are technological competent. They need to be involved in the specification change process so as to proactively examine and solve the problems that would potentially occur during the manufacturing process.

4.2 Good Practices of Product Specification Management

Considering the crucial role of product specifications in NPD success, it is imperative to tackle the problems identified in the previous section. This interview study also identified the good practices of product specification management, which could help solve or prevent the specification problems. The following are the 13 practices which were either interviewee companies' current practices or interviewees' suggestions proposed on the basis of their experience:

1. *At the start of projects, representatives from all relevant departments of collaborating parties participate in a meeting to ensure the same interpretation of specifications.*
   This practice aims to examine specifications at early stages and to ensure the same interpretation of specifications.
2. *All relevant departments examine specifications at early stages, and proactively express any problems or concerns about the realization of the specifications in the production stage.*

By critical reviewing product specifications by all relevant departments and staff, problems can be discovered and solved at early stages.

3. *At the early stage of product development, discuss with clients for the adoption of standard parts/components.*
   Opportunities for adopting standard parts/ components need to be explored at the beginning of projects.
4. *Develop a database of standard parts/components.*
   The establishment of the database enables the selection of standard parts/components in a speedy and convenient way, which provides an incentive for clients to develop standardization.
5. *At the early stage of product development, review specifications and look for opportunities to change the specifications for cost optimization.*
   Cost needs to be optimized at early stages, which can be achieved by proactively exploring the opportunities of specification modification.
6. *Conduct regular meetings with clients to communicate and discuss both parties' progress and project decisions.*
   Mutual understanding of each other's progress and project decisions is of great significance. NPD is full of uncertainties and deviation of project schedule and decision is common. The meeting could help discover problems and prevent conflicts over development activities.
7. *Inform each other, in a prompt manner, for any changes of product specifications.*
   When changes of product specifications are reported in a prompt manner, both parties and take appropriate measures to minimize the consequences of the changes.
8. *In addition to verbal communications, use more formal communications such as email.*
   Formal communication should always be advocated. Black and white approaches of communication minimize communication errors and also facilitate the recording of decisions.
9. *Employ translators to interpret and translate specifications when suppliers and clients use different languages.*
   This practice is indispensable to prevent or reduce misinterpretations of specifications when the native languages of collaborating parties are different.
10. *Use design decision support tools to uncover design problems at early stages so as to reduce specification changes at later stages.*
    Using decision support tools, product design can be systematically reviewed and design problems can be discovered early.
11. *Develop a database of product design records, which provides a reference for the specification development of future products.*
    Using the database, collaborating parties can compare new design with the past design for discovering problems and improving design parameters.
12. *Nurture a long-term collaborative relationship so that collaborating parties can respect*

each other when making important decisions.

An ongoing relationship between collaborating parties could be a foundation for the parties to respect each other's viewpoints and judgments.

13. *Establish a documentary system, which records the development of specifications, including the reasons for all specification changes.*

Recording the development process of product specifications allows collaborating parties to check the how development activities were conducted, which enables prompt solving of problems resulting from poor specifications.

5. Survey Results and Analysis

5.1 Product Specification Problems

The mail survey was conducted to further investigate the specification problems in electronics industry. Table 3 presents the occurrences of the problems. The means of the problems range from 2.68 to 3.44, in which the problems "*frequent changes of client requirements*" and "*specifications provided are too general*" have the highest means of 3.44 and 3.41 respectively, indicating that they are the most common problems in product specification management. On the other hand, the least common problems are "*clients do not listen enough to the opinion/views of suppliers*" and "clients *do not give reasons for changing specifications*", of which the means are both 2.68. The findings suggest that clients are quite respectful to their suppliers. In short, the means of all the problems are significant, indicating that the problems happen commonly in the industry.

Table 3. The ranking of the occurrences of the product specification management problems

Product specification management problems (Likert scale: 1=never happen, 5=happen very frequently)	Mean	S.D.
1. Frequent changes of client requirements	3.44	1.05
2. Specifications are too general	3.41	1.05
3. Frequent changes of external environments	3.14	1.11
4. Insufficient standardization	3.13	1.09
5. Insufficient cost optimization	3.01	1.09
6. Over specification	2.99	1.03
7. Specifications are not well discussed at early stages	2.99	1.01
8. Missing specification	2.94	1.10
9. Wrong specification	2.83	1.10
10. Misinterpretations of specifications	2.83	0.97
11. Clients do not listen enough to the opinion/views of suppliers	2.68	0.89
12. Clients do not give reasons for changing specifications.	2.68	0.99

5.2 Importance and Extent of Implementation of the Product Specification Management Practices

This section presents the importance as well as the extent of implementation of the specification management practices which are introduced in section 4.2 of the paper. Regarding the importance, it can be noted that from Table 4 that the mean values are significantly close, which range from 3.13 to 3.80. It is generally agreed that the practices could be useful in helping develop good product specifications. Among the 13 practices, "*in addition to verbal communications, use more formal communications such as email*" and "*at the early stage of product development, discuss with clients for the adoption of standard parts/components*" rank 1st and 2nd respectively. The last two ranks are "*use design decision support*

Table 4. Importance and extent of implementation of the practices

Product specification management practices	Importance (Likert scale: 1=not at all important, 5=very important)			Extent of implementation (Likert scale: 1=not implemented, 5=fully implemented)		
	Mean	S.D.	Rank	Mean	S.D.	Rank
1. At the start of projects, representatives from all relevant departments of collaborating parties participate in a meeting to ensure the same interpretation of specifications.	3.73	0.99	3	3.20	0.98	5
2. All relevant departments examine specifications at early stages, and proactively express any problems or concerns about the realization of the specifications in the production stage.	3.57	1.03	10	2.91	0.95	12
3. At the early stage of product development, discuss with clients for the adoption of standard parts/components.	3.79	0.85	2	3.28	0.91	3
4. Develop a database of standard parts/components	3.64	1.07	7	3.18	1.16	7
5. At the early stage of product development, review specifications and look for opportunities to change the specifications for cost optimization.	3.52	0.98	11	3.03	0.95	10
6. Conduct regular meetings with clients to communicate and discuss both parties' progress and project decisions.	3.72	0.94	4	3.07	1.09	9
7. Inform each other, in a prompt manner, for any changes of product specifications.	3.60	0.98	9	3.20	1.03	5
8. In addition to verbal communications, use more formal communications such as email.	3.80	0.92	1	3.49	1.06	1
9. Employ translators to interpret and translate specifications when suppliers and clients use different languages.	3.13	1.11	13	2.43	1.12	13
10. Use design decision support tools to uncover design problems at early stages so as to reduce specification changes at later stages.	3.26	1.00	12	2.98	1.06	11
11. Develop a database of product design records, which provides a reference for the specification development of future products.	3.62	1.05	8	2.28	1.02	4
12. Nurture a long-term collaborative relationship between so that collaborating parties can respect each other when making decision decisions.	3.67	0.84	6	3.17	1.04	8
13. Establish a documentary system, which records the development of specifications, including the reasons for all specification changes.	3.70	0.97	5	3.32	0.95	2

tools to uncover design problems at early stages so as to reduce specification changes at later stages" and "*employ translators to interpret and translate specifications when suppliers and clients use different languages*". It should be emphasized that, the two problems should not be neglected because their mean values are significant.

The results of the extent of implementation of the practices are also presented in Table 4. The first and second ranks of the practices are "*in addition to verbal communications, use more formal communications such as email*" and "*establish a documentary system, which records the development of specifications, including the reasons for all specification changes*" which have the highest mean values of 3.49 and 3.32 respectively. The results reveal that the practices of "*all relevant departments examine specifications at early stages, and proactively express any problems or concerns about the realization of the specifications in the production stage*" and "*employ translators to interpret and translate specifications when suppliers and clients use different languages*" are considered to be as important. They have the lowest mean values of 2.91 and 2.43 respectively.

Having presented the ranking of the importance as well as the degree of implementation of the practices, we further analyzed the differences between the importance and the extent of implementation. Figure 1 compares the mean of extent of the product specification management practices implementation and the importance. The figure illustrates that, for all the practices, the mean values of the importance are higher than those of the extent of implementation.

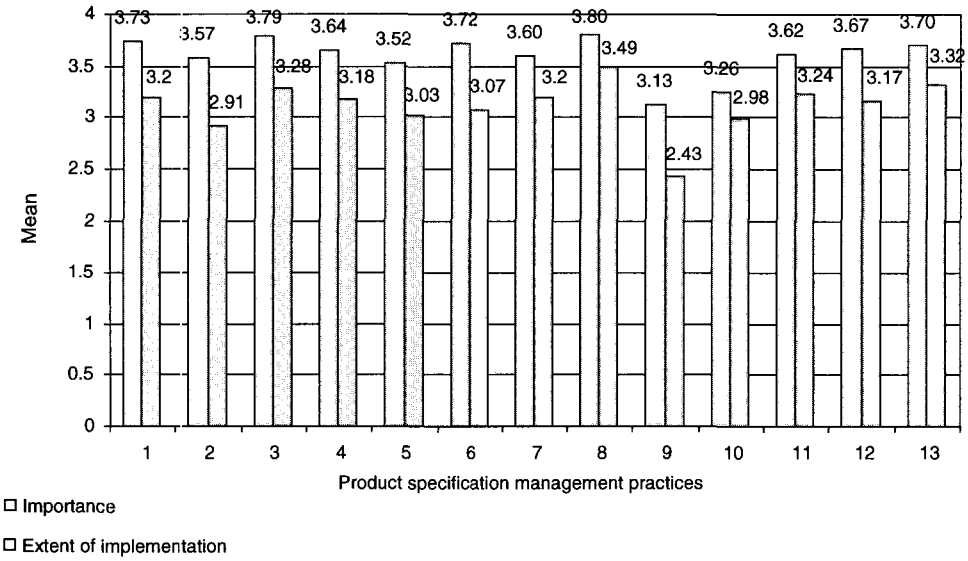

Figure 1. Comparison of the mean values of the importance and extent of implementation of the product specification management practices

Paired-samples t-test was subsequently conducted to statistically test the differences. The results shown in Table 5 indicate that the importance and degree of implementation for all the practices are significantly different. The findings may reveal that the extent of the implementation does not meet the desired level, which also imply that this is room for further implementation of the practices for better product specification management.

Table 5. Paired-samples t-test results about the differences between the importance and the extent of implementation of the practices

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	S.D.	Std. Error Mean	95% CI of the Difference				
					Lower	Upper			
Pair 1	U1 - I1*	.5446	1.13600	.11304	.3203	.7688	4.818	100	.000
Pair 2	U2 - I2	.6733	1.04028	.10351	.4679	.8786	6.504	100	.000
Pair 3	U3 - I3	.5248	1.00592	.10009	.3262	.7233	5.243	100	.000
Pair 4	U4 - I4	.4752	1.23769	.12315	.2309	.7196	3.859	100	.000
Pair 5	U5 - I5	.5050	1.21346	.12074	.2654	.7445	4.182	100	.000
Pair 6	U6 - I6	.6634	.87495	.08706	.4906	.8361	7.620	100	.000
Pair 7	U7 - I7	.4059	1.03129	.10262	.2024	.6095	3.956	100	.000
Pair 8	U8 - I8	.3168	.95844	.09537	.1276	.5060	3.322	100	.001
Pair 9	U9 - I9	.7030	1.18781	.11819	.4685	.9375	5.948	100	.000
Pair 10	U10 - I10	.2871	.89818	.08937	.1098	.4644	3.213	100	.002
Pair 11	U11 - I11	.3861	1.08600	.10806	.1717	.6005	3.573	100	.001
Pair 12	U12 - I12	.5149	1.02581	.10207	.3123	.7174	5.044	100	.000
Pair 13	U13 - I13	.3861	1.05802	.10528	.1773	.5950	3.668	100	.000

Note: *U=importance, I=extent of implementation

6. Discussion, Conclusion and Future Research

This research studies product specification management in client-supplier collaborative NPD by empirically investigating the product specification management problems and good practices in Hong Kong electronics industry. Based on the interviews with practitioners, we identified 12 specification management problems and the survey results indicate that the problems are common in the industry. The top problem is that clients always change their requirements. Clients tend to propose specification changes without concerning sufficiently about the impact of the changes on suppliers' operations. As product specifications guide the development of products, any changes will surely affect development activities, and re-design and re-work would be the common consequences. Another major problem is that the specifications provided by clients are always too general. In this situation, suppliers generally need to com-

municate intensively with clients for the details of the specifications, which may lengthen product development time and lead to more chances of specification misinterpretations. The 12 problems need to be addressed seriously for the success of NPD.

The paper also presents 13 good practices of product specification management. The importance and extent of implementation of the practices in electronics industry are analyzed. The results show that all the practices are important. High ranks practices include using more formal communications, discussion for the adoption of standard parts/components at early stages, and the participation of all relevant departments in a meeting to ensure the same interpretation of specifications. The study also investigates the extent to which the practices are implemented in the industry. It is shown that all the practices are, to a significant degree, implemented. We further compared the importance and degree of the implementation of the practices. The paired-sampled t-test results indicate that the mean values of the importance are all significantly higher than those of the degree of implementation. Based on the finding, it is argued that the practices are not sufficiently implemented. It suggests that the practices should be implemented more intensively for better product specification management.

In conclusion, this study contributes to the understanding of the product specification management in several ways. First, we empirically investigate the problems of product specification management. The findings help us understand the problems or difficulties that collaborating parties are facing. Second, good practices of product specification management identified could be a reference for practitioners to improve their product specification management. Third, the finding about the differences between the importance and degree of the implementation of the practices presents an important implication that the implementation should be enhanced as there is still room.

As emphasized previously, there has been inadequate research on product specification management. Further research should be conducted to broaden and deepen our understanding on product specifications management. On the basis on the current research, it is suggested that future research study the implementation of the specification management practices in the industry, of which the focus would be on investigating the implementation process, barriers as well as the approaches to overcome the barriers.

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