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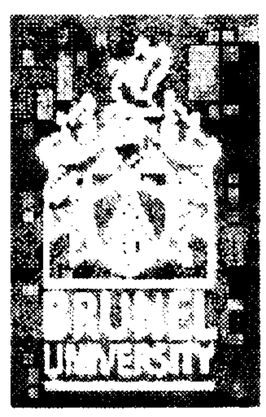
NEW CONCEPTUAL FRAMEWORK OF CROSS-FUNCTIONAL COLLABORATION FOR NEW PRODUCT DESIGN DEVELOPMENT IN GLOBAL CONSUMER ELECTRONICS FIRMS

A thesis submitted for the degree of Doctor of Philosophy



by

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_____ (Signed)

Bum-Kyu Kang

November 2001

NEW CONCEPTUAL FRAMEWORK OF CROSS-FUNCTIONAL COLLABORATION FOR NEW PRODUCT DESIGN DEVELOPMENT IN GLOBAL CONSUMER ELECTRONICS FIRMS

ABSTRACT

There have been very few studies carried out on enhancing CFC (Cross-Functional Collaboration) for the product design development, nevertheless, there is a clear consensus among researchers that this issue is a critical one in new product design development. Besides, almost all of the research work, which attempted to encourage CFC in NPD situations, was carried out focused on the cross-functional team which is the most effective organisation type to encourage collaboration between other functional groups, rather than the functional organisation, which is difficult organisation to facilitate collaboration between other functional groups.

On the other hand, there is still no clear evidence which proves that CFC improves the performance of design development. Nevertheless, this proof is essential premise to support the value of producing the information to improve CFC for product design development. This research attempts to fill in this gap in the deficiency of research.

This longitudinal research has been conducted with complementary research methods: a qualitative research and a quantitative research in the field. As the main body of this research, 15 key-decision makers for new product design development were interviewed, and 243 questionnaires from eight leading consumer electronics companies in three countries (Korea, Japan, UK) were analysed.

In conclusion, firstly, this research has proved there is a plus correlation between the level of CFC and several dimensions of the design development performance of consumer electronics products. Furthermore, a new framework model is developed and proposed after compressing and combining all vital findings of this research work. This developed model presents three major findings of this research. Firstly, the factors affecting CFC for design development of consumer electronics products, secondly, the priority of importance of these factors, and finally, factors directly contributing to design development performance in several dimensions.

Overall, the findings of this research help to people what are valuable factors for building CFC climate and what are prior factor in a quandary concerning where to concentrate their efforts so as to successfully implement their CFC to improve their design development performance. In particular, the findings of this research could further help designers and design managers who lack the experience and knowledge of collaboration situations in the rigid functional organisational boundaries, which many consumer electronics companies face

Keywords: cross-functional collaboration, performance of product design development, framework model, research methods, consumer electronics industry.

ACKNOWLEDGMENTS

I would like to express my sincere thanks to my parents, two elder sisters and my younger brother, Jung-Kyu who have supported me financially and personally. In particular, I would like to especially thank my dear wife, Key-Young, who has assisted me in countless ways over the last four years.

I would like to thank my first supervisor Mr. Ray Holland for his supervision, constructive criticism and encouragement from beginning to end. I also thank him for helping me to adapt to life in England. I would like to thank my second supervisors, Mr. Jim Stewart, Prof. Neville Stanton, for their valuable comments on the study.

Sincere thanks are also due to my advisor Mr. Leslie Wynn, a senior design manager at Xerox, for his valuable advice on many aspects of the research and continuous help, particularly in introducing me to some wonderful people who were the interviewees for the field survey of this research. In addition, I would like to thank all the interviewees, especially, Mr. B.Y. Song, a senior design manager at Samsung, Mr. Taisuke Kashima, a chief design manager at Hitachi and Mr. Nobuhiro Fushiya, a senior design manager at Toshiba, all of them contributed directly to this research.

I am also grateful to Ms. Lynne Sanders for her help and advice in financial issues. My thanks also go to Ms. Maria Bragoli for help in the proof reading of this research, and Dr. N.Y. Kim for her help in the statistical analysis.

My special thanks go to my friends all for all the help they have given me during my research years in England. In particular, I would like to thank Matt Farrell for helping me with my English and for being good friend.

Finally, I would like to thank Dr. C.Y. Ye, Jung-Wok, Sung-Won, Jea-Mung, Jin-Ho, and three kind ladies, Ms. Patricia Eldrige, Ms. Wendy Dean and Ms. Pamela wells, in Design Department at Brunel University.

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Chapter 1: Introduction

Chapter1: Introduction

1.1 Introduction

This chapter presents the framework for this research. The next section (section 1.2) provides a brief overview of the motivations, behind this research, through both an identification of the lack of research related to CFC (Cross-Functional Collaboration) in the design sector and an introduction of a necessary of CFC for the new product design development. Section 1.3 states the aims & objectives of this research. Section 1.4 gives an overview of the research methodology and introduces research aims in each research stage briefly. Section 1.5 introduces a dictionary definition of the term collaboration and discusses the evolving definition of collaboration related to interaction. The last section of this chapter describes the research scope of this research. Also, the characteristics of the global consumer electronics industry, which is one of areas of this research, are dealt with in detail in this section.

1.2 Motivation

1.2.1 Lack of research related to CFC (Cross-Functional Collaboration)

Product life cycles for most products, especially consumer electronics products, are becoming increasingly shorter. Customers are becoming more diverse in their demands, putting more pressure on product firms to respond to these demands (Talluri, et al. 1999). Advanced technologies are accelerating new product development but market uncertainty is increasing.

In this context, consumer electronics companies are focusing on a variety of strategies in order to survive, for example, cost control, improvements in the product quality and user-friendliness of existing products, penetration of rapidly growing new markets and *the launching of new innovation products* (European Commission Report 1997). The development of a new product, particularly an innovation product, is vital to keep a company in the competitive marketplace.

Design development is at the centre of new product development, innovation and a process providing the bridge between idea, customer needs and manufacture as Walsh V., Roy R., Bruce M., Potter S. (1992) pointed out. But, interestingly despite the importance of design development,
"design groups have received comparatively little attention compared with other functional groups in the new product development" (Olson, 1993).

Olson further pointed out (1993),
"Very little research in the literature has focused on design's relationship with other functional groups, particularly, in the human aspect".

Such as Olson's assert, there have been few studies carried out related to the issue of human resources and a cross-functional collaboration, nevertheless, there is a clear

consensus that these issues are critical ones in new product design development. (Herbruck & Umbach, 1997; et al., Davies-Cooper & Jones 1996 et al; Gorb & Dumas, 1987; etc. refer to Exhibit 2).

For example, Herbruck and Umback (1997) stated that

"*Product designers, and particularly design managers, are positioned to play a key*

they need and which will enable them to make more choices during development of a new product design.

As Walsh V., Roy R., Bruce M., Potter S. (1992) pointed out, a product design process can be said to be 'compromises' and 'choices' process with other functional specialists who have got rich and up to date information in their domain. A product designer might be able to gather information, which is from other specialist areas, such as mechanical techniques, prices of parts of a product that will be developed, the market place and target markets, through gathering the information himself/herself directly. But it is difficult, because of the limitation of time and the budget for an actual product design

1.2 Aims & Objectives

Jassawall & Sashittal (1998) asserted.

"CFC (Cross-Functional Collaboration) involves synergy, namely the NPD (New Product Development) outcomes exceed the sum of the capabilities of the individual participants in the NPD process."

Thus, there is clear consensus in the literature that a high level of cross-functional collaboration improves new product development performance (see Exhibit 1)

Exhibit 1. Literature indicating that a high level of cross-functional collaboration improves NPD performance

Slade (1989), Littler D., Leverick F. and Bruce M. (1995), Jassawalla & Sashittal (1998, 2000,), Dawson P. (1996), Kahn K. B. (1996), Leonard D., Straus S. (1997), Herbruck D. & Umback S. (1997), Soulder (1977, 1987) Littler D., Tjosvold (1988) Leverick F. and Bruce M. (1995), Kahn K. B. (1996), Song X. M., Montoya-Weiss M. M., Schmidt B. J. (1997), etc.

It is also interpreted and widely acknowledged that a high level of CFC in a team's organisational structure is very important for the product design development (see Exhibit 2).

Exhibit 2. Literature indicating that a high level of cross-functional collaboration improves NPDD performance

Beckwith D. & Harris D. (1993), Faust W. (1993), Olson E. M. (1993, 1994), Walker D. (1993), Donnellon A & Margolis J (1994), Beckwith D. (1994), Rachel Ellis S. R. (1994), Sonnenwald D. H.(1996) Mukhopadhyay S. K. and Gupta A. V. (1998), Gorb P. and Dumas A. (1987), Bebb H. B. (1992), etc.

Interestingly, the research works, which were related to the issue of cross-functional collaboration, were only focused on multi functional teams, for example, the multidisciplinary project team by Deanne Beckwith (1994), the megateams by Deanne Beckwith & David Harris (1993), the interdisciplinary teams by Anne Donnellon &

Josbua Margolis (1994), the cross-functional team in design by Wiliam Faust (1993.), the concurrent engineering design team's by H. Barry (1992).

Such as, hitherto many well-developed approaches to cross-functional design work have focused on teams. Nevertheless, interestingly, these kinds of cross-functional teams are rarely used in a real context in the CEI (Consumer Electronics Industry). Moreover, previous research has dealt with the subject at a theoretical level and very little practical research has been applied to the CEI. According to the findings of this research survey, over 76% of new design development projects were conducted under the functional organisation in CEI (It is dealt in detail in Chapter 5).

Besides, there is still no clear evidence neither theoretically nor empirically that CFC really improves a design development performance. Nevertheless, this proof is necessary premise to support the value of producing information for CFC in product design development. In fact, there is still debate over whether a high level of collaboration among functional groups leads to successful product design development or not. Some designers are do not convinced that a high level of collaboration among functional groups during the design development process improves performance and design output. Because collaboration with other functional groups might interrupt creative design processes and design output, as a design manger at Xerox Limited pointed out (2000).

In line with this thinking, this research aims to prove that there is a positive correlation between the level of CFC and the performance of product design development. Moreover, this research attempts to produce pragmatic information by means of model assessing what factors affect CFC (Cross-Functional Collaboration), and evaluate which factors are more important and directly contribute to the performance of NPDD (new product design development).

Namely, this empirical research has two main aims as follows.

1. To define the correlation between the level of CFC (Cross-Functional Collaboration) and the performance of design development of a consumer electronics product.
2. To develop a conceptual framework of CFC for new product design development in global consumer electronics firms.

In addition, the two main aims of this research are sub-divided as follows:

The first aim is divided into five categories:

1-1 To define the correlation between the level of CFC and the *total performance* of design development.

1-2 To define the correlation between the level of CFC and the *time performance* of design development.

1-3 To define the correlation between the level of CFC and the *cost performance* of design development.

1-4 To define the correlation between the level of CFC and the *design quality performance* of design output.

1-5 To define the correlation between the level of CFC and the effectiveness and efficiency of design management.

The second aim is divided into four objectives.

2-1 To define factors affecting CFC for the new design development of consumer electronics products.

2-2 To define the priority of importance of the factors affecting CFC for the new design development of consumer electronics products

2-3 To define contributory factors affecting total design development performance

2-4 To define contributory factors affecting each sub-performance item which consists the total design development performance (These are the time, the cost, the design quality, the effectiveness and efficiency of design management).

Moreover, this empirical research has an additional objectives, which are to develop the measurement items in order to assess both the CFC level among the functional

departments during product design development and the performance of product design development.

1.3 Framework of research methodology

This section presents an outline of this research methodology and the aims of each research stage. The research methodology is dealt with in more detail in chapter 3. Figure 1 gives an overview of the research methodology in sequence.

Figure 1 Framework of research methodology

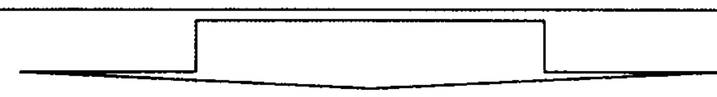
1. Literature search.

- Aims

1) To gain an understanding of previous research and produce a context of the research area
2) To assess the significance of cross-functional collaboration in the product design process
3) To discover the issues related to the cross-functional collaboration
4) To discover measurement items of performance for NPDD (New Product Design Development).
5) To select appropriate research methods and techniques
6) To define the research scope, and examine characteristics of the GCEI (Global Consumer Electronics Industry)

- Methods

In order to achieve the above research aims effectively, literature in this research sector was broadly searched by means of electronic databases, particularly, six database (information) service instruments. These are the BLII (British Library Inside Information), the BIDS (Bath Information and Data Service) including Ingenta Journals, the Infotrac, the ABI/Inform Global (from ProQuest), the Emerald and an the Index to theses.



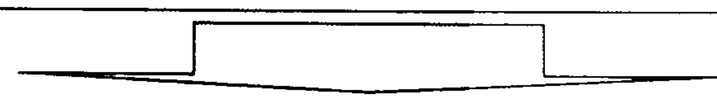
2. Pilot interviews.

- Aims

1) To get general ideas about this research work and research direction to ascertain whether this research has value and to forecast difficulties.
2) To outline characteristics of the GCEI (Global Consumer Electronics Industry)

- Method

Semi-structured interviews were conducted with four current design managers in this research industry sctor. These were Samsung, LG, Daewoo, and Xerox Limited.



3. In-depth Interview survey.

- Aims

1) To discover and identify the issues (contributory factors and obstacles) for CFC in the design development of consumer electronics products.
2) To discover pragmatic performance measurement items (scales) for the design development of consumer electronics products
3) To discover the characteristics of the consumer electronics industry sector, which is the scope of this research.

- Methods

a) In-depth interviews were conducted with design mangers and the other functional group managers in the consumer electronics companies (Samsung, LG, Daewoo, Hitachi, Toshiba, Fuji Xerox and Xerox Limited: total 15 senior managers)
b) A mock-up interview was undertaken with one of the field senior design managers before starting the real interview surveys.
c) Grounded theory was undertaken in this stage.
d) Structured interviews with the open-ended technique were used.
e) Content analysis was also conducted for confirmation of the findings

4. Synthesis and Analysis of the findings from both the literature survey and the interview survey.

- Aims

1) To discover conceptual definitions of contributory factors affecting CFC (Cross-Functional Collaboration)
2) To discover measurement items to measure the design development performance of consumer electronics products

- Methods

a) A focus group was formed which consisted of experts, who are specialists in the industrial design and/or design management sector, 'the affinity diagram technique' was used in order to classify and then group all findings, that are contributory factors upon CFC
b) Contributory factors affecting CFC were found as items to measure the CFC levels among the functional departments during product design development

5. *Questionnaire survey*

- Aims

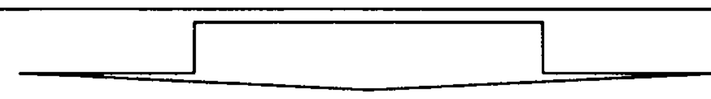
1) To define the priority of importance of factors affecting CFC for new design development of a consumer electronics product.

2) To define the correlation between the level of CFC and the design development performance of consumer electronics products.
   - 2-1) To define the correlation between the level of CFC and the total performance of product design development
   - 2-2) To define substantial factors affecting total design development performance
   - 2-3) To define the correlation between CFC and each sub-performance item (*time, cost, quality, effectiveness and efficiency of design management*) of product design development.
   - 2-4) To define substantial factors affecting the above performance items of design development

- Methods

Two versions' questionnaires were designed based on the above findings: one is for a designer, the other one is for non-designers, who are strongly involved in a design development activity.

a. The questionnaire was designed based on proposed measurement items, and then they were pre-tested with both groups experts which include academic specialists in the design management and current design managers who work for consumer electronics firms.
b. The '*Osgood scales*' was used in the questionnaires



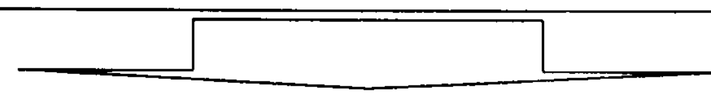
6. *Development of new framework model of CFC*

- Aims

To develop a new framework model of CFC after an analysis of the findings from the questionnaire survey

- Method

a) A SPSS (Statistical Package for Social Science) was used.



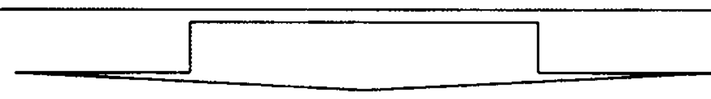
7. An evaluation of the usability of the new framework model of CFC

- Aims

To evaluate the usability of the developed framework model's information on CFC in practice.

- Methods

a) A structured interview with the open-end technique was adopted as a qualitative evaluation technique with current chief/senior design managers from leading consumer electronics companies.



8. Conclusion

All the research findings were reviewed and summarised.
Finally, the new framework affecting CFC is proposed.

Also, future research work, which is based on the research results, is recommended.

1.4 A definition of collaboration

1.4.1. The evolving definition of collaboration

The Cambridge Dictionary (Cambridge Organisation, 2000) defines collaboration as *"to work together with someone else for a special purpose"*.

The Oxford Dictionary (Oxford University Press, 1995) describes collaboration as meaning

"to work together with somebody, especially to create or produce something".

Also, the Encyclopedia Britannica (Britannica.com - see Exhibit 3) refers to the term as *"to work jointly with others or together especially in an intellectual endeavour"*.

Exhibit 3. Britannica.com (2000)

Britannica.com includes the complete, updated *Encyclopedia Britannica*, the oldest and largest general reference in the English language. Selected articles from more than 70 of the world's top magazines--including *Newsweek*, *Discover*; and *The Economist*--provide additional feature and current-events coverage. Britannica.com offers free knowledge and a learning centre for people who seek engaging contexts for today's affairs. Only Britannica.com lets users simultaneously search the world's most respected encyclopedia, expert reviews of the Web's best sites, timely articles from leading magazines, and related books. Special interactive features extend these resources to create a distinctive, authoritative Internet destination.

More definitions of collaboration are found in previous literature in the business management sector. For example, Appley and Winder (1977), who agree with the thinking of McGregor (1960) and Sarason (1972)' collaboration, state that *"collaboration is a value system upon which new solutions to pressing environmental problems, with particular focus on the world of work"*.

Appley and Winder (1977) also defined collaboration as a relation system in which:

1) *individuals in a group share mutual aspirations and a common conceptual framework;*
2) *interaction among individuals is characterized by 'justice as fairness'; and*

3) *these aspirations and conceptualizations are characterized by each individual's consciousness of his her motives toward the other; by caring or concern for the other*

On the other hand, there are numerous terms and phrases that have been used analogously with the word 'collaboration' in much of the NPD (New Product Development) literature, such as 'cooperation', 'inter-functional integration' and 'interaction'. For instance, Jassawalla & Sashittal (1998) stated that 'integration' is used as an umbrella term to describe a variety of types of cross-functional collaboration, and these terms are often used interchangeably with each other in NPD literature.

Kahn (1996), who borrowed the ideas from Appley et al. (1977) and Schrage (1990), makes an important contribution to this line of thinking by defining inter-departmental integration as an umbrella term that subsumes interaction and collaboration. In relation to interaction the author refers to formal, transactional communication links, and referring to collaboration he means informal, cooperative relationships that build a shared vision and mutual understanding among participants in the NPD process. Kahn (1996) further explains collaboration as follows;

"Collaboration represents the unstructured, affective nature of interdepartmental relationships. Collaboration is defined as an affecting, volitional, mutual/shared process where two or more departments work together, have mutual understanding, have a common vision, share activities are intangible, not easily regulated, difficult to sustain without joint efforts, and represent a higher level of interrelationship."

1.4.2 Philosophies underlying collaboration in comparison interaction

According to the previous literature, collaboration and interaction are distinguished as two distinct processes, because each process represents unique attributes of integration as well as having unique implications for product development performance.

Kenneth B. Kahn (1996), who used the idea from Sheth and Parvatiyar (1993), explained the differentiation between collaboration and interaction philosophy.

The collaboration philosophy for interdepartmental relationships in comparison to the interaction philosophy is an unstructured and involved process. In the collaboration philosophy, continuous relationships between departments are also stressed, not just transactions between departments. There is an emphasis on the strategic alignment of departments through a shared vision, collective goals, and joint rewards, along with an emphasis on informal structure, to manage relationships (Kahn 1996, Song et al. 1997).

The interaction philosophy for interdepartmental relationships is a different philosophy to the collaboration philosophy. The interaction philosophy is believed to stem from transaction-based philosophy, which has predicated much of business theory and managerial practice. The interaction philosophy favours communications between departments, which encourages managers to hold more meetings and establish greater information flows between departments. Companies ascribing to this philosophy reflect elaborate meeting schedules and extensive information networks for the routing of standardized documentation. The underlying purpose of interaction activity is to facilitate transaction between departments (Kahn 1996). The interaction philosophy also considers contact between departments as temporary and lasting only as long as a certain meeting remains or information is exchanged; such contact is temporary incurs costs. Due to these associated costs, managers view meetings and information exchanges as negotiations, where each department tries to get the best deal at the

conclusion of the meeting of information exchange. Hence, departments in interaction companies carefully weight the resources during interdepartmental activities (Kahn 1996).

The result from Kahn's empirical research work (1996) based on the survey in the electronics industry suggested that both collaboration and interaction between departments influenced product development and product development management performance. In particular, this also emphasised that collaboration has a stronger effect than interaction on the performance of NPD.

Collaboration was highlighted by many other researchers as a good predictor of performance (refer to Table 8). For example, Soulder (1977, 1987) stated
"cases of severe disharmony between departments (low levels of collaboration) resulted in dramatic failures, whereas harmony between departments (high level of collaboration) resulted in significantly more successful projects".

Ruekert and Walker (1987) also directly pointed out that interaction did not relate to relationship effectiveness across all departments. They suggested that interaction might not have as strong an impact on performance as collaboration may have. Schrage (1990), who has the same ideas as Ruekert and Walker (1987), also insisted that
"collaboration might have a stronger impact on performance factors than interaction because the mutual sharing of information and resources will be more cost-effective and promote greater goodwill across departments".

To summarise, the characteristics of collaboration were well illustrated in contrast to the characteristics of interaction as interdepartmental relationships. Namely, collaboration is characterised by an informal structure relationship, an interdependent, cooperative and continuous relationships, by comparison interaction is characterised by a formal structure relationship, an independent, competitive and based on transactions relationships among other functional groups. Also, according to the previous literature

on the NPD sector. collaboration for interdepartmental relationships are described as having a strong and more positive effect on NPD performance and product development management performance than interaction for interdepartmental relationship in NPD.

1.5 Research scope

There are not only a lot of types of collaboration work but also product development processes, according to product items, product development purposes, company size, and who is over the owner of a product design development project (In-house design development or Out side house design development; namely design development by agents).

In order to produce more clear and pragmatic guideline information taking into consideration the above factors in the product design development process, this research has three concrete boundaries as this research scope. These are

1.The global consumer electronics industry

2.New product design development

3.In-house design development

1.5.1 Definition of the boundary of the global CEI (consumer electronics industry)

The identifications of the boundary of the consumer electronics industry and a list of its items were discovered from both the NACE code system (see Exhibit 4) stipulated by the Commission of European Community (1985) and the Standard Industrial Classification Manual produced by the NTIS (National Technical Information Service 1987).

Exhibit 4. The NACE coding system

This system classifies economic activity in terms of the nature of goods and services produced or by the nature of the production process employed. More detailed information on the NACE code is contained in the General Industry Classification of Economic Activities within the European Community, published by Eurostat (1985 reprint of the 1970 edition). Revisions of the NACE classification have been incorporated in Council Regulations (OJL297, 24th October 1990 and OJ 696/93, 15th March 1993).

In particular, the NACE (revision 1) 32.3, published in 1985 by the Commission of European Community more precisely identified the consumer electronics sector. The NACE describes the consumer electronics industry though a report named 'Panorama of EU Industry' as including:

> *"All the audio-visual products and their accessories intended for use in the home such as black-and-white and colour television sets, video recorders, video cameras and camcorders, compact disc players and audio equipment in general. The sector also includes other brown goods" such as terminals for cable television and decoders for pay-TV channels. Other products are aerials and dishes for satellite reception, car radios and radio guidance systems, mobile telephones, personal IT terminals and telecommunications terminals. Video games consoles are another large group included in consumer electronics.*
>
> *Thus, with the change from analogue to digital systems and the convergence of telecommunications, information technology and the technologies and applications of consumer electronics, the traditional definition of consumer electronics as "brown goods" is becoming increasingly inappropriate. In addition to video and audio equipment, we must add multimedia home computers and telephone terminals (radio-telephone). "*

But, there is some vagueness in descriptions of the consumer electronics industry boundary, because the boundaries of consumer electronic products are classified a little bit differently according to each classification organisation and/or according to electronics companies. For example, Euromonitor Plc (1997) includes in-car entertainment in the consumer products sector, but the standard industrial classification manual by the ONS (Office for National Statistics 1992, see Exhibit 5) does not include these items in the consumer products sector.

Exhibit 5. Office for National Statistics

The Office for National Statistics (ONS) is the Government Agency responsible for compiling, analysing and disseminating many of the United Kingdom's economic.

social and demographic statistics including retail price index, trade figures and labour market data as well as the periodic census of the population and health statistics. The head of the ONS is also Registrar-General for England and Wales and the agency carries out all statutory registration of births, marriages and deaths in England and Wales.

Each electronics firm has also interpreted the meaning and boundary of consumer product items differently with their own criterion. For example, many companies include multimedia projectors in the consumer electronics products department, but Hitachi, one of the largest companies in this industry, has incorporated this item into the information systems product sector, even though they have a consumer products sector (according to a survey organisations into each company's homepage in 2000, March).

Furthermore, collapsing and/or a vague boundary exist between some consumer electronics products and others such as industrial electronics products. For instance, some health care and information technology (e.g. computers, printers.) might have started in an industrial product sector, but now these items belong to both the industrial and the consumer electronics product sector.

For this reason, it is worth noting McCalman's definition of electronics products. McCalman (1988) prescribed,
"*the electronic industry begins with the silicon-based integrated circuit (IC) and defined that electronic products are outwards to their applications, with a multiplicity of equipment and components*".

In this research, consumer electronics product categories follow the prescription of CE products indicated by the European Community (NACE coding system) basically, because the European Community (NACE coding system) classifies consumer electronics products in detail, and it is the most widely adapted system. In addition, this research also takes the extended definition of the CEP (Consumer Electronics Products) boundary derived from McCalman's definition of the electronics industry; namely,

'consumer electronics products are electronics products for general consumer users' in order to encompass the new and the latest technology products such as. digital cameras. DVDs. multimedia PCs. and cellular phones. personal printers etc.

Another limitation of this research is that it focuses on the global consumer electronics industry, meaning middle and large sized companies which have their own design department. The reasons are that many of the major consumer electronics manufacturers are already global or near global in terms of their manufacturing operations. and many other companies in this sector are looking at the global market even if. at present they simply operate within their national local market (Euromonitor Plc report 1997). McCalman (1988) also indicated that

"the days of protection of the home market through favourable contracts seem to have disappeared, and in the stark reality of competition many national consumer electronics companies who are unable to operate on the world markets will fall".

Many consumer electronics firms, which previously started at a local base, have already produced and sold their products in the world marketplace and have competed with other global companies. Chilver (1985), Chairman of the Electronics Economic Development Committee, also asserted that one of the trends for success in the consumer electronics industry has been to adopt a more international market with improved recognition of the globalised scale of competition. Therefore, it is widely acknowledged that globalisation in the consumer electronics industry is one of the unavoidable mega trends to survive in the present highly competitive economic market.

1.5.2 Characteristics of the CEI (consumer electronic industry)

1.5.2.1 The CEI profile & description

The top ten companies in this industry according to EACEM (European Association of Consumer Electronics Manufactures, 1996) account for three-quarters of world production, six of them being Japanese, two European and two South Korean. The main companies at world level are Hitachi, Matsushita, Sony, Toshiba, Samsung, LG, Philips, Thomson, etc.

Japanese firms are the main producers of consumer electronics for the world market. The value of Japanese products in 1994 was ECU 130 billion, or 1.6 times that of the USA (ECU 81billion). In the audio-visual sector, Japanese suppliers control more than 99% of their national market and export more than 30% of their production plants, which account for half the local production in the USA and a quarter in Europe. According to some estimates, EU firms produce about 16% of all audio-visual products in the world, while their American counterparts produce 8% of them. South Korean firms account for about 10% of the total and export most of their production. (EACEM, 1996)

1.5.2.2 The CEI Market

In most of the consumer electronics markets, new technologies (e.g. multimedia) are replacing older technologies. The changing internal dynamics of the consumer electronics markets means that manufactures have to adopt a broad market approach in terms of product portfolios. Manufactures must offer a complete range of products. This has the following advantages (Euromoniter, 1997):

- It covers the whole customer base, thereby reducing the possibility of being locked into older technologies;
- It keeps manufactures at the forefront of new developments, without abandoning sales from users who are slow adopters of new technologies;

- It makes multimedia developments easier.

Overall, consumer demand in this industry can be divided into two large segments according to the EACEM (1996) as follows:

"Up-market users demand high quality products and service (e.g. high definition TV sets in 16 9 format, NICAM sound) while down-market users are looking for cheap and easily used products. It is also accepted that many of the functions on consumer goods (such as video camcorders) are not in fact used because of their complexity. User-friendliness, price and the quality of products are the main factors leading to success in the consumer electronics market, and suppliers are attempting to balance these elements in order to obtain the appropriate combination for the various market segments."

Also, the EACEM report divided the major consumer electronics sectors largely into three markets, namely Asia, North America and Europe, geographically.

1.5.2.3 Strategies of the CEI

Both published reports by the EACEM (European Association of Consumer Electronics Manufactures, 1996) and Euromonitor Plc (1997) dealt with strategies used by consumer electronics companies.

The main points within both reports about CE firms' strategies are as follows:
strategies of consumer electronics companies are focused on operational efficiency, cost control, global operations, software, multimedia development, alliances & co-operation and the launching of innovative products.

a) Operational efficiency

Global competition in the consumer electronics industry is intensifying, with both price and customer services becoming central competitive weapons. Competitive pricing requires the best service, leading edge technology and flexible systems, cost control, research and development will be central for future operations.

b) Low-cost manufacture

Low-cost manufacturing is resulting in automated mass production systems being introduced into new and exciting factories. There is a need for low-cost manufacturers to relocate their production bases to countries where production costs are low. This is resulting in global manufacturing operations, with particular growth areas being:

- emerging Asian countries, especially those like Malaysia and China, and countries like Mexico which are members of major free trade areas;
- in the developing world, there has been a shift of production to low wage, light restriction countries like the Republic of Ireland in the UK.

c) Global operations

Many consumer electronics companies are using global strategies. That is they are: contesting particular national markets which they see as offering the best potential for growth; and bringing their world-wide resources to bear on their operations in a given market or market sector.

Many of the major manufacturers are already global or near global in terms of their manufacturing operations, although even the largest operators like Matsushita recognises a need for further development towards truly global operations.

The global base of operations will become more important, reflecting the expanding geographical spread of major markets. For operators from established markets, global extension taps into the huge growth potential of the emerging nations. It also reduces the dependence on a single market or single region.

To deal with the size of the global economy, companies are:

- consolidating through mergers and acquisitions to reach the scale required to compete in the global arena:
- global rationalising operations and seeking world standards for efficiency and productivity;
- selling incompatible business and seeking global leadership in global segments and niches.

However, a global operation does not mean creating a single global market. Local differences always persist and trade barriers and cultural differences will result in distinct local markets. This means all companies will to some degree under- or over-invested in certain assets, mainly infrastructure and marketing.

They will be a need to spend more on both, especially when compared with the situation where a truly global marketplace exists. Moreover, there will remain a degree of inconsistency in a company's marketing strategy. Companies, as a result, must build these factors into their strategy, without losing sight of the overall objective of global operations.

d) From hardware to software

The cost of developing new technology such as Digital Video Discs is high. Despite leading edge technology and high profile hardware sales are often held back by a lack of suitable software and content. Wide screen, high definition television is being held back in the US and Europe by a lack of high definition television broadcasting by the terrestrial and satellite television companies, and the sale of new formats like DVD could also be held back by a lack of movies available within the format.

For this reason some manufacturers have sought to gain increasing control over software providers. Such horizontal integration is also being spurred by the multimedia revolution, given that there needs to be greater co-operation between hardware and software products now that a software product may incorporate computer, audio, visual and stills picture information.

e) Focus on multimedia development:

Multimedia and digital technologies are shaping the corporate strategies of the consumer electronics manufacturers. Multimedia equipment and systems treat test, sound and image information in the same way as digital information. The digital format permits integration of diverse kinds of data, a capability that most of the leading consumer electronics manufactures perceive as critical in the face of the growing dependence of society on information and communications.

Multimedia strategies involve radical corporate restructuring. As technologies merge so companies have to reorganise to take account of future market dynamics. Samsung is typical of many companies in this industry sector. Samsung Electronics will invest US $10 billion in multimedia projects in the next five years according to the report by Market Research International (1997). Much of the spending will go into the development of telecoms equipment, communications terminals and DVDs. The company sees 1996 as the start of efforts to become a multimedia market leader. To define multimedia strategies the company is integrating the audio and visual divisions and the PC and peripherals division into a multimedia supervisor department.

f) Alliances & co-operative ventures:

Alliances are a common feature of the electronics industry. Established alliances cover areas such as joint research, joint hardware and software development, co-operative manufacturing, OEM, joint marketing and sales channel relationships.

At present, a growing number of alliances have taken the relationship further. In the area of mapping out the future, strategic alliances are central. The objective of this alliance is to bring together the diverse infrastructures that currently exist and to nurture the development of open standards for digital entertainment applications. Strategic alliances are being formed in technology, in expertise and in the coverage of markets.

The power of these alliances allows manufactures to maximise the fit of their products, services or total solutions to meet the customer's requirements. Perhaps most important, working with strategic relationships accelerates time to market. Customers get solutions they need faster, with a cohesive approach to customer delivery and support.

1.5.2.4 The future of the CEI

The future of characteristics of consumer electronics could be delineated from the key issues, which were discussed by some of the world leading experts in this industry. The future characteristics of the CEI can be illustrated with three main keywords as follows:

The first predicted future characteristic of the CEI is that advanced technologies will accelerate development of new high-tech products, and they will also increase uncertainties within the market. Perry (2000), a senior editor of IEEE Spectrum, described trends in relation to consumer electronics products:

"Most 20th-century consumer electronics products have evolved predictably. A new technology proved feasible, a standard was set for it, and high products were rolled out and snapped up by the ever-eager early adopter. Then prices dropped and the products become a mass-market item. That may not be the case in the 21st century, products launched last year went from announcement to mass-market rollout in the blink of an eye."

The future of the consumer electronics sector depends greatly on the development of new technologies. As another example, Bill Gates (1995), chairman of Microsoft Corp., stated that future technology of software would change hardware. Which is explained further in his book 'The Road Ahead';

...that CD (Compact Discs) Player will be not needed in the future, because the music will be stored as bits of information on a server on the highway. "Buying" a song or album will really mean buying the right to access the appropriate bits. This means that hardware, that is products, will have disappeared or be changed a lot, because of the technology of software.

Secondly, one of the characteristics of future consumer electronics products is indicated by Sasaki who emphasised the importance of low-volume and high-variety production in the CEI. Sasaki (1988), who is Sharp Corp.'s senior corporate advisor, stated that

"Consumers will want products that allow them to express their own individuality-products tailored to their own tastes, design concepts and lifestyles. So, to respond, companies must implement low-volume high-variety production. In addition, flexible automation systems and computer-aided design and manufacturing are making true computer-integrated manufacturing a reality of sizes, shapes and functions."

In the same way, Slywotzky (2000), who is a vice president of Mercer Management Consulting, predicts that customers will be *'product makers'*, whilst " they are *'product takers'* in twentieth century. He (2000) said of the near future *"individual customers are allowed to design their own products by choosing from a menu of attributes, components, prices, and delivery options by on-line systems"*.

It seems that customers may gain control over the design of products. In order to respond to this environment, companies should implement low-volume and high-variety production.

Finally, the Internet is characterised as one of the most effective contributors in the future of the CEI. Paul Liao (2000) who is chief technology officer of Matsushita Electric Corp and president of Panasonic Technologies Inc., emphasised the impact of the Internet to consumer electronics firms in an interview with IEEE Spectrum Journal He responded to the question 'what advance in consumer electronics in the next 25 years will have the biggest impact?':

"The Internet is not consumer electronics, but within 10 years it will be integral to consumer electronics. There are two things driving this. The first is that the technology Internet is incredibly flexible. But more important than that, the Internet is open and largely unregulated, allowing the unfettered forces of innovation to drive the creation of new application, new services, and new products."

There is no doubt the Internet will not only influence and involved in life styles, but it will also change industry structures. The consumer electronic industry is not an exception.

In addition, the other characteristics of consumer electronics products in the future are driven towards digital products from analogue products as the Market Research International (1997) report pointed out.

Today, companies in the consumer electronics industry are preparing for stronger competitiveness through reengineering and new product development in order to survive in such as rapidly changing circumstances in future.

1.5.2 Definition of a new product and categorisation

This research includes 'new product design development' as another research scope in order to produce accurate information.

New product development, particularly new product design development is a more difficult and risky development situation when compared to just simple modified design development, because of the high level of uncertainty. Therefore, more consideration and collaboration is needed.

However, how can 'a new product' and 'newness' be defined? This is because there are many different types of new product. The most widely adapted definitions of new product categories were described by Booz, Allen and Hamilton (1982) and Cooper (1993).

Booz, Allen and Hamilton (1982) identified six categories of new product. Four are typified by varying forms of newness, in terms of their operational newness to the supplier and also in terms of the newness of the customer base to the supplier;

Four of the six categories are as follows; (the remaining two categories will be dealt with later)

- *New-to-the-world products:* New products that create an entirely new market
- *New-product line:* New products that allow a company to enter an established market for the first time
- *Additions to existing product lines:* New products that allow a company to enter established product lines
- *Improvements in revisions to existing products:* New products that provide improved performance or greater perceived value and replace existing products

Although some people refer to all of the above four types as 'new products', it is obvious that some are newer to the supplying company than others. It is for this reason that many analysts have divided product development simply into two areas, namely, 'old product development', representing products improvements, and 'new product

development', representing products that pose greater development challenges. This distinction was originally made by Kraushar (1985), and has subsequently been built on in many studies of product development. Table 1 shows the four types of product development suggested by Booz, Allen and Hamilton, subdivided according to the level of newness from a supplier, as well as the newness from a customer base to the that supplier.

Table 1. Main types of product development (Sources: Bruce M., Biemans W. G.1995; Booz, Allen and Hamilton, 1982)

		Newness of the customer base (from the viewpoint of the supplier)	
		Low	**High**
Operational newness (from the viewpoint of the supplier).	**High**	Radical product development: aimed at the existing customer base 'new-product line'.	New style product development: aimed at the new customer base 'new-to-the world product'.
	Low	Routine product development: aimed at the existing customer base 'improvement and revisions'.	Extended product development: aimed at a new customer base 'additions to existing lines'.

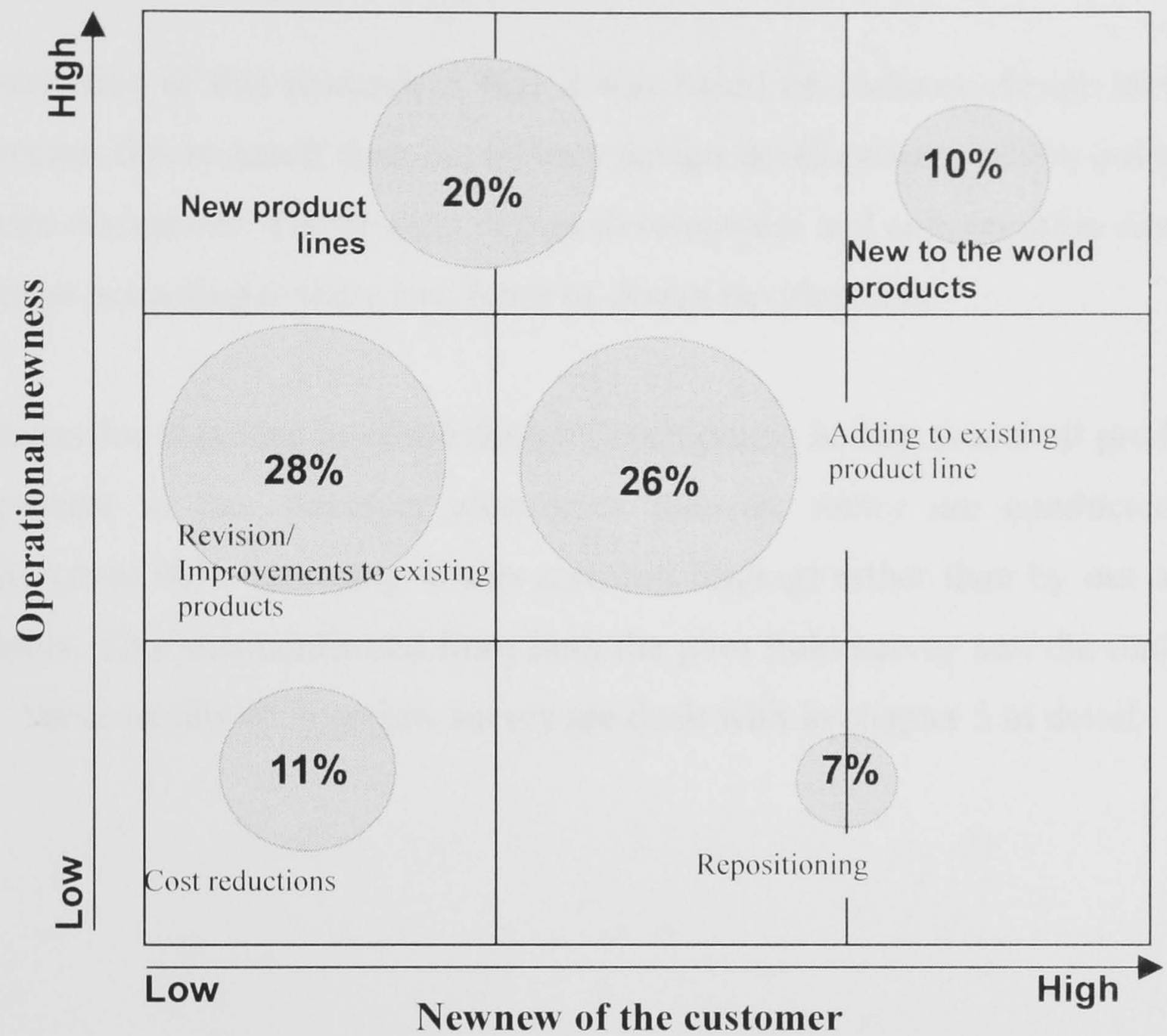
They suggest two other types of product developments. The two additions are:

- *Repositioning:* Existing products that are targeted to new markets or market segments.
- *Cost Reductions:* New products that provide similar performance at lower cost

Figure 2 shows the percentage of products appearing in each of the six categories.

Statistically, only 10 percent of all new products are truly innovative and new to the world. However, this figure is not small with as regard to other considerations. As Kotler (1991) and Baxter (1995) point out, these kinds of new products involve the greatest cost and risk because they are new to both the company and the market.

Figure 2. Type of new products (Source: Booz, Allen & Hamilton, 1982)



By contrast, Robert G. Cooper (1993) defined the term 'new product' simply from two distinct points of view. These are as follows;

- *New to the company:* in the sense that has never made or sold this type of product before, but other firms might have
- *New to the market or "innovative":* the product is the first of its kind on the market.

Most companies feature a mixed portfolio of new products

In order to prevent confusion from complex definitions of a new product, this research adopts the definition of a new product by Robert G. Cooper; namely, 'new product' means both the products to the company and new products to the market.

1.5.4 In-house Design Development

Final limitation of this research is that it was based on in-house design development, which means this research does not include design developments within out side design consultant companies. The product design development and collaboration situations can be different according to these two types of design development.

The reasons for choosing in-house design development is that almost all product design developments in the consumer electronics industry sector are conducted in-house company (over 90% according to this research finding) rather than by out side design consultants. This was confirmed from both the pilot field survey and the main research survey. These results of interview survey are dealt with in chapter 5 in detail.

Chapter 2: Background research: Driving forces for CFC in NPDD

Chapter2: Background research: Driving forces for CFC in NPDD

2.1 Introduction

This chapter presents driving forces behind CFC in the design development process from the several viewpoints as a background to this research. Section 2.2 and Section 2.3 describe the with a significance of NPD (New Product Development) and the importance of design activity within NPD. Section 2.4 discusses the nature of the product design process from a new angle to help to explain the necessity of collaboration in the design process. Section 2.5 deals with interconnection issues of information, design activity and roles between design group and the other functional groups. Five sub-sections are given in this section as follows: 2.5.1 information interaction in product design, 2.5.2 the multiple convergent approach, 2.5.3 the people oriented design process, 2.5.4 interface between design and other key functions, finally, 2.5.5 the role of the product designer.

2.2 Significance of New Product Development

"New products are the lifeblood of manufacturing" (Floyd, 1993).

"new product development is an activity vital to competition" (Hart, S., 1996)

Booz, Allen and Hamilton (1984) reported that new products account for 34% of all profits in the 1980's, an increase from 20% in the 1970's according to results of research work from a survey of 700 U.S. companies in 1981. Floyd, Levy and Wolfman (1993) insisted that new products represent as much as half of their sales. Even more importantly they stated that most companies' sales and profit growth would stem more from new products. Furthermore, rapidly changing technologies and fierce global competition quickly erode sales of existing products.

The success of economics has been characterised by healthy product development activity since the beginning of the industrial revolution. Healthy product development demands a constant stream of new products which meet consumer demands. However, it is also a risky business (Hart, S. 1996). Particularly, the uncertainties are highest at the start in NPD. It is not known what the product is going to look like, how it will be made, what it will cost or what customers will think of it as Baxter (1995) pointed out. The design development is one of the earliest stages in NPD faces lots of uncertainties.

On the other hand, every product also has a life cycle. Professor Charles Handy explores the theory of the 'Sigmoid curve' in The Empty Raincoat (1994). He points out that it sums up the life of people, political systems, and corporations as well as products. Products have birth, growth, blossom and fruit and products wither and die (see Figure 3). Charles Handy also emphasised that managers should start new product development before the first curve peaks (See Figure 4). From this basic reasoning, a new product is developed, and then dies.

Figure 3. The life-cycle of a product (Source: Rogers B., 1996)

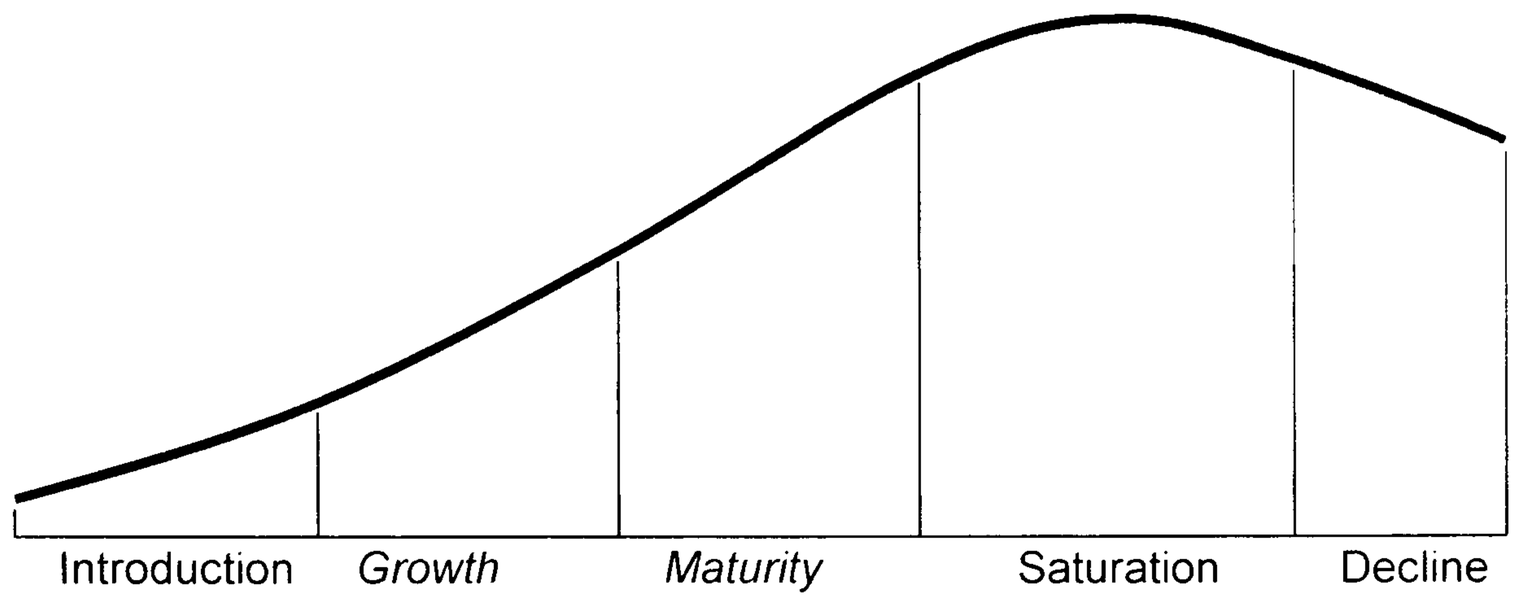
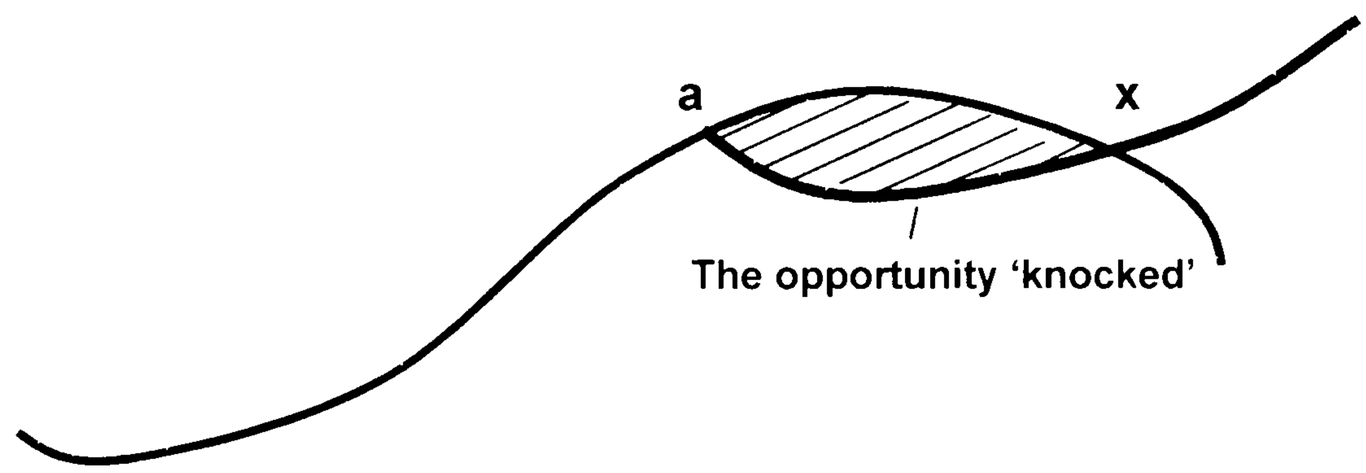


Figure 4. The Sigmoid curve (Source: Rogers B., 1996).



On the other hand, there are stronger reasons, why new products are continually developed as explained by Lee & Jung (1987) as follows;

Firstly, when a company takes 'product differentiation' as an important marketing strategy - almost all companies in the CEI (Consumer Electronic Industry) take this as the basis strategy of marketing. They have to develop new products continually in order to maintain 'product differentiation'. Moreover, they should show the next model more rapidly to their customers if their products are to be a success in the market place, since these products are likely to be modified by other competitors.

Secondly, companies, particularly consumer electronics and car companies, usually make a product using a planned obsolete strategy. The planned obsolete strategy means

that the company makes a product that has a short life cycle so that sale occurs frequently. There are three kinds of method, firstly, material planned obsolescence, secondly, style planned obsolescence and thirdly, functional planned obsolescence. To adopt this strategy in a company, a new product should be developed by continually planning.

Also, new technologies drive the development of new products. In the consumer electronics industry, many new products are developed using new technology rather than simply changing the appearance of an existing product.

A report by the KIDP (Korea Industry Design Promotion) (1999), which surveyed 673 CE (Consumer Electronics) firms out of the 89033 manufacturing in South Korea, indicated that 62.6% new products had been developed based on innovation both in design and technology over the previous 5 years. Table 2 shows these results.

Table 2. Types of new products in Korean consumer electronic firms. (Source: KIDP -1999)

Innovation both in design & technology	Design oriented innovation rather than technology	Technology oriented innovation rather than design
421 (62.6%)	178 (26.4%)	74 (11.0%)

In context, as Floyd (1993) states, every company must carry out a new product development (NPD) programme to maintain or build the company's sales. Also, the use of a truly effective new product development (NPD) process greatly enhances a company's potential for long-term success.

2.3 Significance of design within NPD (New Product Development)

Cooper R. & Press M. (1995) stated that NPD, particularly new product design development is essential for corporate survival. Walsh, Roy, Bruce and Potter (1992) also emphasised that

"design development is at the centre of new product development and innovation, and a process providing the bridge between ideas, customer needs and manufacture."

Bill Hollins (1990) also described the reason for increasing the importance of product design as follows;

"The customer now has plenty of choice for almost of every product within a price range, because there is overproduction in cars and many electronics goods. With this increased choice, consumers have become more aware of the good and bad features of product,.... As a result, they select the product that most closely fulfils their opinion of being the best value for money. This is not price but a wide range of non-price factors such as quality, reliability, aesthetics, delivery, after-sales service, ease of operation, performance, safety and status. Nearly all these price matters can be related to product design. Therefore good design matters, and good design needs effective managing."

On the other hand, Baxter (1995) described the importance of design from another viewpoint; that is risk management. He pointed out that the most important of all the stages in new product development is the initial stage, such as the design stage. Baxter (1995) outlined the reasons as follows;

"because, the cost of actually doing the development work so far has been small until design stages yet - research is that almost desk research and design work is relatively inexpensive drawing and modelling. So, as the below bar chart figure 5 shows, the cost benefit ratio for the early stages of development is much better than for later stages."

Figure 5. Investment: return ratios for different stages of product development (Source: Baxter, 1995)

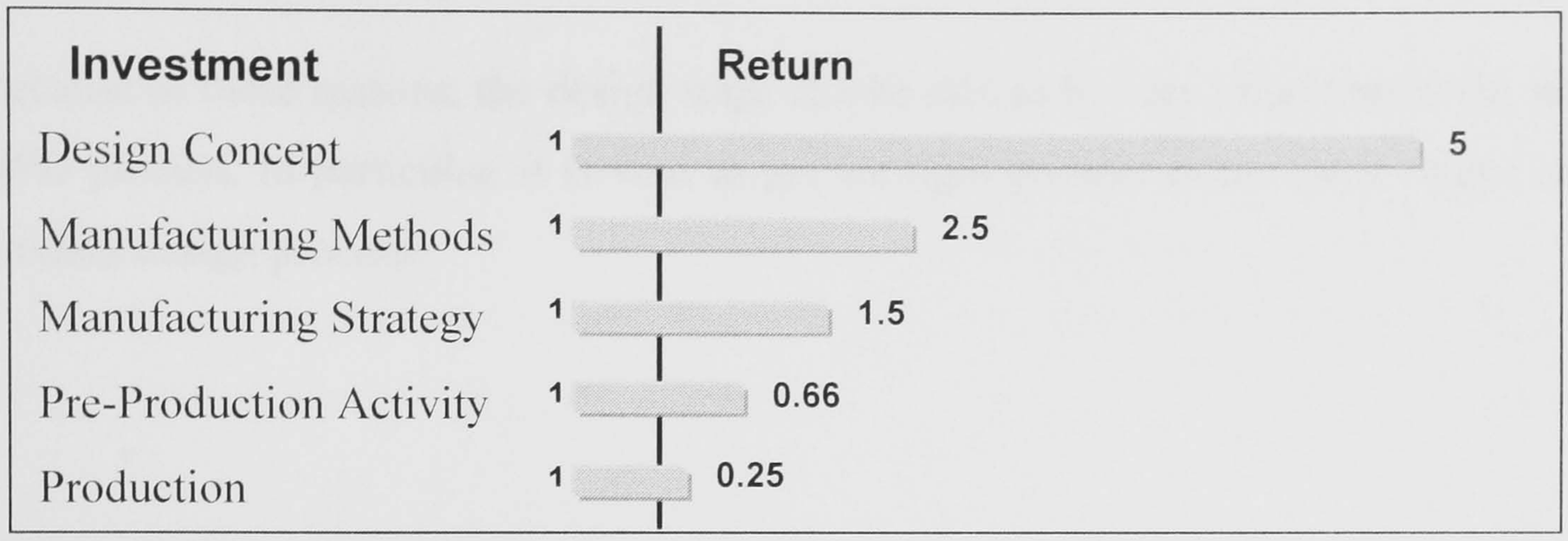
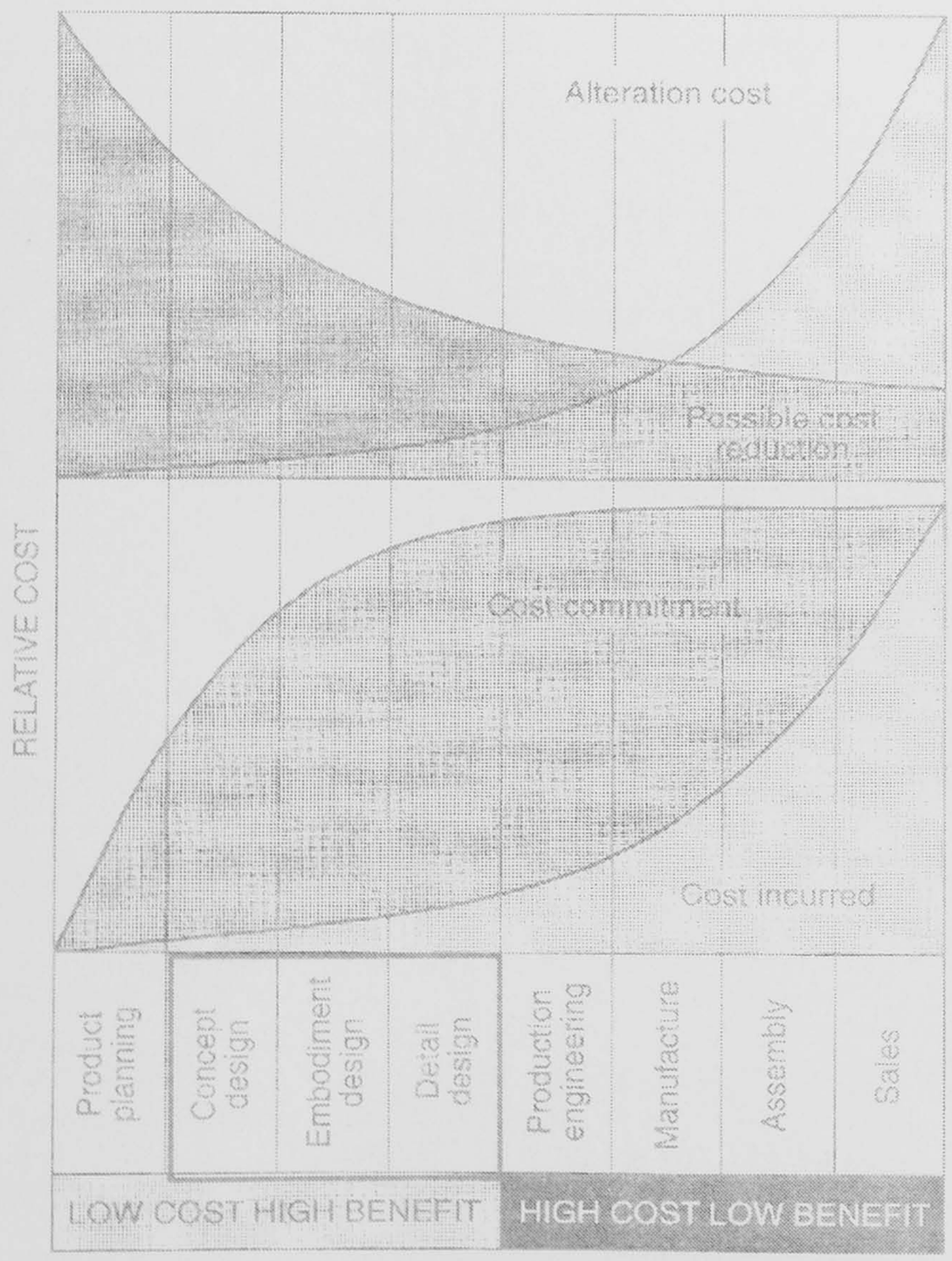


Figure 6. Costs and benefits of different design stages (Source: Baxter M. 1995 p. 28, and Cooper 1993)



On the other hand, by the time concept design is completed, the business opportunity will have been established, the technical targets will have been specified and the product's principle of operation will have been finished. Also, a great many decisions about the product have already been made and a considerable amount of the eventual cost of a new product has been committed. (Baxter M.1995)

Therefore, a key to the success of product development work is to invest time in the early stages. Figure 6 takes this point further and shows how the costs incurred during the development process are minimal

to begin with and start to become significant during the embodiment and detail of the design and rise steeply during production engineering.

Because of these reasons, the design stage can be said to be very important in the whole NPD process. In particular, it is vital to get the right product in the early stages of the product design process.

2.4 Understanding the nature of the product design process

The product design process (which is simply called the design process here) is very important in relation to the whole product development process, because it is the point at which nearly all critical matters are discussed and decided during the design stage (Baxter 1995). Also, the design process stage includes the full feature and function set of the proposed product with a close relationship with other functional groups, which are related to product development (Fox, 1993).

There are many design process types according to product items and/or companies circumstance such as company size, organisational structure, project characteristics, etc. It is, therefore, difficult to identify the product design process in detail, however, there have been many attempts to draw up maps or models of the product design process by several researchers. The common idea behind all these 'maps or models' of the design process is that it consists of a sequence of distinct and identifiable activities which occur in some predictable and identifiably logical order (Lawson, 1997).

Eok (1995) divided the design process into three generations from a historical viewpoint as follows;
'The systematic design process' by Alexander & Christopher Johns as a first generation, *'The participant design process'* by G. Broadbent as a second generation and *'Solution-focus of design process'* from the concept of 'conjecture and induction (Popper)' has been suggested by March as a third generation.

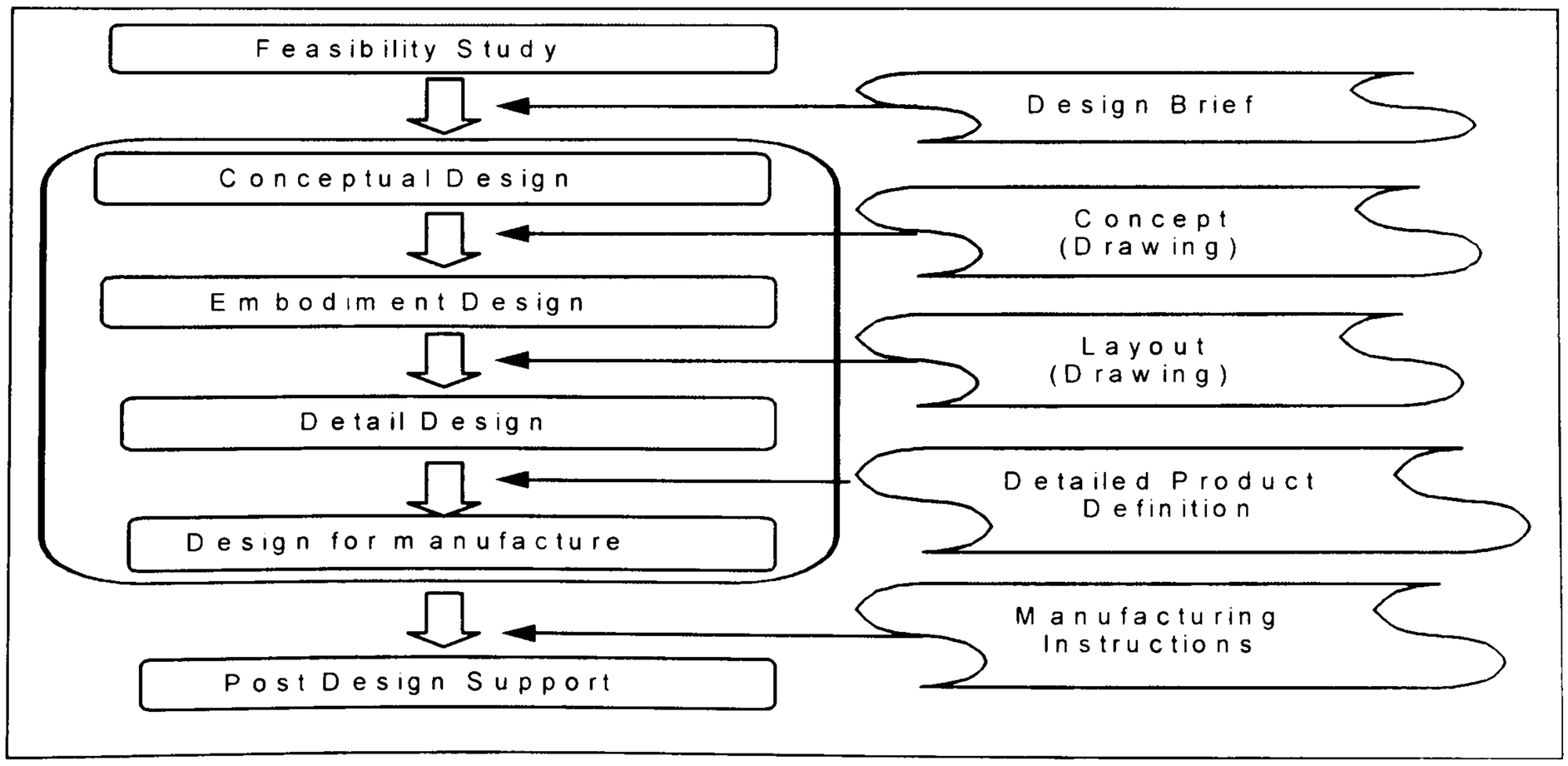
On other hand, Knut Holt (1990) expanded the design process into four categories from different angles. These are 'Design as a problem solving process', 'Design as a creative process', 'Design as a need fulfilling process' and finally 'Design as a human activity process'. Thus, Design process models are presented and explained from numerous viewpoints.

In this research, the design process is discussed in relation to a sequence, linear iterative process, circle iterative process and the negotiation process to explain why cross-functional collaboration in the design process should be dealt with rather than focus on the reliability & validity and/or historical development of design process models.

In this paper, the main ideas for the design process model focus are divided into three categories. The first is 'the feedback and iteration design process' in terms of both 'descriptive design process models' and 'prescriptive design process models' as explained by Nigel Cross (1994). The second is 'the cycle iterative design process' described by Allen Hickling (1982), and finally 'the negotiation design process' put forward by Bryan Lawson (1997).

Many product design process models simply *describe* the sequences of activities that typically occur in designing; other models attempt to *prescribe* a better or more appropriate pattern of activities (Cross 1994).
There are a number of descriptive design process models. For example, a typical and simple model in this category is the 'BS (British Standard) 7000-idealised design process model' produced by the Board of the BSI (British Standard Institution).

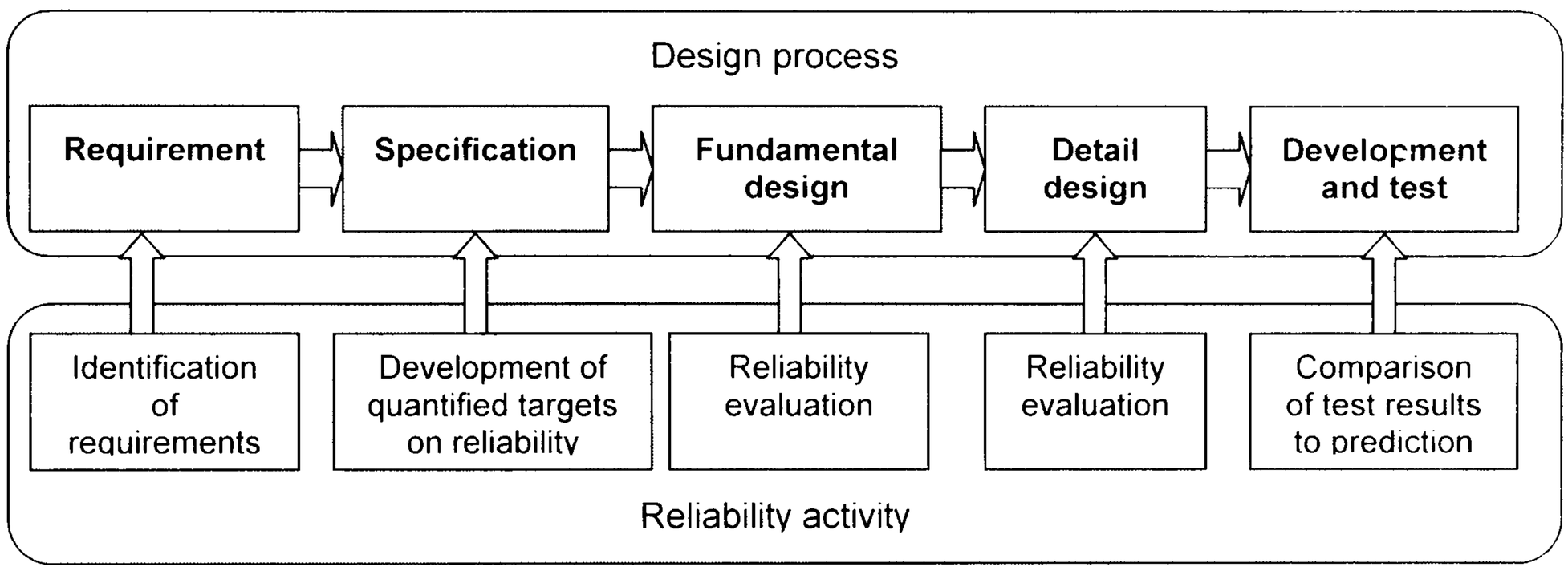
Figure 7. Idealised design process (Source: BS7000 Guide to managing product design 1989).
The BS (British Standard) 7000 model is a brief description of an idealised product



design process in general. This design process shows a typical model of sequential linear process from the design brief to the end point of the design process. It is well explained how each design stage should be guided.

In addition, there are many other design process models, which are extended concepts of this kind of descriptive process model, such as Ben Wang's 'design process model' (1997) and 'The High Design Process Description model' created by Deanne Beckwith (1994).

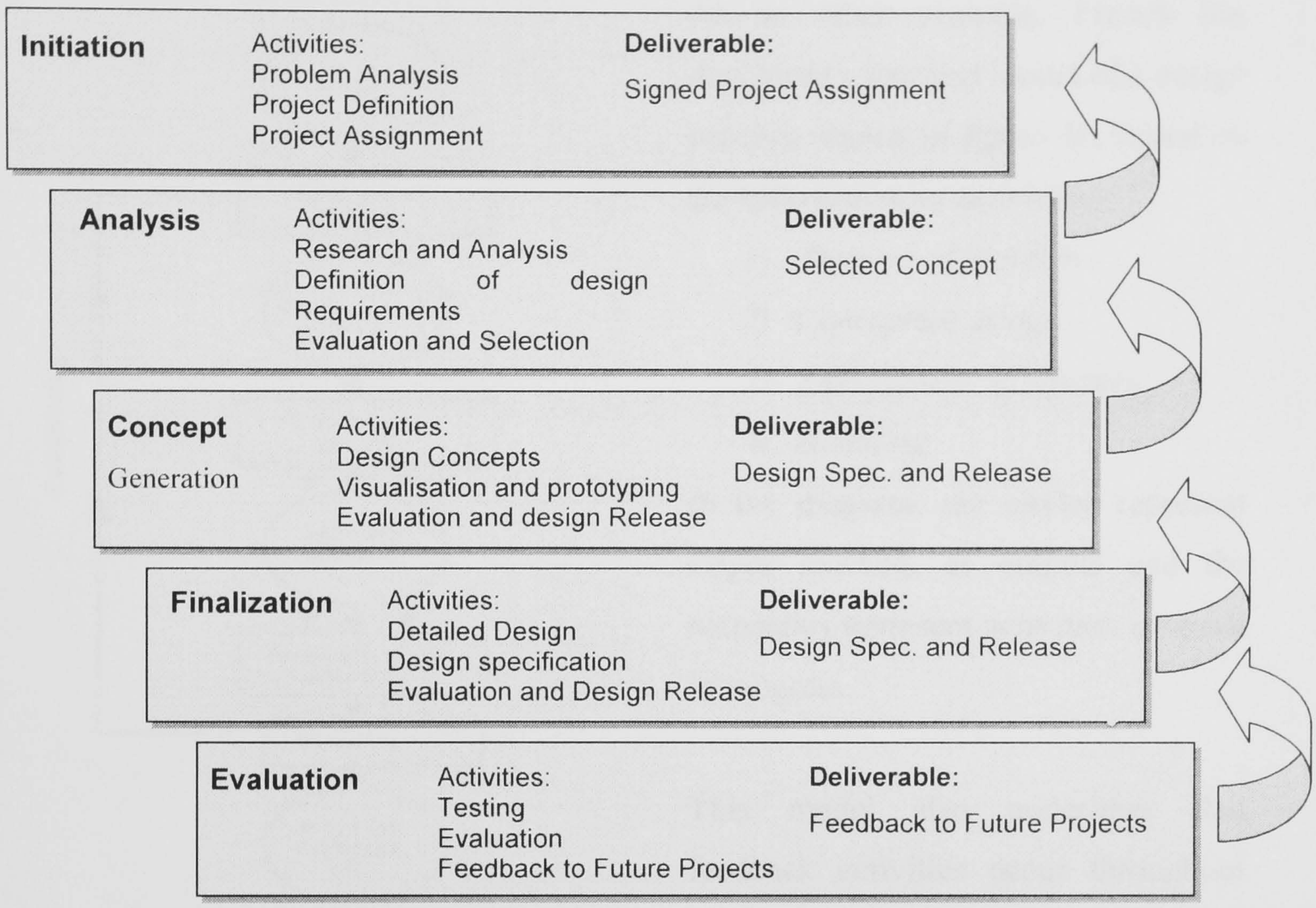
Figure 8. Design process and reliability activities (Source: Ben Wang (1997).



Both models illustrate a product design process in five activities and processes as Figure 8 and Figure 9 show. Beckwith D. (1994) particularly emphasises the initial design stage and the evaluation design stage in her model as follows;

"Initiation involves as many people as possible to make an inventory of skills likely to be needed, and to decide who will do what. An important exercise of the Evaluation stage is the review of both the customers' level of satisfaction and process, so that feedback continues to improve performance."

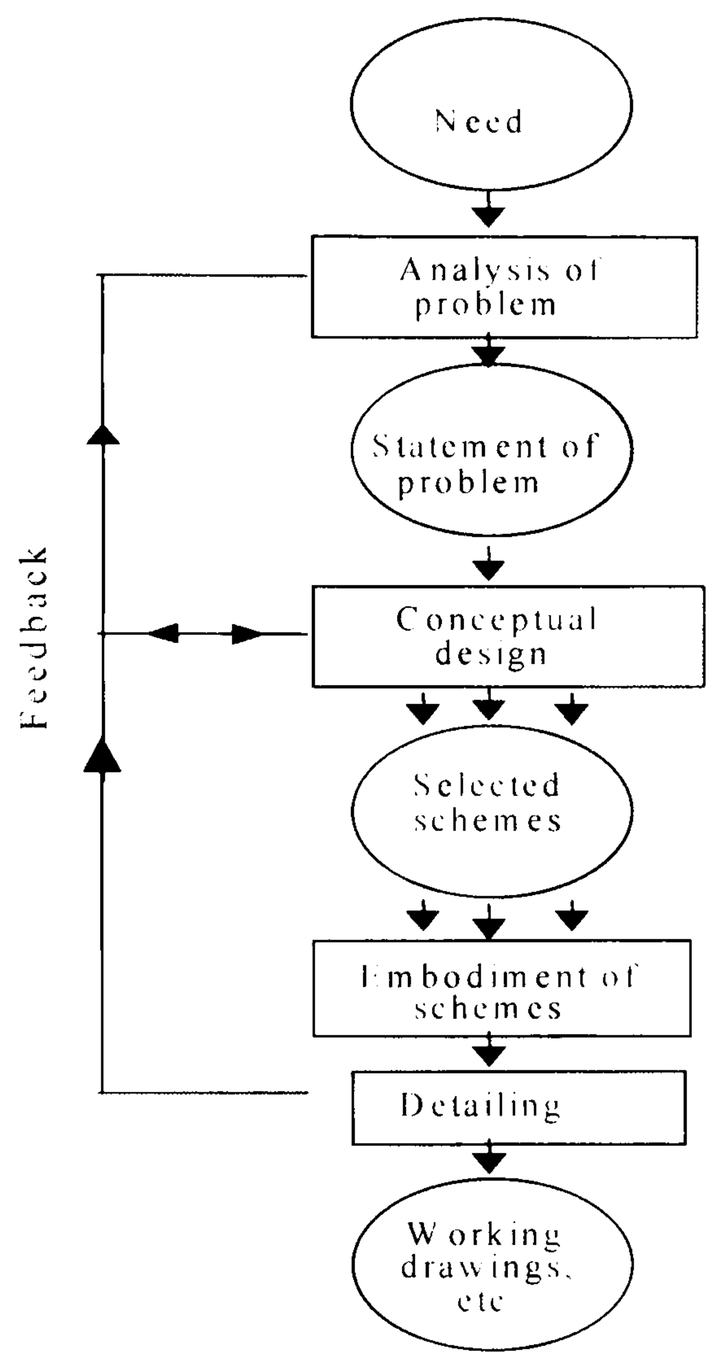
Figure 9. The high design process description. (Source: Beckwith D. 1994).



These sorts of descriptive design process models are often drawn in the flow-diagram form, with the development of the design proceeding from one stage to the next, but with feedback loops showing the iterative returns to earlier stages, which are frequently necessary. Descriptive models of the design process also usually emphasise the importance of generating solution concepts early in the process, thus emphasising a 'solution-focused' nature of design.

In fact, usually the design process can be considered as *a heuristic process*. One stage does not always lead directly onto the next design stage, so an iterative feedback loop is shown in many design process models.

Figure 10. French's model of the design process.



As an other example, French has developed a detailed model of a design process, shown in figure 10, based on the following four activities:

1) *Analysis of problem*
2) *Conceptual design*
3) *Embodiment of schemes*
4) *Detailing*

In the diagram, the circles represent stages reached, or outputs and the rectangles represent activities, or work in progress.

This model also underlines that feedback activities occur throughout all the design process (Cross N., 1994).

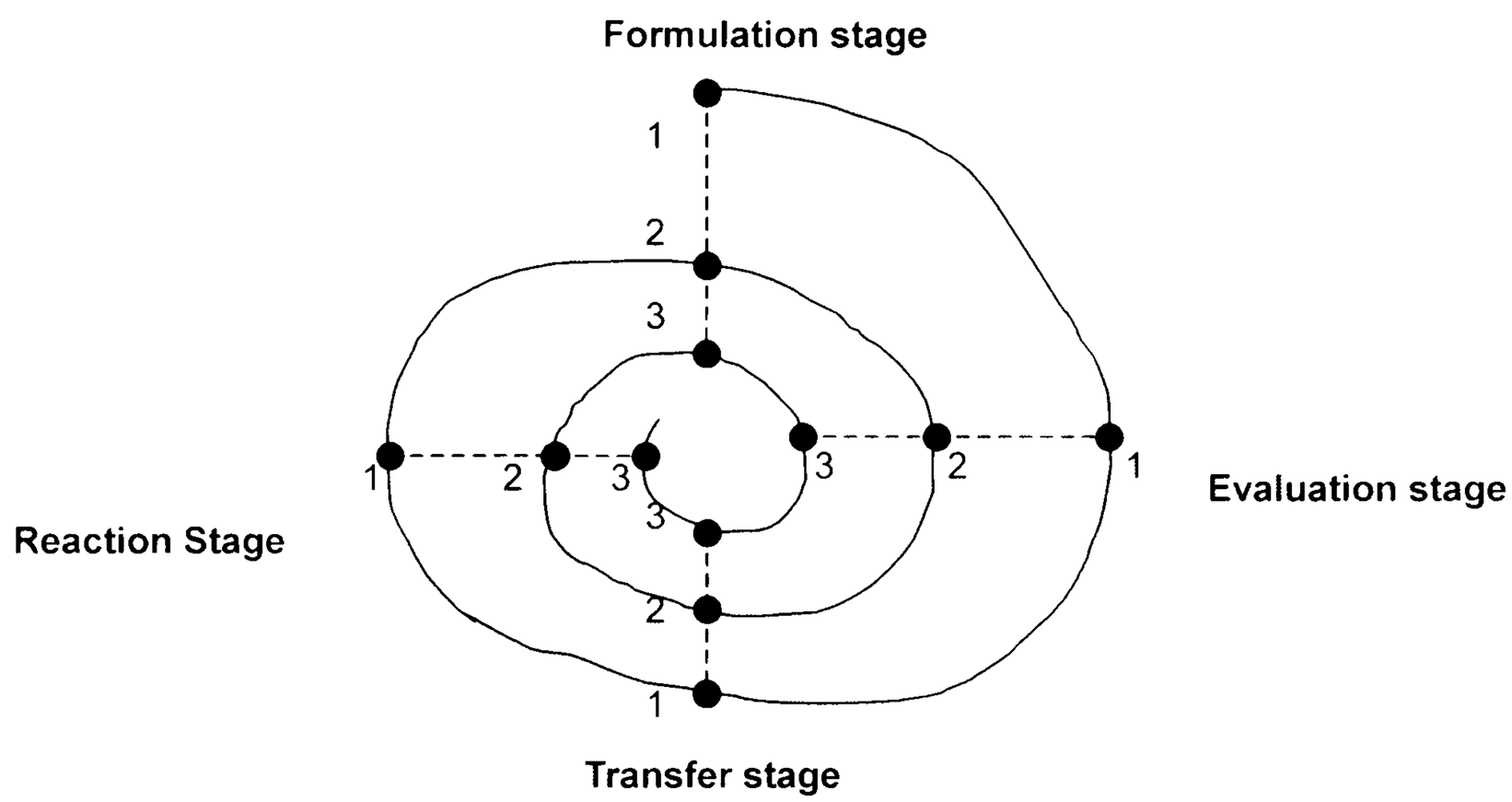
Mark Oakley (1984) explains the design process from a slightly different angle, but it can also be seen as a linear and sequence feedback process, which is drawn in the form of a converging spiral. This model emphasises that as each cycle is traversed, more knowledge should be gained as familiar ground is explored. Occasionally, major discontinuities will be encountered which could be envisaged as precipitating shifts to spirals of different dimensions.

In this model, the main components of the four activities are identified as follows:

Figure 11. A spiral model of the product design process (Source: Mark O.1984)

- ***Formulation***: Problem investigation
  Problem definition
  Product specification
  Design brief
- ***Evaluation***: Idea generation

Solution refinement
Prototype development
Design freeze
- ***Transfer***: Manufacturing drawings / data compilation
Process modification finalised
Start up tests
Full-scale production
Delivery of new product to customer
- ***Reaction***: Customer appraisal
After-sales service activities
Problem investigation



The descriptive design process models can be explained based on sequence and linear iterative processes.

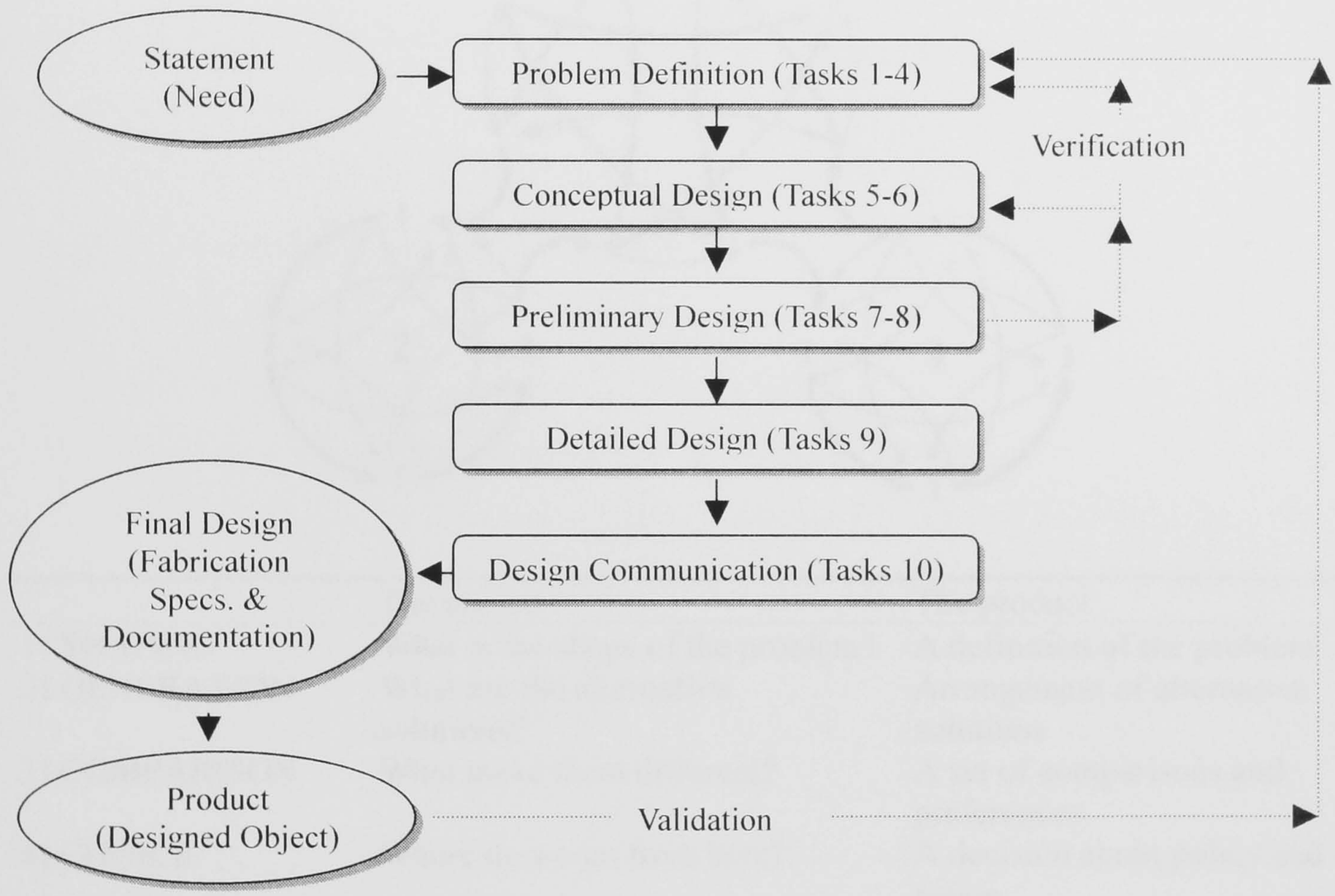
On the other hand, there have been several attempts at building *'prescriptive models'* of the design process. These later models are concerned with trying to persuade or encourage designers to adopt improved ways of working. They usually offer a more algorithmic, systematic procedure to follow, and are often regarded as providing a particular design methodology (Cross, 1994).

Considerable work on these kinds of models has also been developed by many researchers. one of these models by Dym & Little (2000) has reinterpreted *Feedback* and *Iteration* in the design process. They have intentionally left out these two elements

in order to emphasise design thinking and behaviour in their lately published book, 'Engineering Design'. Dym & Little (2000) explain,

"The first of these (design processes) is feedback, that is the process of feeding information about the output of a process (or system) back into the process so it can be used to obtain better results from the process. The second element is iteration, these iterative (design) activities occur at more refined, less abstract points in the design process."

Figure 12. A prescriptive five-stage model of the design process (source: Dym & Little, 2000)

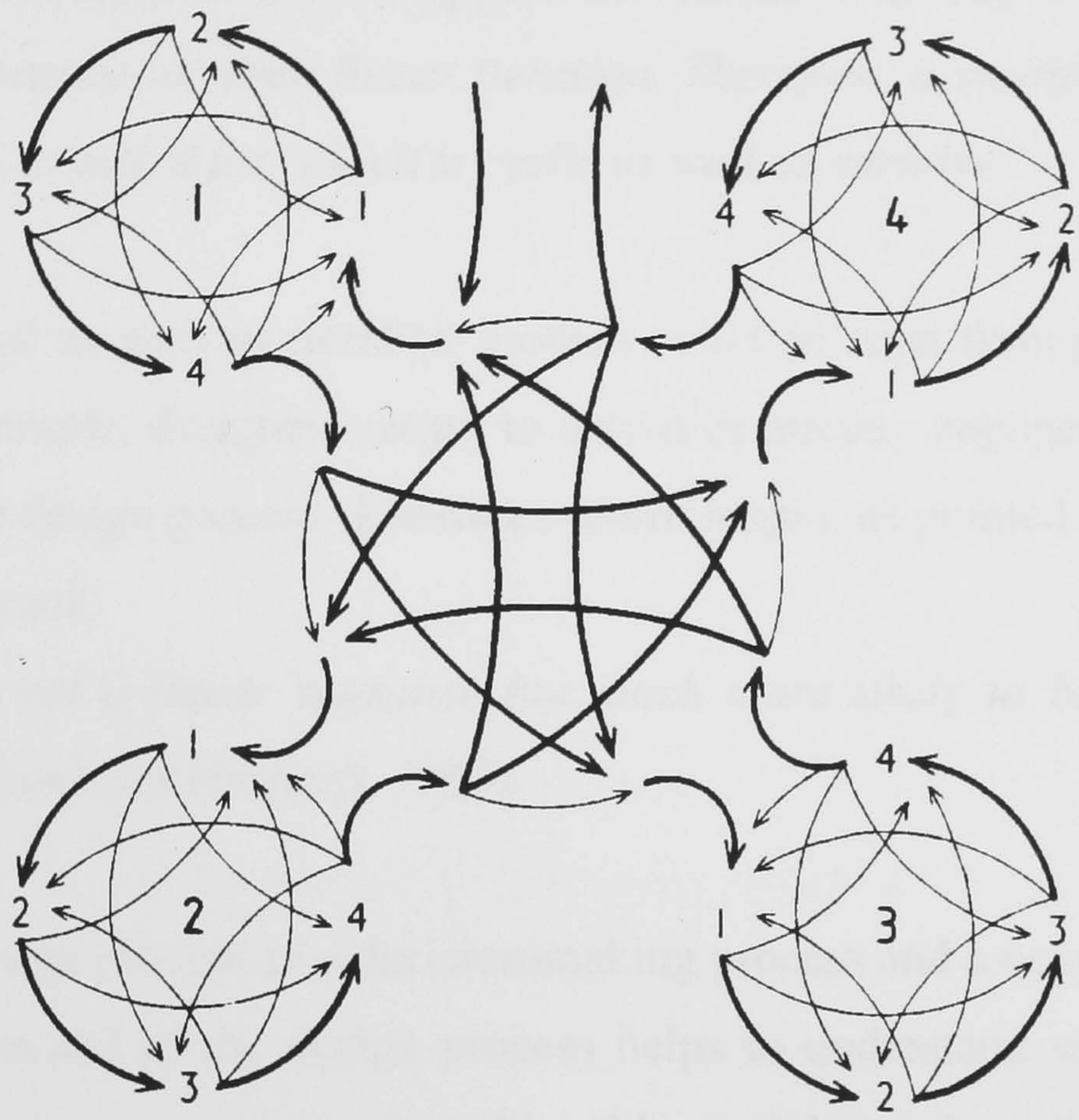


A prescriptive five stage model of the design process in which they show feedback loops (in dashed lines) explains both verification, internal feedback during the design process; and validation, external feedback obtained from users when they actually use the designed object.

On the other hand, Allen Hicking (1982) explained a design process from a different viewpoint, that the design process should emphasise the *cycle iterative process* rather

than the *linear iterative process* with his prescriptive design process model. He strongly argued for the linear process and the recycling process in designing.

Figure 13. The extended whirling process (Source: Hicking 1982).



	The choice	The product
1) SHAPING	What is the shape of the problem?	A definition of the problem
2) GENERATION	What are the alternative solutions?	Arrangement of alternative solutions
3) COMPARISON	What make them different?	A set of comparisons and preferences
4) CHOICE	Where do we go from here?	A decision about policy and action

The conclusion in his research is that a linear process is not enough to explain the design process well, the main reason being that it over-simplifies the process. Hicking added further explanation as follows in the book, 'Developments in Design Methodology (1982).

"The linear iterative process is the view of the process held to be most 'rational' by the majority in many fields today. However, a few have moved beyond this. They see the

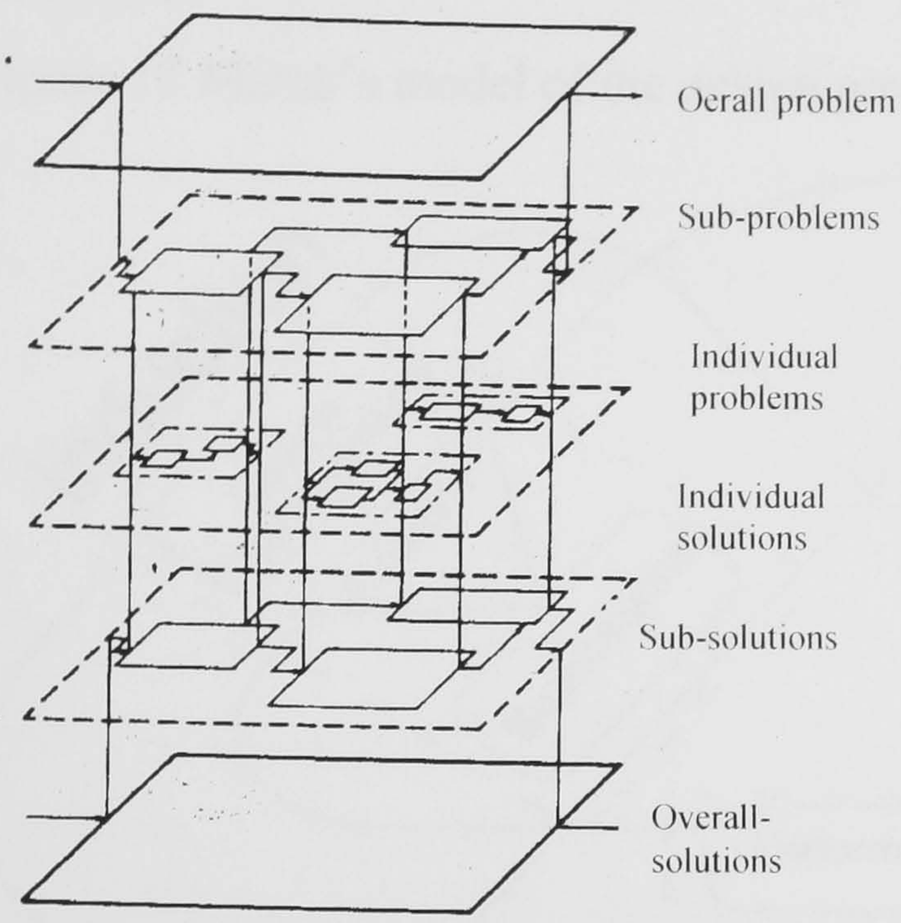
process as a learning process. There is also, in some cases, a trend towards trying to achieve continuity in the process. This has led to a change in attitude towards skipping backwards and forwards in the process, from one in which it is merely allowed, to one in which it is actually enabled to happen. But neither learning nor continuity is well described by linearity- or even linear iteration. Therefore, a modification of the linear iterative process is called for, which is cyclic as well as iterative."

In fact, a cyclical as well as iterative process could be used throughout all the design process. For example, designers return to activities already engaged in any number of times during the design process (known as return loops), as pointed out by Ray Holland who quotes Coward,
"...it is clearly not a linear sequence but much more likely to be "many loops and networks" (Holland and Hartwell, 1995).

If we see the design process as a decision-making process and a negotiation process, the cycle whirling model of the design process helps to understand what happens within each part. In order to accommodate this, this model can be extended by adding a subsidiary cycle for each of the parts (Hicking 1982: see Figure 13). Therefore, the cycles design process could make more subsidiary cycles according to the situation, such as project size and characteristics.

Another example is the VDI (Verein Deutscher Ingenieure) design process model that is also well explained focusing on problem-solving processes and subsidiary processes. The VDI model has produced a number of 'VDI-Guidelines', including VDI 2221, 'Systematic approach to the Design of Technical Systems and Products' in Germany.

Figure 14. VDI 2221 model of development from problem to solution



The VDI-Guidelines follow a general systematic procedure of first analysing and understanding the problem as fully as possible, then breaking this into sub-problems, finding suitable sub-solutions and combining these into an overall solution. The procedure is shown diagrammatically in Figure 14.

This kind of procedure has been criticised in the design world because it seems to be based on a problem-focused, rather than a solution-focused approach. However, according to Lawson (1984), a designer prefers a 'solution-oriented strategic' rather than 'problem-oriented strategic' approach. Lawson (1984) pointed out through his empirical research that a designer uses the 'synthesis' and 'solution-focused methods' to approach problem-solving against a scientist use's of 'analysis' and 'problem-focused methods' to approach their problems.

A more radical model of the design process, which recognises the solution-focused nature of design thinking, was suggested by March (1984). His rational model explains a synthetic solution approach to the design process in the context of three pillars, which are called PDI (Production, Deduction and Induction). He explained his model as follows:

"The diagram suggests a cycle, iterative procedure PDIPDIPDI... with constant refinements and redefinition being made of characteristics, design, and supposition as the composition evolves. This model is also envisaged as representing a critical, learning process in that statements inferred at later stages may be used to modify those used in earlier stages and thus to stimulate other paths of exploration. For this reason

no arrows are shown along other paths, although the general direction of argument is clockwise."

Figure 15 March's model of the design process (source: March, 1984).

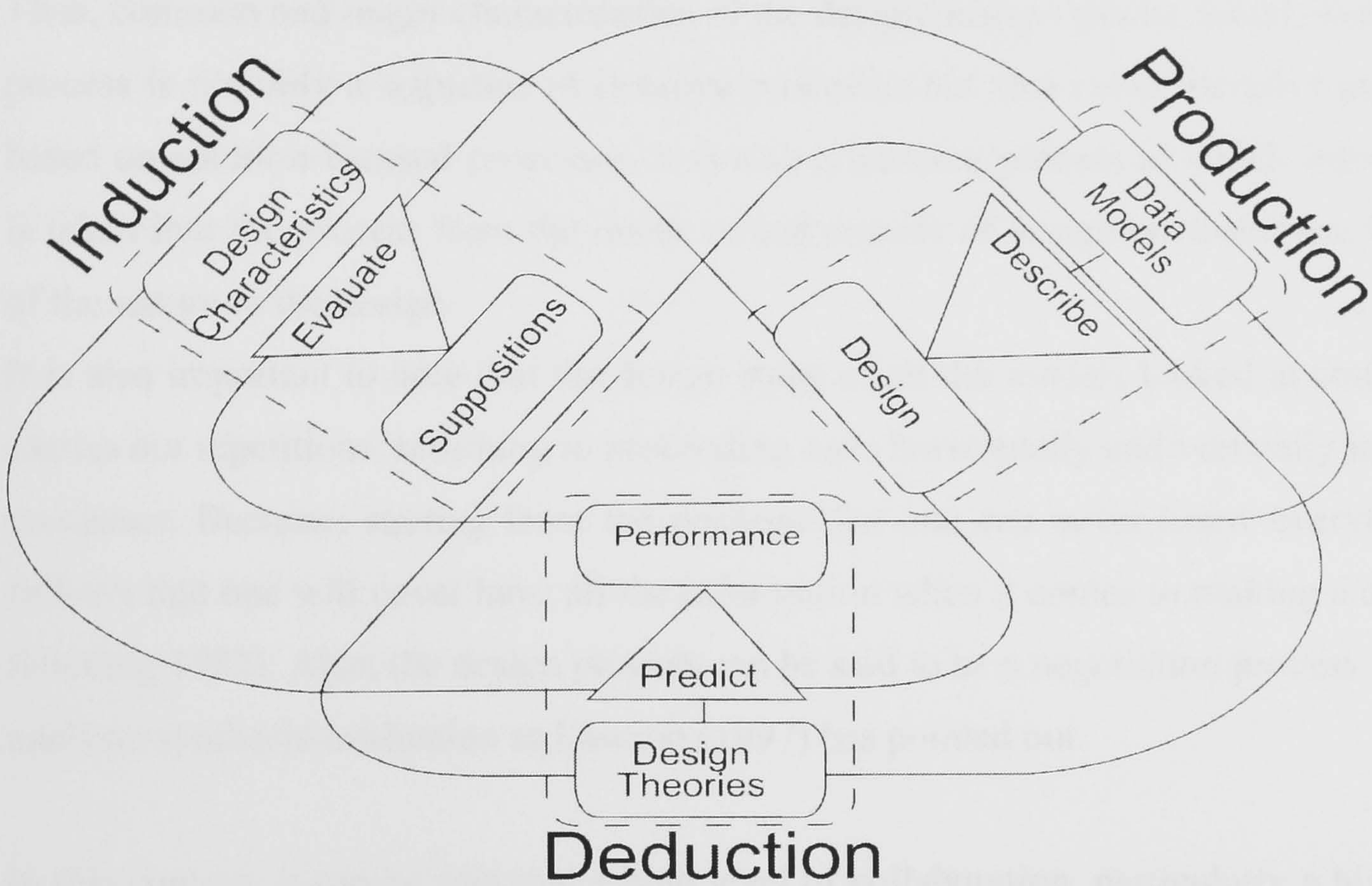


Figure 16 Negotiation process

indicate any starting and finishing points or the direction of flow from one activity to another.

Thus, common and major characteristics of the design process can be found. The design process is not only a sequence of iterative processes but also cyclic iterative processes based on solution-focused processes. It is also a learning process in which information is taken into the process from the inside or/and outside of design environment, because of the nature to the design.

It is also important to note that the design stage of all the models looked at continually carries out repetitions, returning to proceeding ones horizontally and vertically in design processes. Because, starting from the position that one can never know everything, it follows that one will never have all the information when it comes to making a decision (Hicking 1982). Also, the design process can be said to be a negotiation process through analysis-synthesis-evaluation as Lawson (1997) has pointed out.

In this context, it can be said that a high level of collaboration, particularly a high level of cross-functional collaboration could not only help to enhance these kinds of feedback (iterative) activities effectively in the design process, but also reduce unnecessary feedback work, which comes from a lack of information and poor decision-making. Therefore, cross-functional collaboration and well-linked partnerships can reduce lead-time and enhance design performance through supporting the right information at the right time during the design process.

2.5 Interconnection within the design activity

2.5.1 Information interaction in product design development.

A product does not only have an inherent function but also many other multiple sub-functions. The inherent function here means that products have their main function, for instance, the main function of a car is to transfer someone or something, a watch tells the time, a radio broadcasts, etc. The sub-functional here means that products also have other functions apart from main functions; for instance, a car has symbolic meaning such as signifying the reputation of a car owner and/or reflects the personal taste of the owner, etc (Kang 1994). From a customer's viewpoint, as Bill Hollins (1990) mentioned, when customers purchase a product they consider not only its main functions of quality and price but also many other factors (sub-functions), such as safety, aesthetics, delivery, reliability, ease of operation, individual and social symbolic meaning, which can be related to product design.

From this context, therefore, a product can be seen as an aggregation of all information and intelligence from each field to fit with objectives (Eok 1995). Because, when products are being developed, this kind of all information is considered. Therefore, design development can also be viewed as an added and mixed information process (Bays & Leifer, 1996), namely, an NPPD (New Product Design Development) process can be said to be not only an additional process of functions but it also balances focus on these functions. In this line of thinking, Ellis (1994) pointed out that the role of designers, who are the core in NPD, is to provide a combination of diverse information as co-ordinators in NPD processes.

For these reasons, Rassam (1995) insisted

"information gathering is a key factor in setting strategy and managing design".

This point was also emphasised by Alan South, group leader in product design at Cambridge Consultants (1995): he states,

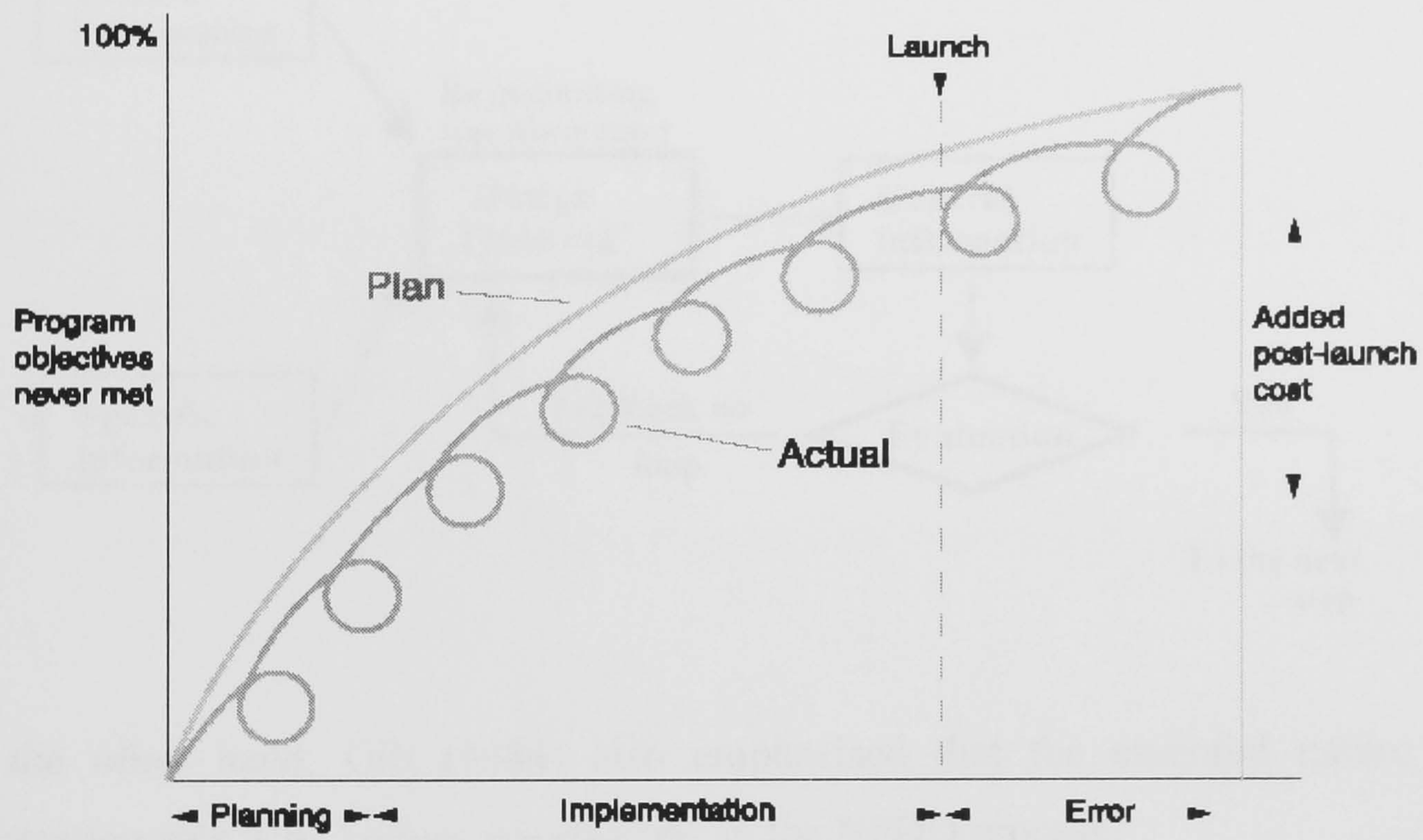
"Good design comes out of synthesising the right product from information on your competition, markets and technologies."

On the other hand, information timing is a critical factor, as Rassam (1995) also pointed out;

"there exist many painful feedback processes and delayed launches in the NPD process, because they have not 'synthesised' the relevant information at the right time".

This can be seen in Figure 17.

Figure 17 Late changes and black holes (Source: Arther D Little Ltd.)

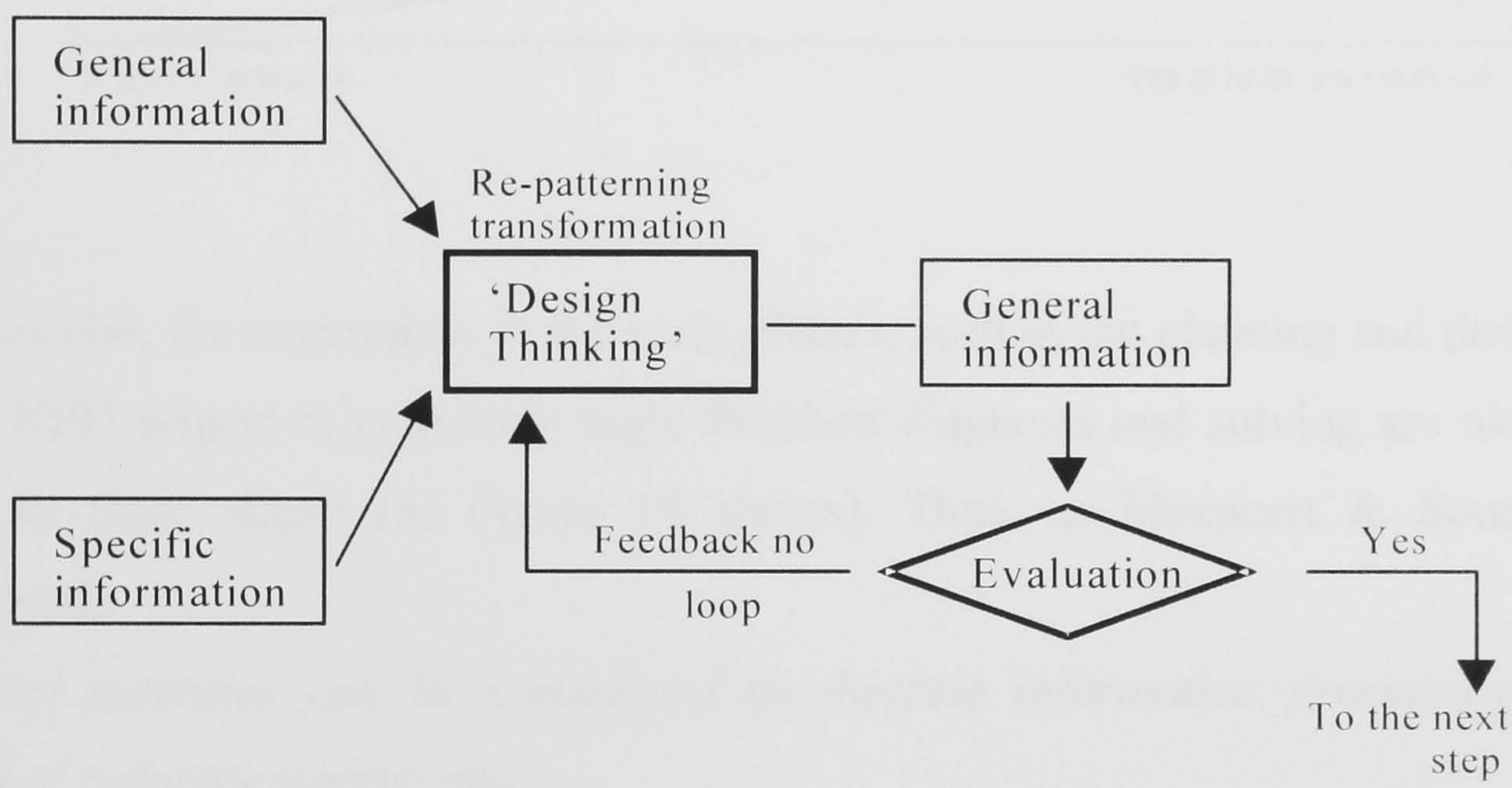


Obviously, some changes to the initial design and several iterations are inevitable because of the nature of the design development process, as previously mentioned in chapter 2 'Understanding of the product design process', but a lot of unnecessary feedback in reality could be reduced with the support of the right information and the right timing in the design process.

Gill (1984) further explains the role of information as a central activity and the main source of problem solving in design processes;

"The role of information in design is central to the design activity, being the 'processing agent' that is used to 'break down' the problem as it is explored in both breadth and depth. It is information both 'general' and 'specific' that is collected, re-patterned and blended together as mental imagery to synthesise solutions" (see Figure 18).

Figure 18 the central role of information in the design activity (source: Gill, 1984)

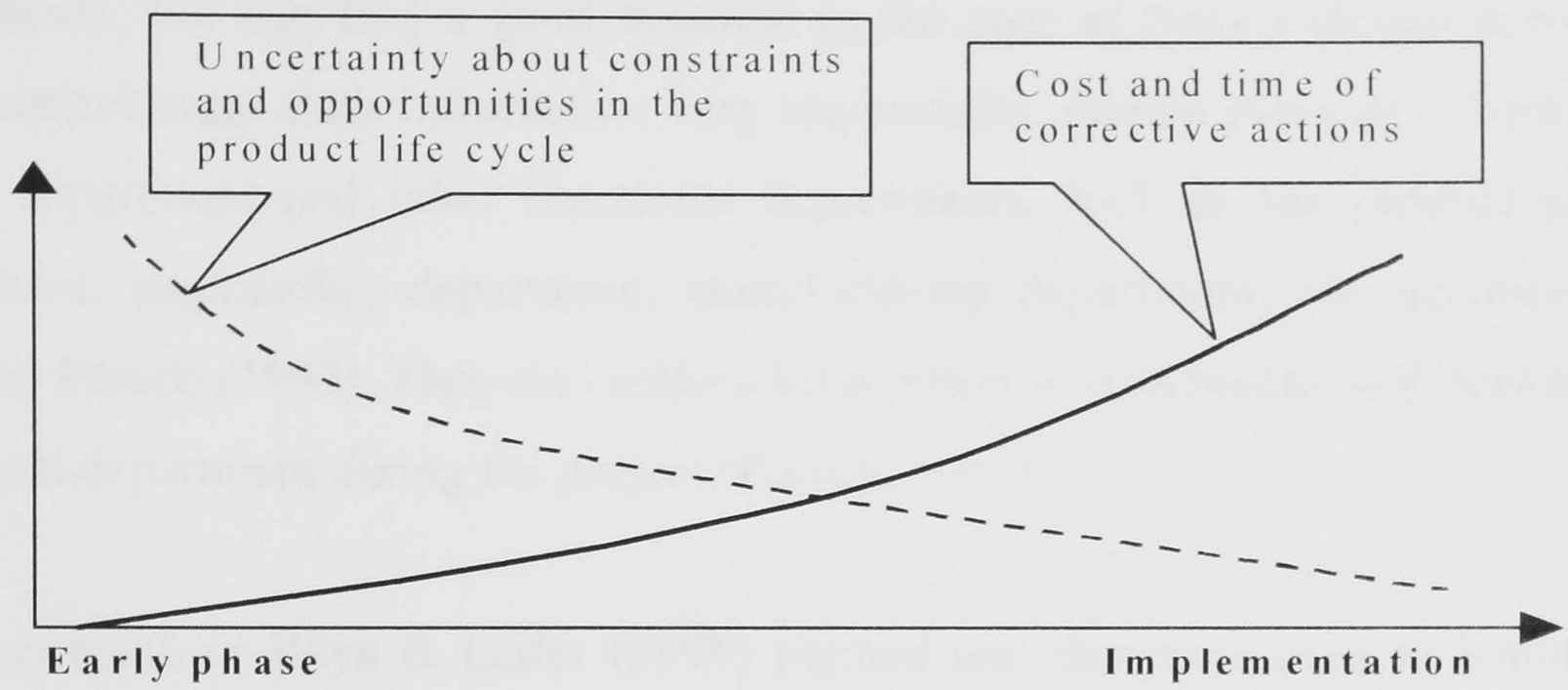


On the other hand, Gill (1984) also emphasised that the essential nature of the information role is to *'reduce uncertainty'* in the NPDD process,

"Indeed information has been defined as 'that which reduces uncertainty' and design as decision making in the face of uncertainty with a high penalty for error"

Hart S. (1995) pointed out that the notion of reducing uncertainty is the main objective of product development activities which is reiterated throughout the literature on NPD

Figure 19 Uncertainty, cost and time of corrective actions in the product development process (source: Verganti R. 1999)



In particular, the uncertainty in the early phases, such as the planning and design stages, of an NPD project is extremely high. Problem diagnosis and solving are also difficult tasks in these stages (as Figure 19 shows). Thus, as Moenaert & Souder (1990) illustrated,

"project activities can be considered as discrete information processing activities aimed at reducing uncertainty".

However in order to reduce uncertainty, it is not sufficient that information is processed; it also has to be transferred between different functions (Bonnet 1986; Moenaert & Souder 1990). Although it is not easy to transfer information between different functional groups without metamorphosis, because high barriers exist among the different functional groups. It is well known that many noises come from the boundary areas among functional groups in the NPD process. Ray Holland (1999) expanded upon this idea in his lecture on 'Research methodology',

"they (each functional group) often look likely to communicate with different languages in their decision-making process".

In order to overcome these kinds of barriers and better facilitate an efficient design development process, more efficient communication is needed among functional departments. We can find a good example in the case of Sony's design department, which interchanges their information very sequentially, almost every day, between the design department and other functional departments, such as the product planning department, engineering department, manufacturing department, etc. according to a report by Powell (1992). They also make a lot of effort to collaborate well between each functional department during the project (Powell, 1992).

In this context, as Baya & Leifer (1995) pointed out, designers need to handle large amounts of information over the course of a design process. Gill added further explanation that a designer needs many different sources of information during the design development process. He (1984) stated *'part of this information can be stored in the designer's memory as part of his/her assembled experience, but this is unlikely to be enough.'* Other sources have to be used; Gill gives some examples in detail;

- *Vendors of materials and supplies*
- *Regulating agencies of the government*
- *Trade associations on the field of the project*
- *Testing organisations*
- *Professional specialists (consultants)*
- *Financial, insurance, other commercial sources*
- *General sources, e.g. libraries*
- *Company management and other resources*
- *The client as customer*

Thus, various kinds of information interact at all stages of the design process and there is no predictable balance in either type or amount. Information on all aspects of the problem - materials, components, principles, economics, opinions, numbers measurements, ideas - are all weighed in that 'balancing act' that is so characteristic of designing as Gill (1984) mentioned.

Therefore, new product design development can be interpreted as information intensive as Fujimoto (1989) pointed out. It requires an accumulation of data and insights from

diverse and different functional perspectives. As a new product is being designed and developed, information is constantly accessed, interpreted, transformed, and deployed (Rosenthal & Tatikonda, 1999). In design decision-making, a designer should monitor available information consistently and control it with measurements which exist in the current design world in order to reduce uncertainty (Faludi 1973). Availability of such information essentially determines the extent to which a new product achieves the required functional capabilities, ease of manufacture, and a fit with overall strategies.

For these reasons, it is emphasised that cross-functional information interaction has to be dealt with as a key issue in design development in order to, ultimately, enhance the performance of new product development.

2.5.2 The multiple convergent approach

There are many useful lessons to be learned from literature dealing with the importance of networks and integration in the NPD process, and that which attempts to break down discipline boundaries in functional departments. Namely, eliminating the walls among R&D, marketing and manufacturing functions, techniques such as concurrent engineering and a quality function deployment can pave the way to more effective NPD as Song et al. (1997) stated. One of the process models in this main reengineering stream of NPD is the 'multiple convergent process', which is conceptually derived from the idea of parallel processing by Susan Hart (1995).

Realising that there are many functionally distinct tasks that must be carried out at specific points throughout the NPD process, it become clear that the tasks will be carried out simultaneously at some juncture and that the results must converge. Due to the iterations in the process, this convergence is likely to happen several times (Hart, 1995). As mentioned in the previous section 2.5.1, the design process can be said to be a series of information gathering, information interpreting, information transforming, information deployment and balancing activities, within different functional tasks to discover an optimising solution.

The multiple convergent model (Hart, 1995) reasonably explains a design process in this context of the information flowing process and the reason why strong cross-functional collaboration should be included in the design development process. In other words, firstly, a designer combines diverse information from each functional group and, secondly, produces new information after adding a value process into the information they have through synthesising, analysing and creating work, thirdly a designer diffuses updated information to other functional groups through several channels, such as meetings, presentations (e.g. rendering presentation, prototype model presentation, etc.).

The design process can be said to be a repetition of these kinds of convergence and diffusion activities.

Figure 20. The early stages of the multiple convergent process (source: Hart, 1995).

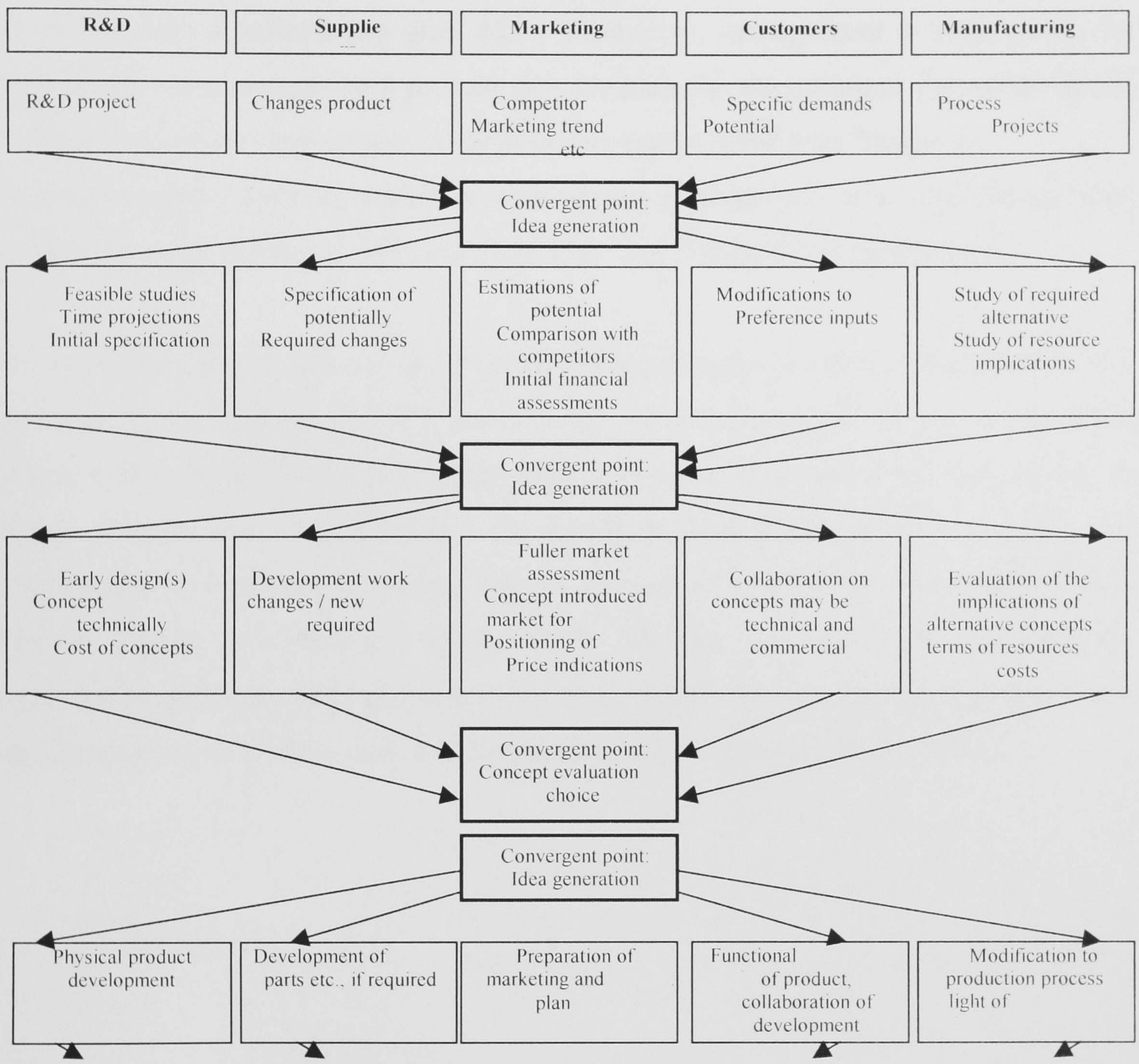


Figure 20 shows an example of the early stages of the multiple convergent processes. This process model is explained by Hart (1995):

"Iterations among participants within stages are allowed for in the convergent points and horizontal communication system they embrace. The framework can easily accommodate third parties. Mechanisms for real integration throughout the process among different functions are set in the convergent points."

In order to enhance the performance of multiple convergent and diffusion repetition processes in new product design development, *the collaboration relationship* among various functional groups is a key issue. On the other hand, this process brings a diverse set of specialised information and skills. Ultimately, management is responsible for successfully co-ordinating this process and creating the environment for collaboration amongst the people who possess skills in his/her professional area. However, "*to bring together individuals from a wide variety of functional areas and having them work in harmony is much easier said than done*", as Olson (1993) pointed out.

To summarise, the amount of information sharing among functional departments is a key issue in the success of NPD, particularly, in the case of the design development process which is needs this information sharing process, because of the risky nature of design development characteristic. The multiple convergent process provides the opportunity for information sharing for the success of NPD, even more NPDD (New Product Design Development) (Hart, 1995). One of key issues in enhancing the performance of the multiple convergent process, particularly among different functional departments is cross-functional collaboration (Davies-Cooper & Jones, 1996).

2.5.3 People oriented design process

Herbruck & Umback (1997) asserted,

"In new product development, if an organisation has all the right information, as well as the technical and financial resources necessary, unless its human resources are fully committed and communicating effectively, opportunities may be lost".

Also, Dr. Hammer (1996) himself has confessed that he and other reengineering gurus forgot about people,

"I wasn't smart enough about that...[I] was insufficiently appreciative of the human dimension" he admitted in a Wall Street Journal.

Herbruck & Umback (1997) pointed out that many companies, in their haste to reengineer, downsize, and redesign, fail to recognise that such efforts are aimed at inanimate pieces of machinery, ignoring the human issues. As the report of Insights Quartly concluded (1992),

"70% percent of reengineering projects fail because of neglect of the human factor".

Thus, many failed reengineering projects have indicated a poor consideration of the human aspect, nevertheless, as Blyton & Turnbull (1992) stated, human resource management is not only a strategic activity in itself, but one which is now central to the achievement of business objectives.

This point was also emphasised by Hart (1996). Hart pointed out that nearly all contributions to the literature regarding NPD do not respect the basic discipline of the link between people and process. In other words, many researchers just faced dealing with a multiplicity of insulated issues based on each discipline, such as engineering, design, marketing, organisational behaviour, strategy, decision making processes, etc. Therefore, it brings to light *the cross-disciplinary gaps* in NPD, which are related to the

relationship between 'process and people'. For this reason, he insisted on the need for interconnection between people and process and described the reasons why consideration is needed for the common currency. Summaries of his main ideas were divided into the following points:

1. *'People' and 'process' are inextricably linked: the process cannot unfold without the appropriate people, nor can the process be organised to facilitate cross-functional inputs without reference to the people involved. Although so apparent as to appear something of a truism, the linkage between the process - its tasks and decisions- and people- their skills and organisation-has been widely ignored by researchers in most of the single disciplinary research.*
2. *'People' and 'process' encapsulate other important themes, for example, the role of information in promoting cross-functional integration, and sharing a link between the themes of 'People' and 'information'. In addition, 'People' as a theme is clearly connected by 'organisational structure and style'. Similarly, the theme of the 'process' is related to that of 'information' because the NPD process can be viewed as one of information process (Snelson & Hart 1991).*
3. *'People' and 'process' relate to the most commonly cited reasons for NPD success:*
   - *The need for interdisciplinary inputs. In order to combine technical and marketing expertise, a number of company functions have to be involved: R&D (engineering), manufacturing, , marketing and sales. It is also important that NPD process adopted ensures that they work well and effectively together.*
   - *The need for quality inputs to the process. Both technical and marketing information, which are building blocks of NPD, have to be both accurate and timely, and must be constantly reworked in the light of changing circumstances during the course of the development.*
   - *The need for speed in the process. The value of being first into the market with a new product is very significant*

Thus, despite importance of these issues, interaction between people and process come together, interact and build consensus to achieve complex new product (NP)- related

objectives remains poorly understood (Badawy et al.' 1991). On the other hand, more is known about " the nature of the market, the type of technology, or even the synergy or fit between the project and the firm", than about the key human interaction and collaboration issues of new product development, according to Cooper (1996) and Jassawalla (2000). Boddy and Buchanan (1986) further emphasised this point, particularly about the design area,

"*designers frequently ignore the human factor implications of their work.*"

Herbruck and Umback (1997) also emphasise this point in relation to the design area, "*The opportunity for the designers, then, is to forge a new link between people and process in the business environment... product designers, and particularly design managers, are positioned to play a key strategic role in the linking of people and process through the redesign or creation of NPD processes*".

There is no doubt that the collaboration issue, particularly in different functional groups, can be one of the main linking elements of people and process in the NPD and NPDD process. This collaborative group work among functional departments in NPDD was also emphasised by David Walker (1993) as follow,

"*Instead of relying on individual brains, the group is of one big brain. In this way the coverage of various possibilities is multiplied.*"

In this context, the collaboration theme as a people issue needs to be considered in the design development process and design management for the above-mentioned reasons.

2.5.4 Interface between design and other key functions

The above-mentioned driving forces for CFC in previous sections of this chapter can be further explained beyond the discussions of the interface between design and other key functions.

In this stage, key functional departments that are strongly involved in NPD (New Product Development), particularly NPDD (New Product Design Development) within Design departments, have been searched. As a result of the literature search, R&D (to create), Marketing (to market), and Manufacturing (to make) departments have been discovered as key functional departments in manufacturing companies due to their clear, direct impact on product development and product management success (Song et al. 1997, 1998,). Woodward (1965), Lorsch (1965), and Lawrence (1967, 1986) also highlighted '*marketing/sales*', '*production/manufacturing*' and '*R&D engineering*' as the key task functions within manufacturing organisations in the NPD process. Olson (1993) also pointed out the same idea based on his research work,

"The functional groups whose contributions to the NPD process have been most widely recognized in the academic press are R&D, Manufacturing, and Marketing."

On the other hand, the design group is emphasised with Marketing and Technology as key functional groups in the NPD process, according to Rachel Davies-Cooper and Tim Jones (1995). They insisted,

" the literature indicates that there are broadly three key function areas involved in successful NPD; Marketing, Design and Technology."

In order to develop successful new product, Leonard-Barton, et. al. (1994) underlined that a company must excel in two seemingly contradictory ways. First, it must constantly build and refresh its individual area of expertise so it has critical capabilities needed to stay ahead of the pack. And second, it must get its ever-changing mix of

disciplines to work together in the ever-changing competitive environment. From this context, the cross-functional collaborative work starts to be recognised as a significant issue in NPD. To successfully accomplish their unique and shared tasks, each functional group involved in new product development is dependent to some degree on other functional groups in the firm (Olson, 1993; Song, etc., 1997). In this context, Olson (1993) stated that regarding the perceived value of 'the designers'.

"one group that has received comparatively little attention, yet whose contribution to the successful development of a new product is equally crucial or more, is design. Because designers are often perceived as "arty types" instead of business people, because little research has focused on design's relationship with other functional groups, few insights into how to manage the interface of design with other functional groups are available to project or other functional managers"

Despite the importance of design to NPD, until recently little attention has been given to the role of design and considerably less to the interfaces between design and other functions in the NPD process (Davies-Cooper & Jones 1995, Olson 1993, 1994).

More reasons can be added as to why the cross-functional collaboration and interface issue should be dealt with in the design process. One of them is the nature of design problem. The nature of the design problem almost always involves a diverse number of disciplines, namely, the solutions to design problems focus on finding an optimum balance between other functional values, for example, between performance and cost, between appearance and how easy a product is to use, between materials and durability etc. Similarly, as Walsh, Roy, Bruce, Potter (1992) prescribed, the design activity has been essentially characterised as '*Compromise*' and '*Choice*' activities (They also gave two more, '*Creativity*' and '*Complexity*', which together they call the '4Cs' of design – by analogy with the familiar '4Ps' of marketing: Product, Price, Place, Promotion).

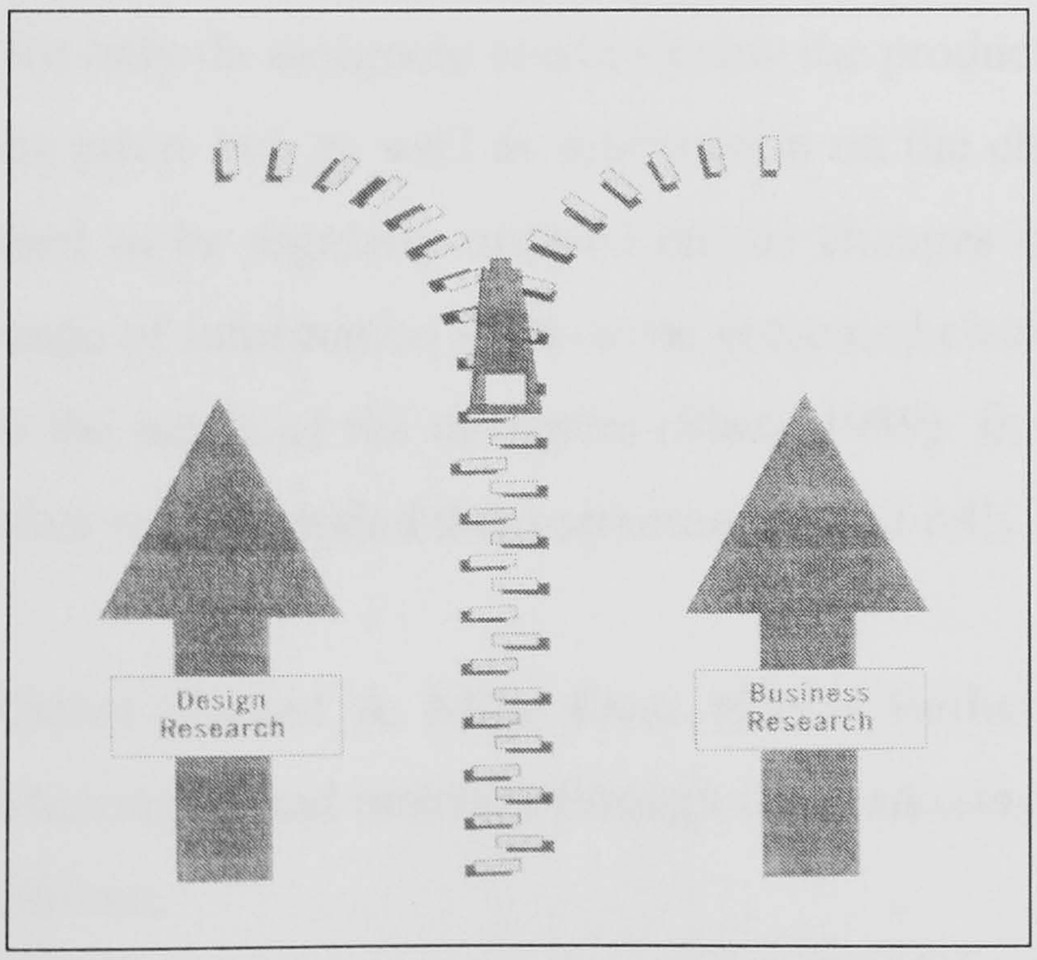
Alan Topalian (1990) also pointed out the harmony needed between the design and other functional people from this context. He stated,

"design issues always receive serious consideration before decisions are taken. It also implies that designers and staff who are from other functional disciplines work in parallel through all stages of a wide range of activities."

However, the above-mentioned "*work in parallel*" by Alan Topalian (1990) does not mean an autonomous or independent process. It is an integrative process, which zips together the respective tracks as the process moves forward, as explained by Beckwith and Harris (1993) quoting Dewar Sloan's Zipper Theory. Danial T. Wolf (1992) who is a strategy consultant at Dewar Sloan, Inc. calls this the Zipper theory and described it as follows;

"Design Research has to move forward with Business Research in an iterative fashion, interlocking the exercise as it moves, reaching sequential consensus and cross-play.... [otherwise] there is a tendency to downplay the critical role of Resource Research while the Design Research and Business Research zip along until there are resource inconsistencies

Figure 21 Dewar Sloan's Zipper Theory (Source: Beckwith D. & Harris D. (1993)



The Zipper theory metaphor suggests zipping up the premises, goals, knowledge, and criteria all along the way to refine movement into a smoothly melted design process Beckwith and Harris (1993) (See Figure 21).

Rachel Cooper & Mike Press (1995) also added that

"the various functions are not independent–they are interdependent, namely separate functions begin to work together".

Also, Rothwell and Whiston (1990) insisted, *"there should also be regular communication between marketing, production and manufacturing to ensure that all products are appropriate to the company's existing or planned manufacturing capability"*. For these reasons, there appears to be an increasing need to improve the cross-functional collaboration process and interfaces between the design and other key functional groups, particularly, R&D, Marketing, Manufacturing.

Each interface between the design group and the other key function groups are summarised in sub-sections below.

2.5.4.1 The Design - Marketing interface

Throughout the development programme, Hopkins (1981) points out
"there ought to be a continuous interaction between marketing and design".

Not only do designers need to know the product, the competition, the target market and the price, but, as well as information on the characteristics of the consumer, they also need to be regularly updated on the changes in their requirements (Dace 1989). This range of information needs to be presented clearly and, at all times, must be appropriate to the needs of the designers (Slade 1989). In order to achieve this successfully, it is often recommended that marketing should fully understand the design process.

Rachel Cooper & Mike Press (1995) further described the Design and Marketing relationship and interface through the marketing mix. Summary of their main ideas is as follows:

"Design is related to every aspect of the marketing mix; in 'Product', Design influences quality, function, service, usability, appearance and other features; in 'Price', the way a product is designed can affect the cost of manufacturing and, also add value; in 'Place', Designers are involved in the packing and distribution and they also design outlets, for

example retail stores, exhibition stands, leisure facilities etc.; in 'Promotion', design always has key role in the production of advertising, support literature, point of sale displays etc. The critical nature of the design – marketing interface means that market research must be undertaken in such a way as to inform designers both quantitatively and qualitatively about the end user of their design, for example, supply market size, customer profiles, the market segment defined and lifestyle information."

2.5.4.2 The Design – R&D interface

As with the marketing interface, it is recommended that there should also be regular contact between Design and R&D (Walsh et al. 1992). In order to operate effectively, designers need to be aware of both current research taking place within the company and relevant developments in new materials and processes occurring outside, particularly during the early stages of a project. They need to be able to consult with R&D, who themselves also need to communicate with market research and marketing about new products which may be developed in the future (Hopkins, 1981).

Frequently in small and medium sized enterprises design and R&D activities are often undertaken by one group – in the manufacturing industry. However, in larger organisations, R&D exists as a discrete function or out-sourced from agencies or academia (Cooper R. & Press M. 1995). R&D information is essential to designers working on product design development; they need to know what is happening at the forefront of technology, in terms of materials, machines and manufacturing methods. Such knowledge feeds the creative process and enables designers to develop innovative and leading edge concepts. For example, Teflon was developed in the aerospace of industry but later resulted in saucepans, skis and bearings (Cooper R. & Press M. 1995). It is essential to realise that communication of developments in R&D contribute to innovation and effective design, and therefore must be encouraged for effective design, and therefore must be encouraged and supported through bringing the functions together.

Indeed, not only does knowledge of advances in R&D increase the ability to produce innovative new products, but also an understanding of design activities enables R&D to contribute more effectively to the design process (Cooper & Press 1995).

2.5.4.3 The Design - Manufacturing interface

Susman et al. (1992) pointed out,

"companies increasingly recognise that integration of design and manufacturing contributes to improving product quality, lowering cost, and speeding up the product development process".

A report by the DTI (Department of Trade and Industry 1991) also emphasised the relationship between design and manufacturing groups:

"not only must designers have the best knowledge of what the market wants, but the better they are informed on the materials and manufacturing capabilities of their business, on what is available to their business, then the better will be their designs".

One of the most important matters, which cannot be ignored, is that in every discipline design concepts must be transferred from the drawing board into reality. This involves a production process; therefore it is inevitable that there must be a good relationship and interface between designers and production. Cooper & Press (1995) also explained the relationship between these two groups,

"Designers must also be kept aware of all of the production issues, which will aid economic and efficient manufacture or assembly. The communication process between both functions must also involve efficient and clear transfer of design instructions and specifications to enable effective manufacture."

More statements, which underline the necessarity of collaboration between design and manufacture have been given by many researchers and writers. Francis et al (1988) and

Rosenthal et al. (1992) also insisted that it is beneficial to involve production and manufacturing from the start and that there needs to be a continuous interaction between manufacturing and design. There should be regular consultation between design and manufacturing to discuss any problems that arise. the outcomes of which have to be fed back to the design team to ensure that the final product is entirely appropriate to the manufacturing capabilities of the company.

On the other hand, De Meyer (1992) suggested that CAD is a useful tool for improving the design to manufacture transfer.

2.5.5 Role of product designer

Many roles of industrial designers have been discussed by many writers and researchers. According to Thomas Walton (1989), who is an editor of the Design Management Journal, design is most effective as a full partner in the development process. This means that, rather than a peripheral-"make it pretty"- role, design should be used to contribute to all phases of corporate activity: from strategy to product/service definition to production as well as to marketing and support.

In particular, three industrial designers' roles have been stressed in previous literature, these include customer interpreter, integrator and catalyst.
Cilve Rassam (1995) explains these three designer's roles in his published book.
The sub-sections are dealt with mainly Rassam ideas.

2.5.5.1 the designer as customer interpreter

Bill Morggridge, founder of Morggridge Associates which is now part of the international IDEO group, emphasises that a good design is one that apples to people:
"*I always related design to people. Therefore design is about creating products that satisfy people, that are enjoyable, that function in the right way. A good design is for the end user.*" (Morggridge B; in Rossam 1995)

The ability of the designer to understand the customer is crucial in developing successful products that consistently compete well in the marketplace.
It is also a role for which the designer is ideally suited by education and background. The Technology Partnership's Michael Cane, who has a background in both engineering and industrial design, explains why:

"People with an engineering or electronics education are trained in problem-solving. They are trained to make analyses by breaking a problem into bits; theirs is a world about technologies with clear-cut questions and logical answers. But arts-school educated designers are trained to work from a different basis. They work from an emotional point of view: how will people react to this product, why would they want it, how will they use it...So the reason why industrial designers can be so useful in a commercial sense is that they approach things from a people perspective. It is natural to them to think about customers and market....

Although interpreting customer information is traditionally seen as the role of the market department, in Nick Butler's experience most marketing people are in their jobs to move products, and see their jobs as an extension of the sales function, so they look at the market from the point of view of the company's existing products. This is a view shared by many other industrial designers including Kenneth Grange, who finds that Marketing tends to be focused on the present rather than future: 'They don't stand back from the market and ask what it needs.' A good industrial designer is more likely to question the marketing philosophy and take account of the capabilities of the engineering department" (Rossam 1995).

2.5.5.2 the designer as integrator

Seth Ellis (1994) pointed out,

"the product development activities of firms engaged in manufacturing exhibit a structural relationship among engineering, marketing, and industrial design".

It is understood that no single professional discipline can by itself come up with all the ideas for a new product. This is why industrial designers can be so valuable: they are used to dealing with a number of key disciplines such as engineering, marking and product (Rassam 1995). The idea of the industrial designer as *a pivotal integrator* of various professional disciplines is a very powerful one in the design profession. Those

whose education achieved a satisfactory balance of engineering and arts-based subjects have a particularly good understanding of business processes and manufacturing, and appreciate what technology is all about. They are aware of manufacturing processes and are sensitive to the refinements of form and colour.

Rassam (1995) who uses Richard Seymour's idea states,
"the relationship between the designers and everyone else 'must be seamless'".

Richard Seymour of the Seymour Powell design consultancy also pointed out that
"we spend a lot of time making sure that relationships are right. Sometimes we act as moderators between the marketing people and the engineers."

Seth Ellis (1994) takes this point even further. He believes that designers will increasingly be called upon to act as *integrators*, beginning with the earliest stages of the product-development process. Ellis (1994) has explained that
"designers-with modest training in engineering and marketing- have the unique ability to create 'visions' for future products that combine technical and manufacturing input with 'softer' information on customer needs and priorities"

The role of the designer is evolving toward being an effective liaison between marketing and engineering, as an integrator, as a product creator, and as a visionary. Marketers understand the customers but may not be well trained in the technical aspects of product development, while engineers tend to be trained in technology but when they do visit, they are often quick to jump from the specific case to unwarranted generalisation. It is the responsibility of marketing to understand customers statistically and to know how they can be segmented, to identify the requirements and desires of attractive segments, to calculate segment potential, and to translate those requirements into technical specifications. Ellis (1994) further stated,
"Product development consists of concurrent, interactive, iterative processes. Marketing, industrial design and engineering must become a single organism that

works collaboratively and interactively, developing solutions to present and future market opportunities. One of the principal roles of the multifaceted industrial designer is to act as a liaison between marketing and engineering."

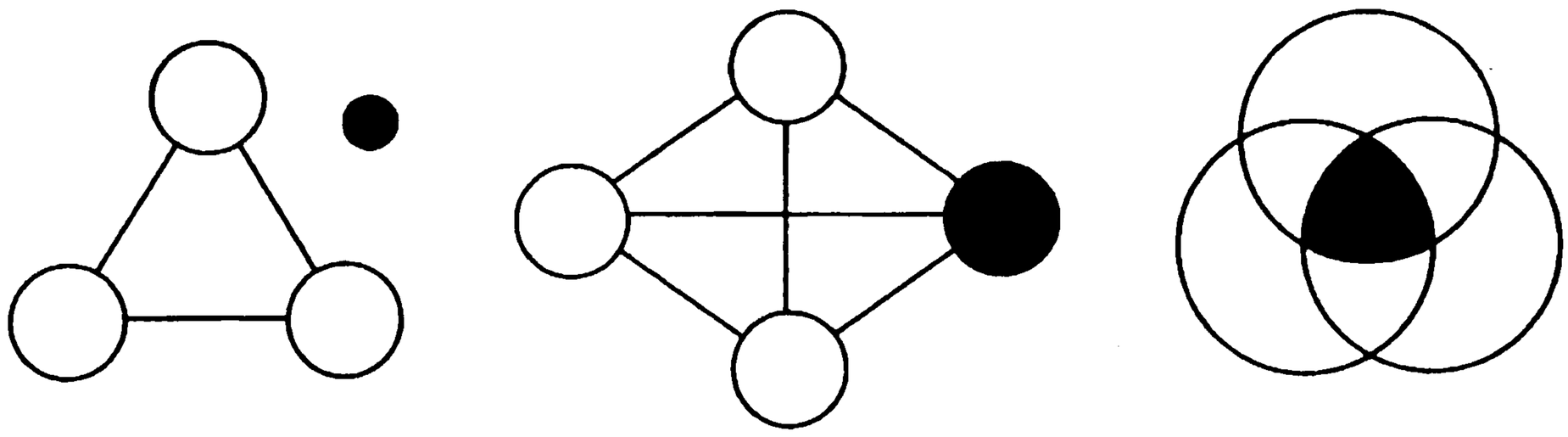
2.5.5.3 the designer as catalyst

Rassam (1995) also pointed out the designer's role as catalyst as follows:

If one takes to a wide range of industrial designers it becomes clear that, in the way they perceive their role, there are really two types. There are those who have the role as something of a magician - the inspiring, creative force behind a new product; a more modest but more realistic view - as the catalyst or moderator of a complex set of ideas and contributions from other professionals.

Also, Thomas Walton (1989) illustrates the shift of a designer's role clearly in the following diagrams (See Figure 22.)

Figure 22. The shift of a designer's role



Design outside the mainstream | **Design as a partner in decision-making** | **Design as Catalyst**

Thomas Walton (1989) stated,

"Much norm presently is the concept that design is an artistic veneer somewhere outside the business mainstream. By contrast, two alternatives are models for

competing in today's marketplace. In the first, design is integrated as a fully participating component in the corporate decision-making dialogue...design has an even higher profile, acting as the catalyst that promotes synthesis among a multiuse of corporate objectives".

In other words, a designer did not participate in the critical decision-making process of NPD in the past. The activities of the designer were also usually to give the form and visual aspect of a product, after making significant decisions in the upstream process. After that, designers came to be recognised as partners in the critical decision-making process, in the main decision-making process of NPD. Thomas Walton's idea is also strongly supported by K. W. Chung (1999), who is the president of KIDP (Korea Industrial Design Promotion), in his recent book, 'Design Management'.

Now, it is widely acknowledged that designers are given *the role of catalyst* in order to make efficient, effective and smooth decisions with other functional specialists.

In order to successfully fulfil these roles; customer interpreter, integrator and catalyst, by negotiating with other functional specialists, a CFC element needs to be a central issue in product design development and design management.

2.6 Summary of key driving forces for CFC in NPDD

The several driving forces for CFC in the design development are presented in this chapter as a background to this research. after description of the significance of NPD and the importance of design activity within NPD. In summary, the key driving forces for CFC in the design development can be described as follows:

Firstly, the nature of the product design processes can be explained as not only a cyclic iterative processes but also solution-focused negotiation processes. These points were emphasised, particularly, by Allen Hicking, (1982) March (1984), and Lawson (1997) through their design development process models. CFC is beginning to be recognised as an important issue in facilitating this cyclic iteration and solution-focused negotiation design development process.

Secondly, abundant information sharing and its efficient transformation among various functional groups are underlined as key issues in the success of the design development process (Rosenthal & Tatikonda, 1999). One of the main roles of information sharing with functional group in NPDD is to reduce uncertainty which is one of the main objectives of product design development activities. CFC is also being embossed as a vital issue in order to effectively and efficiently carry out information-sharing among the functional departments.

Thirdly, human resource management is not only a strategic activity in itself, but one which is now a central issue for interdisciplinary inputs to achieve a successful design development. Despite the importance of this issue, a human issue has been ignored in NPD/NPDD area (Herbruck &Umback, 1997). That is there is consensus in the literature that CFC needs to be dealt with significantly as a centre of human resource management issues.

Finally, three particular roles of a designer- as a customer interpreter, integrator and catalyst, can be seen as the other driving forces for CFC. A designer is a full partner in NPD process (Thomas Walton, 1989). This is because a designer, who has a good understanding of both an engineering and a marketing domain, is used to dealing with a number of key disciplines such as engineering, marketing and production (Rassam 1995). CFC in product design development is recognised as one of the main issues in successfully fulfilling role of the designer.

Chapter 3: Research Methodology

Chapter3: Research Methodology

3.1 Introduction

The framework for the overall design of this research methodology has already been briefly explained in Figure 1 in chapter 1. This chapter introduces research methods, which this research used, in detail. Some of precise research processes were dealt with in each chapter. This chapter starts with an introduction to the outline of research instruments (Section 3.2). The next section, section 3.3 deals with research instrument development, research methods, and research aims based on eight research stages in sequence. These stages are as follows: first, literature search, second, pilot interview, third, In-depth interview survey, fourth, synthesis and analysis of the findings from both the literature survey and the interview survey, fifth, questionnaire survey, sixth, development of the new framework model of CFC, seventh, evaluation of the usability of the new framework model of CFC in practice, and finally, a conclusion is given as a summary of all these research results.

3.2 Overall design of research methods

This research was conducted based on both a literature search and practical field research. Also, this practical field research was undertaken based on both qualitative and a quantitative research. An interview survey with key-senior managers in consumer electronics companies, which is the scope to this research, was conducted as a main qualitative research technique. Also, a questionnaire was used with a large amount of people in the targeted industry sector as a quantitative research technique.

Qualitative research and quantitative research are complementary to each other, although both research approaches represent different processes and have different procedures as Halfpenny (1979) pointed out. He stated,

"qualitative research and quantitative research can view a subject from different perspectives and hence the sources of information obtained allow a more holistic view of the subject under investigation".

In this research, qualitative research was undertaken principally by using qualitative data for two reasons.

First, this research issue deals with very diverse, soft and intangible data, which is difficult to quantify, during the research process.

Second, there is a need for the grounded theory approach, because of the lack of a critical mass of research findings related to this research theme: that is CFC in NPDD (New Product Design Development) which is a very creative development stage of the whole NPD process.

Tayler S. J. and Bogdan R. C. pointed out (1984),

*"The grounded theory approach is a method for discovering theories, concepts, **directly** from the data, rather than from **priori** assumptions, other research, or existing theoretical frameworks".*

The grounded theory approach is dealt with in great in the next section.

Practical data in this research was collected from eight leading global consumer electronics companies through the case studies. These companies are Xerox limited, Fuji Xerox, Hitachi, Toshiba, Samsung, LG, Daewoo, and KEC. Five, that is Samsung, Hitachi, Toshiba, LG, Daewoo, of them are the top ten companies, according to their net profit 1995/1996, in this industry sector (Euromoniter report 1997, see Table 3).

Table 3 Ranking of company by net profit1995/1996 (Euromoniter 1997).

Companies	Net profit (US $ Millions)	Ranking
Samsung Electronics	**3,119**	**1**
Philips Electronics	1,455	2
Hitachi	**1,387**	**3**
Toshiba	**884**	**4**
LG Electronics	**643**	**5**
Mitsubishi Electric	579	6
Sony Corp.	530	7
Sharp	453	8
Sanyo Electric	153	9
Daewoo Electronics	**59**	**10**

A "'Case Study' is a research method, a way of finding out more about some aspect of reality through a very detailed analysis," (Langrish J., 1993).

This research conducted interviews survey with senior level managers who strongly involve the NPDD (New Product Design Development). The main reasons for choosing current senior mangers as interviewees as follows,

1. They possess the most broad knowledge about this research issue (that is a cross-functional collaboration) from their work experience.
2. They are not only directly posed to charge in this research issue, that is a CFC between departments in their organisation, but they have a role to arbitrate and coordinate problems which came from a boundary between functional departments (Kahn, 1996).
3. They are also respected people who have a broad overview of other functional departments in their organisation (Philips, 1981).

4. They are direct receivers of the information which comes from these research findings

The major research instruments for this research were as follows.

1) Surveying research from a wide cross-section of literature in this research area
2) Synthesising and analysing the findings from the literature survey
3) Selecting appropriate research methods and techniques
4) Using an 'In-depth interview' with open-ended technique: firstly, to discover extensive phenomena and issues related to CFC and CEI, secondly, to evaluate the final information produced from this research work as a conclusion.
5) Using 'Content analysis': to confirm the information, which had been gathered from the In-depth interviews.
6) Using combination of expert experiences and judgements indicated by a focus group using the '*affinity technique*': for synthesis and analysis of the research findings
7) The questionnaire; to include as much as many people's knowledge, and to examine the result of project level design development performances.
   The '*Osgood scales*' was used in this questionnaire.
8) The SPSS (Statistical Package for the Social Sciences): to analysis the data come from questionnaires.

3.3 Research methods and research instrument development in each stage

Eight major stages were undertaken to assure the appropriateness of this overall research. Research methods, research instrument development and the purposes in each research stage are illustrated in the following sub-sections in detail in sequence.

3.3.1 Stage 1: Literature search.

Firstly, an extensive literatures search was carried out, in order to achieve the following purposes.

1. To achieve an understanding of previous research and to provide a context related to this research theme
2. To discover the factors (issues) within CFC for NPDD.
3. To discover performance measurement items for NPDD.
4. To define the research scope, and characteristics of the GCEI (Global Consumer Electronics Industry).
5. To enable the selection of appropriate research methods and techniques

In order to achieve the above aims effectively, the literature was mainly searched for by means of electronic databases, particularly, six database (information) service instruments. These are the BLII (British Library Inside Information) Service, the BIDS (Bath Information and Data Service) including Ingenta Journals, the Infotrac, the ABI/Inform Global (from ProQuest), the Emerald and the Index to theses. Both the electronic database system in Brunel University and the electronic database system at Loughborough University were also cross-searched.

Literature searches were also undertaken from the start of this research to the end on a regular basis.

Each database service instrument, which was used as a major source of this literature search, is briefly explained in Table 4.

Table 4. Database service instruments[1]

BLII (British Library Inside Information)	The British Library Inside Information (BLII) data covers details of every major article in some *10,000 journals*, with international coverage over a wide range of subject areas. The data is supplied by the British Library Supply Centre and provides very up-to-date. Coverage from 1992 onwards.
BIDS (Bath Information and Data Service) include Ingenta Journals[2]	This service was launched in February 1991. BIDS is believed to have been a world first – a national service providing widespread network access to commercially supplied bibliographic databases. BIDS is hosted by the University of Bath and performs an important role in the information strategy of the Joint Information Systems Committee of the Higher Education Funding Councils (JISC), and is one of three data centres funded by the JISC, along with MIMAS (located at Manchester University) and EDINA (located at Edinburgh University). In September 1998, the University of Bath entered into arrangements with Ingenta Ltd under which parts of the BIDS service are provided under a facilities management arrangement by Ingenta on a fully accountable and not-for-profit basis. A major benefit of the relationship is the seamless access for BIDS users to around 2,500 full text electronic journals (This database provides an index of published journals with some full text articles. Coverage includes science, technology, medicine, social sciences and management). The BIDS ISI service provides access to four bibliographic databases supplied by the Institute for Scientific Information (ISI), covering scientific and technical information, social sciences, arts and humanities. Three Citation Indexes cover data from *7500 selected international journals, from 1981 onwards.* **URL:** http://www.bids.ac.uk/
Infortrac	*Covers a wide range of business and management topics.* This

[1] http://www.library.dmu.ac.uk
[2] http://www.bids.ac.uk/info/login/bidsbackground.htm

	database gives access to a combination of newspaper and journal articles, trade publications, company profiles and investment reports. These are mainly in the USA, but Infortrac covers many important HRM (Human Resource Management) titles. It has provided indexing and abstracts for over 1000 titles from 1982 onwards, with articles from over 450 journals available in full-text. It is updated daily. HRL: http://www.infotrac.londen.galegroup.com/itweb/dmu
ABI/Inform Global (from ProQuest)	Contains abstracts of articles drawn from over 1000 business and management periodicals, and full-texts from about 600, including trade and academic publications. ABI/Inform is the leading business abstracting database in the world and its coverage is international and comprehensive. Also, it covers the following Newspapers. - The Guardian: daily newspaper covering the UK - The Independent-London: daily newspaper from London, England, covering the UK - The Observer: Weekly London newspaper published on Sundays - The Sunday Times: newspaper from London, England. - The Times of London: daily newspaper from London, England. **URL:** http://global.umi.com/pqdweb
Emerald	This database contains the full-text of 98 journals published by MCB University Press making it useful for research into all business and management topics. Coverage includes marketing, general management, human resources, quality, property, operations, production & economics, library & information services, information management, training & education and engineering. **URL:** http://www.emerald-library.com/
Index to theses	This **database** is an index to postgraduate theses produced by students at UK academic establishments. **URL:** http://www.theses.com/

3.3.2 Stage 2: Pilot interview

In the early stage of this research, pilot interviews were conducted before doing the main practical research work.

Burgess (1994) stated,

"The interview is the opportunity for the researcher to probe deeply to uncover new clues, open up new dimensions of a problem and to secure vivid, accurate inclusive accounts that are based on personal experience".

This pilot interview had the following purposes.

1. To get a general ideas about this research work and its direction in order to ascertain whether this research has value or not and to forecast difficulties which may be encountered.
2. To outline the characteristics of the GCEI (Global Consumer Electronics Industry)

Method

Semi-structured interviews were conducted with four current design managers in companies. These included Samsung, LG, Daewoo, and Xerox Limited.

Miller (1983) claimed that the semi-structured interview is defined as focusing on a core of standard, questions or topics, with other questions generated from the interviewee's response. It provides the advantage that all individuals' responses can be compared to the core questions and other issues spontaneously raised by the interviewee, can be taken account of. Miller (1983) further suggested that the semi-structured interview provides enough freedom for interviewees to steer the conversation and allows them to express their opinions confirming the influencing factors for further case studies. Therefore, the semi-structured interview was considered the most appropriate for this initial interview to achieve the above objectives.

These pilot interviews were conducted between 17th December 1999 and 10th February 2000.

The interview with the design manger at Xerox Limited was a face-to-face interview in the meeting room at Xerox Limited. This interview took approximately two hours. The other interviews were conducted by phone. Each phone-interview took between one and two hours. Table 5 gives more details about the interviews.

Table 5 General background information about contacted interviewees

Name of company	Name of interviewee	Department	Job title	Approximately time for interview
Samsung Electronics	Kung-Muk Kim	Design Group	Design manager	1 hour
LG Electronics	Jae-Hoon Kim	Design Center	Design manager	40 minutes
Daewoo Electronics	Jung-Wok Go	Design Center	Design manager	1 hour 10 minutes
Xerox Limited	Leslie Wynn	Human interface & Design Development	Design manager	2hours

3.3.3 Stage 3: Interview survey

The main in-depth interviews were conducted in the third stage of the research process.

This survey involved gathering retrospective data based on personal experiences. The interviews in this research stage and the questionnaire in the next research stage constitute the main body of this research.

The aims of in-depth interviews were as follows,

1) To discover and identify the empirical contributory factors affecting CFC in the design development process of consumer electronics products.
2) To discover the performance measurement items (criteria) for product design development and design management in practice.
3) To outline the design development circumstances of consumer electronics products, such as product design development forms and types of organisation structure

This in-depth interview research process can be divided into two steps as follows, Firstly, the preparation stage to conduct interviews, for example, selecting appropriate interview methods (techniques), developing an agenda, preparation to make contact with consumer electronics firms and find suitable interviewees, a mock-up interview. Secondly, the interview processing stage.

3.3.3.1 Step 1: Preparation stage

Consumer electronics companies were searched for in two main ways; these include '*the Kompass Service*' (Reed Business Information, 1999), and '*the Internet search engines*' to conduct field research surveys, which were an interview and a questionnaire survey using in the next steps of this research.

The Kompass Service is one of the most well-known database services, which has company lists and addresses according to the industry sectors (see Exhibit 6).

Exhibit 6. The Kompass (Reed Business Information, 1999)

Kompass Product and Services, 37th edition, England, (http://www.kompass.com/).
The Business to business search engine - 1.5 Million Companies
23 Million key product and service references
2.9 Million executive names
600 000 trade and brand names
50 000 Kompass classification codes in close to 70 countries.

The Internet Search Engines are also a powerful research instrument. Since, the Internet search engines can easily access many kinds of information from each company's homepage. In addition, some consumer electronics companies were contacted through personal relationships with researchers and people who assisted in this research.

As a result, a total of nearly sixty appropriate global consumer electronics companies were contacted. These companies were contacted by post and/or email, and/or phone. Eventually, seven companies agreed to do interviews for this research and eight companies consented to take part in the questionnaire survey in three countries (the UK, Korea and Japan). The seven companies involved in the interviews are leading companies in the consumer electronics industry sector.

On the other hand, during the period of contacting companies, the structured interview questions were designed based on both findings from the literature search and the pilot interview survey. In other words, the agenda for the interviews was produced in this stage. The interview questions were categorised into four dimensions.

Also, the interview agenda was pre-tested by Ray Holland, who is an academic expert in the design management sector, and Leslie Wynn, who is a senior design manager at Xerox Limited, an expert in a practical sense.

The interview questions were as follows.

Agenda for interview

A. In order to get general background information about the interviewee and his/her firm.

Question 1. What is the name of the company you work for?

Question 2. What is the total number of employees?

Question 3. What is the total number of designers?

Question 4. What is your job title?

Question 5. What is the name of your department?

Question 6. How long have you been working for this company?

B. In order to discover contributory factors affecting CFC (cross-functional collaboration)

Question 7-1. What are contributory factors affecting CFC (Cross Functional Collaboration) for product design development in general?

Question 7-2. Why do you think these contributory factors you mentioned are important?

Question 7-3. What are the obstacles affecting each of the above contributory factors?

C. To define the design development circumstances of consumer electronics products, such as, product design development forms and types of organisation structures (the following questionnaires (question 10) are also used here).

Question 8. How many projects does a designer usually undertake at the same time?

Question 9. What percentage of new product design development is conducted in each of the following categories (in-house design, from design consultant) in your company? (Refer to Appendix 1).

Question 10. What percentage of new product design development is conducted in each of the following categories (a. Functional organisation, b. Project organisation c. Lightweight project Matrix Organisation, d. Heavyweight project Matrix Organisation) in your company?

D. In order to get pragmatic information from a real company setting, namely to get information about the measurement items (scales) for design development and design management.

Question 11. Does your company have any criteria or/and scales in order to measure the performance of product design development and design management?

In addition, in order to conduct a more effective and efficient interview, a mock-up interview was carried out with Leslie Wynn, before starting the actual interviews. Some problems in relation to the interviewer's interview techniques were indicated and addressed during this mock-up interview stage. It took approximately 2 hours.

The agenda for the interviews was sent to the interviewees before the interviews were conducted so that they had time to think about the issues.

3.3.3.2 Step 2: Interview Processing stage (research methods)

So as to use appropriate research methods for this interview survey, the following research techniques were undertaken.

Firstly, structured interviews were used to conduct effective interviews in a limited time period.

Secondly, the 'Grounded theory' approach was used to conduct the interviews as it allows to theory emerge from the data according to Glaser B. and Strauss A. (1967). They pointed out that

"Grounded analysis promises the opportunity to gain a holistic understanding of the key interpersonal, group and organisational issues from the perspectives of managers directly participating on NPD activities".

This theory has already been used by several previous researchers, such as Niederkofler M. (1991) and Jassawalla etc (1998) in the business management sector.

One of the primary concerns in this research was not to confine the structure of ideas to existing theoretical categories. Rather than force reality into a pre-formulated, elegant theoretical design and ignore some of the important issues that did not 'fit', it appeared more valuable to design and redesign a model firmly based on empirical research, one that would capture as much of the "real world" scenario as possible.
To build grounded theory in this context it is also best to obtain firsthand knowledge.

Thirdly, In-depth interviews (see Exhibit 7) were undertaken in order to gain enough information with the most knowledgeable managers from the above-mentioned three functional groups. These three functional groups, which are acknowledged as key functional groups that are strongly involved NPD, particularly, NPDD are the design, engineering, and marketing groups (Davies-Cooper and Tim Jones 1995).

Exhibit 7 In-depth interviews

There are three phases with in depth interviewing: input, analysis, and output. *Input* refers to the information obtained from the interviewee, the interviewer's questions, and the interviewee's answers; *analysis* refers to the inferences made by the interviewer about the interviewee's input and behaviour during the interview; end output refers to the conclusions the interviewer makes at the end of this analysis. (Banaka 1971)
Banaka (1971) also defines an in depth interview as
"the gathering of a sufficient amount and kind of information (Input), for thorough analysis (analysis), in order to make accurate decisions about an interviewee's behaviour under certain conditions (output)".

In addition, Smith H. W. (1975) emphasised that the in-depth interview is needed for situations in which the researcher poorly understands his respondent's frame of reference, information levels, and opinion structures.

In this interview survey, in order to extensively gather any different viewpoints about issues affecting CFC in the design development process, not only the design managers but also managers in the marketing departments and engineering departments were interviewed. In total fifteen senior managers were interviewed. In other words, ten design managers including four chief design managers, two marketing managers, two mechanical engineering managers, and one technical senior manager with an engineering background were interviewed.

Fourthly, an open-ended interview technique was also used to get more appropriate and meaningful answers during interview.

"An open-ended question is a question that leaves the respondent free to respond in a relatively unrestricted manner. By contrast, a closed question restricts choice of response by forcing the respondent to respond in terms of present categories or alternatives" (Smith H. W. 1975).

Finally, "content analysis" was also incorporated to collect appropriate information and confirm the findings from the interviews. The data was collected during the interviews, and the data was double-checked with recorded cassette tapes, and then confirmed by each interviewee by Fax, or Email, after the interview.

Patton (1990) describes Content analysis as follows,

"Content analysis is a method of 'identifying, coding, and categorising the primary patterns in the qualitative data,' and a primary tool for making sense of interview transcripts. A simplified description of content analysis is conducted as follows: In order to gain a high level of familiarity with the data, initially listen to the interview tapes and transcribe them. Then each transcript will be examined and: (a) managerial response will be coded to categorisation and comparison across interviews, (b) notes will be written and be drawn about our own learning and what we believe the themes and patterns are that exist in the data.

Themes and patterns might exist in the gathered data if managers from several firms raise similar issues."

3.3.4 Stage 4: Synthesis and Analysis of the findings from both the literature survey and the interview survey

The analysis and synthesis of the findings from both the literature survey and the interview survey constitute the fourth stage of the research.

The aims of this synthesis and analysis stage are the same as the previous in-depth interview survey stage. To remind readers the aims include,

1) To discover and identify the empirical contributory factors affecting CFC in the design development process of consumer electronics products.
2) To discover the performance measurement items (criteria) for product design development and design management in practice.

Methods

Extensive contributory factors affecting CFC were highlighted both within the literature and the interview survey. In particularly a many contributory factors affecting CFC were produced from the in-depth interview survey. But, many factors were repeated or were very similar.

In order to achieve the first aim of this research stage, '*the affinity diagram technique*' was used with the *focus group*, which consisted of specialists in the product design and/or design management sector, to define contributory factors affecting CFC after classifying the many discovered factors. This is used to gather large amounts of verbal data and organize it into groupings based on the relationships between the items (Brassard M. & Ritter D. 1994).

Exhibit 8 shows the affinity diagram technique in detail. Also, the members of the focus group panel for the analysis in this research are shown in Table 6.

Exhibit 8. The affinity diagram (Brassard M & Ritter D. 1994)

*It is **a creative**, rather than logical process.*

Steps in constructing an affinity diagram.

1. All members of the group agree on and understand the problem statement.
2. Each member of the group writes down verbal responses to the problem on 3 by 5 cards or post-it notes, one response per card. This is done independently and in silence. (This step will be versioned in this research, that is, findings from fishbone diagrams will be transferred on papers which are not only attachable but can also be put on a board, Also all letters are the same font and the same size,...)
3. The cards are laid on a table or the post-it notes are stuck on a flat surface in no apparent order.
4. The team members then silently move the cards or notes into clusters that appear to share similar ideas. The notes can be moved as many times as is necessary until the group is satisfied with the clusters. A cluster can contain any number of cards--even one. Often seven to ten clusters will come out of this activity.
5. The group then clarifies and discusses the relationship between the items and assigns a title for the cluster. Many times one of the cards within the cluster will serve as a title for the entire cluster, if not, develop one and place it over the cluster. If there are any items that fell into a miscellaneous cluster, see if they now fit one of the designated clusters

Table 6 The members of the focus group panel

Name of panel members	Careers
Deuk-Soo Kim	- Head of Design Institute / D&C (Design & Communication) Co. Ltd., (1994-1997) - Senior Manager / Design Depart. HaeTae Co. Ltd. (1979-1994) - PhD research student in Business Management at De Montfort University (year 3, 1998-2001)
Sara Maria Ekenger	- Lecturer in Design Management (Module leader on Marketing for Designers and project formulation and supervision on Negotiated project and dissertation) at De Montfort University (1999-2000)

	- MA in Design Management (1998-1999) - Interior Designer (Store – Planner) / IKEA (1995-1998)
Mike Marsden	- Lecturer in Product Design (Module Leader) at De Montfort University - Product designer at Design Unit
Peter Chen	- Lecturer in Art & Manufacture at De Montfort University - PhD research student in Art & Manufacture (Multimedia) at De Montfort University (year 2, 1999-2000) - MA in Design Management (1997-1998)
Bum-Kyu Kang	- PhD research student in Design Management at Brunel University (year 3, 1998-2000) - Assistant design manager (product designer) / Design Department / KEC (Korea Electronics Co.,) (1993-1998)

For the second aim of this research stage, one-dimensional analysis was used. Namely, to eventually develop performance measurement items for the design development of consumer electronics products, all findings through both the literature survey and the practical field survey by means of interviews were summarised and analysed in this section based on the category of item and theme.

The findings from the results of this synthesis and analysis stage also served as the principal basis for designing the questionnaire; the next research stage, in order to define the priority of the significant factors affecting CFC, the correlation between the level of CFC and the performance of product design development, and to define the substantial factors affecting the design development performances.

3.3.5 Stage 5: Questionnaire survey.

As complementary research against qualitative data comes from interview surveys, quantitative data from the questionnaires was also used, which had been gathered from a number of experts from the industry being researched.

The aims of the questionnaire survey were to achieve the following objectives.

1) To define the degree of importance among the factors affecting CFC for the design development of consumer electronics products.

   In addition, the difference in opinion about the degree of importance of each factor affecting CFC for product design development are defined between the following two paired groups

   1-1) Between the designers and non-designers group.

   1-2) Between the less experienced specialists (career spanning under 5 years) group and the more experienced specialists (career spanning over 6 years) group.

2) To define the correlation between the level of CFC and the performance of product design development, and define substantial factors affecting the design development performance.

   This research aim is divided into the following four objectives.

   2-1) To define the correlation between the level of CFC and the total performance of product design development

   2-2) To define substantial factors affecting the total design development performance

   2-3) To define the correlation between the level of CFC and each performance item of product design development in this research. Namely, a) the correlation between the level of CFC and *the time performance* of product design development, b) the correlation between the level of CFC and *the cost performance* of product design development, c) the correlation between the

level of CFC and *the total quality performance* of product design output. d) the correlation between the total level of CFC and *the effectiveness and efficiency of design management performance*.

2-4) To define substantial factors affecting the above each performance items in design development

In order to achieve the above aims, questionnaire with appropriate measurement scales were developed.

This questionnaire survey stage can be divided into three steps as follows.
Firstly, a designing of questionnaire, a pre-test of the composed questionnaire, a translation was made into other languages (A Japanese version and A Korean version), and appropriate consumer electronics firms were contacted.
Secondly, the actual questionnaire survey step (e.g. distribute the questionnaires and collect them)
Finally, the analyses of gathered data by SPSS.

3.3.5.1 Questionnaire design

This research takes an exploratory route because no similar research was found in the design development and design management domain. Two versions of the questionnaire were developed. Version one is for designers and version two is for the other functional group of people who belong to non-design departments but who are strongly involved, share information with each other and influence design activities during the design development process.

The questionnaire was designed with four sections, from A to D (See Appendix 6). Version one consisted of the full question sections from sections A to D. In other words, sections C and D in the questionnaire were designed to measure the performance of

design development and design management. Therefore, version two, which is for non-designers excluded the sections C and D in this research, because they (non-designers) are not sure that they can precisely measure the performance of design development and design management.

On the other hand, this research took the twenty-four factors affecting CFC as measurement items which had been developed by the focus group based on the findings from both the literature and interview survey in the previous stage of this research. The focus group produced two factor groups affecting CFC. These are the twenty-four factor group and the eleven factor group. This research took twenty-four factors affecting CFC than eleven factors, which were finally grouped as factors affecting CFC from the above twenty-four factors in this questionnaire. This is because of the following two reasons.
Firstly, to discover more precisely the ideas of the respondents. Some of the eleven factors are a too broad, which the focus group pointed out.
The second reason was to use the opportunity to define the final factors affecting CFC by the results of quantitative analysis (that is Factor Analysis/Principle Components Analysis) will be combined and compressed to produce a dataset. This Factor Analysis/Principle Components Analysis, which is a method of reducing the number of variables or dimensions used to describe a dataset, was conducted with the data from the questionnaire survey, which is dealt with in the next research survey stage.

For these reasons, this research presents twenty-four factors as measurement items in order to assess the CFC level and to define the priority of importance among the factors in this questionnaire.

The 'Osgood scale' was also used for this questionnaire.

The questionnaire (version One) has five categories.

1. The initial part of the questionnaire (the first page of the questionnaire) gave an assurance that the information received was used only for academic proposes and

explained the research title, the research aims, and gave a the definition of CFC (Cross Functional Collaboration).

2. Five questions in section A were designed for gathering general background information about the respondents.
3. Twenty four questions in section B were designed in order to identify the priority of twenty four contributory factors affecting CFC in the design development process of consumer electronics products, which had been identified and developed from the previous research stage.

   Respondents were asked to indicate on a 7-point scale (1= little importance, 7= extreme importance) how important each factor is as a factor affecting CFC in the design development process of consumer electronics products. A lower score indicates that the respondent thinks the factor is less important than the other factors, conversely, a higher score indicates that the factor is more important than the others.
4. The above same twenty-four questions in section B were used again in section C, in order to measure the level of CFC (cross-functional collaboration) based on a recent new design development project. The reason is that a recent project can be said to be one of the easiest projects to remember and measure the performance of.

   Respondents were asked to indicate on a 7-point scale (1= It was not very satisfactory, 7= Very satisfactory) based on each question, in order to measure the level of satisfaction with each factor in relation to the latest product design development project they had been involved in. The total level of CFC was assessed using the mean value of all factors affecting CFC.
5. In section D, the metrics structure questionnaire was developed to measure the performance of product design development. In order to discover opinions about the total performance of design development and design management, the weight of importance of each measurement item for total design development performance was also asked about. This is because, the weight of importance of each measurement item could be different according to different design development

situations. This could depend on the company, product item, product development concept and market situation.

Respondents were asked to indicate on a 7-point scale (1= It was not very satisfactory, 7= Very satisfactory) in order to measure the level of satisfaction with each item for measuring of product design development in the above same latest project. They were also asked to rate the weight of importance of each measurement item (It was noticed that the total sum should be 100).

The total performance of product design development was assessed by using the sum of each weighted measurement item affecting design development performance.

Table 7 For example: Matrix for design development performance

Measurement items	Weight of importance (the total sum should be 100)	Measurement scale (degree of satisfaction)
Time: (Actual time against plan)	**10**	1 2 3 4 5 6 7 (Very dissatisfied – Very satisfied)
Cost: (Actual cost against plan, Cost comparisons between competitive models)	**10**	1 2 3 4 5 6 7 (Very dissatisfied – Very satisfied)
Total Design output Quality (e.g. Fitness for objectives, Good appearance, Effectiveness of manufacturing, How easy to use, etc.)	**75**	1 2 3 4 5 6 7 (Very dissatisfied – Very satisfied)
Effectiveness and efficiency of design management.	**5**	1 2 3 4 5 6 7 (Very dissatisfied – Very satisfied)

For example, if a respondent gives an answer, as in the above matrix in Table 7, the value of total design development performance was calculated as follows:

The value of total design development performance:

a time (3*10) + a cost (6*10) + a quality (3*75) + a management (5*5) = 340

The total levels of CFC were calculated using the above algorism for each respondent. Therefore, all the design development performance values can be measured between 100 and 700 in this survey. On the other hand, each performance measurement item can be analysed by itself from the above matrix results

Ultimately, section D was designed in order to define the correlation between the level of CFC and the level of design development performance.

In addition, the aim of the questionnaire was indicated before each question, to help respondents to gain a better understanding of the purpose of all the questions in each section. An example was also given in this section in order to reduce the number of mistakes the respondents might make.

On the other hand, the questionnaire was pre-tested by both an academic expert who are specialists in the design management area and experts who are design managers working for a consumer electronics firm. This was done in order to make sure all the contents of the questionnaire were clearly designed to be easily understood.

3.3.5.2 Step 1: The preparation stage for the questionnaire survey

The developed questionnaire was tested using a design manager in each of the three companies (Manager Leslie Wynn at Xerox limited, Manger Jun S. W. at Daewoo, Manager Kim S. K. at LG) before proceeding to the real questionnaire survey stage. Before and after this pre-test stage, the questionnaires were also showed to and finally confirmed by academic experts in design management; Mr. Ray Holland played an active role in the confirmation of the questionnaire. Through this questionnaire testing stage, an example was added at the beginning of each question section to help

respondents understand, and some of the language was modified. During these steps, the questionnaire was modified twice before finally being distributed. (See from Appendix 4 to Appendix 6)

After all these processes, the final questionnaire was translated into Korean and Japanese by an expert translator. This enabled the researcher to survey Korean consumer electronic companies in South Korea and Japanese consumer electronic companies in Japan. These two countries, Korea and Japan, are the strongest countries in the world in the CEI (Consumer Electronics Industry), according to a report in Euromoniter (1997). The questionnaire from English to Korean was translated by the researcher, who is Korean. No one else is responsible for the translation of the questionnaire into Korean. The translation from English to Japanese was conducted by "Ilbononet"[3], the largest and most reliable translation company in South Korea. "Ilbononet", which only deals with translations from Korean and Japanese, has 25 full-time expert translators and 200 part-time translators. This questionnaire was translated by a bilingual translator, and confirmed again by the other translators in the same company.

3.2.5.3 Step 2: Questionnaire processing stage (data distribution and collection)

The questionnaires were distributed to eight global consumer electronics firms in three countries (Korea, Japan, and the UK). All eight of these companies are top level, leading companies in the global consumer electronics industry sector. These companies also produce and sell their products for the global market based on local factories and subsidiaries throughout the world. Seven out of eight companies are the same companies that were contacted in the interview survey of this research. One company,

[3] http www ilbono.net

which was included in this questionnaire, was KEC (Korea Electronics Co.), in South Korea; it is also a large consumer electronics manufacturing company working in the worldwide marketplace. Exhibit 9 briefly explains about KEC.

Exhibit 9 About KEC (Korea Electronic Co.,)[4]

1. Overview about KEC (Korea Electronics Corporation)
Established back in 1969 during the early years of the Korean electronics industry, KEC is on track to become one of Korea's leading general electronic components & products manufacturers with sales of over US$ 1.2 billion by the early 2000s. Backed by a 330,000 m2 production facility in Kumi, South Korea, the nine-company KEC Group, and a growing overseas network, 2. Main electronics products: Colour TVs, VCPs, CRT monitors/LCD monitors

Version One questionnaires were distributed to designers. Version Two questionnaires were distributed to other functional departments that strongly involve the NPDD (New Product Design Development). These departments, which are widely acknowledged by both the literature (Rothwell & Whiston 1990, Song et al. 1997, 1998, Woodward 1965) and the field interview survey, are the marketing (including sale &planning) department, the R&D (engineering) department, and the manufacturing department.

Both version questionnaires were distributed to the above-mentioned eight global consumer electronics companies. In administering the mail survey of this questionnaire, this researcher followed an adapted procedure for the survey research (Dillman 1978) with the modifications suggested by Song X. M., Montoya-Weiss M. M., and Schmidt J. B (1997). The first mailing packet included a personalised letter to the managers who had been contacted and met for interviews during the previous research stage. These senior managers were contacted and asked to help with the distribution and collection of the questionnaires. Most of these questionnaires were distributed by the managers, but stamped addressed envelopes were enclosed in the questionnaire envelope, in the case of consumer electronics companies in Japan. The other questionnaires, which were distributed to consumer electronics companies in Korea and the UK, were collected by

directly visiting the companies. Several phone calls were made in order to improve the return ratio of the questionnaires.

3.3.5.4 Step 3: Analysis stage of questionnaire data

In the third step, the gathered data from the questionnaire survey was analysed by means of the SPSS (Statistical Package for the Social Sciences) -Version 10.0 and the Excel programme (MS Office 2000).

As Norusis (1993) pointed out,

"the SPSS (Statistical Package for the Social Sciences) is one of the most popular and most powerful statistics software packages available for the social sciences area".

In order to analyse the questionnaire survey data, Excel (MS Office 2000), T-test Analysis, Regression Analysis, and Factor Analysis/Principal Components Analysis were used as a main analysis instruments in the SPSS. These analysis packages were discussed and suggested by Dr. Denis Anthony (1999), who is the author of the book 'Understanding Advanced Statistics', and Dr. Kim N. Y. who is a lecturer in the Statistics department at Korea University.

The aims of each statistical package were as follows.

1) Excel (MS Office 2000): for the cording data, and the analyses of the general characteristics of the respondents from the questionnaire survey. The data that was collected from section A in the questionnaire was dealt with using this. Also, it was used to deal with mean data for the identification of the grades of importance given to the contributory factors affecting CFC.

4 http://www.keccorp.com

2) Factor Analysis/Principal Components Analysis: to reduce factors affecting CFC after grouping based on principle similarities.

   Denis Anthony (1999) explained these analysis tools as follows.

   - *"Principal Components Analysis is a special case of Factor Analysis"*
   - *"Factor Analysis/Principal Components Analysis is a method of reducing the number of variables or dimensions used to describe a dataset"*
   - *"Factor Analysis/Principal Components Analysis is typically used to explore data"*

3) Independent T-test analysis: to define the difference in opinion about the degree of importance of each factors affecting CFC for product design development between different groups (between the designers group and the non-designers group; between the less experienced specialists group and a more experienced specialists).

4) Regression Analysis & Correlation Analysis: firstly, to define the correlation between the level of CFC and the performance of product design development, and secondly, to identify contributory factors affecting the design development performance in several dimensions.

   Denis Anthony (1999) also explained these analysis tools as follows.

   - *"Regression Analysis explores the possible relationship between two or more variables"*
   - *"Regression is a technique for predicting one dependent variable from one (simple linear regression) or more (multiple regression) independent variables. It makes assumptions about the data (e.g. normality and linearity)"*
   - *"Correlation Analysis is a measure of how much one variable appears to be related to another variable, but it does not prove causation"*
   - *"Correlation Analysis is the basis for other more powerful techniques such as Regression, Factor analysis, and principal Components analysis"*.

Chapter 6 deals with processes of these analyses and the results in detail.

3.3.6 Stage 6: Development of a new framework model of CFC

After the above-analyses of data, which has been produced from a literature survey, interview survey, and questionnaire survey, all the findings were compressed and reproduced with in a new conceptual framework model of CFC (Cross-Functional Collaboration) for design development of consumer electronics products. This visual framework model includes the main information, which was produced from this research.

This model further described in chapter 6, which deals with the analysis and results of the questionnaire survey in detail.

3.3.7 Stage 7: Evaluation of the usability of the new framework model of CFC

The usability of the new framework model, which was developed using the information from the results of this research, was evaluated at the end of this research stage.

Aim

To evaluate the new framework model's information on CFC and to examine the usability of this framework model (information) in practice.

3.3.7.1 Research methods for an evaluation of the new framework model.

The results of this exploratory research were produced from the qualitative research work rather than quantitative research. This is because of the nature of this research topic, which deals with very diverse and intangible data.

In order to assess the usability of the new framework model in the evaluation stage of this research, a structured interview with the open-end technique was adopted as a qualitative evaluation technique.

This research focused on contacting high quality interviewees rather than a number of interviewees during this evaluation stage of the research. Eventually, five chief or senior design managers in this research sector were contacted as interviewees. The companies they work for include Hitachi, Samsung, LG, Daewoo, Xerox limited.

In addition, the reasons for choosing current chief or senior design mangers as interviewees for the evaluation of the usability of the new framework model were the same as has been previously noted in Section 3.3.3 the in-depth interview stage in this chapter.

The following three main stages were used in this research for this evaluation. They were also further divided into six steps.

3.3.7.2 Stage 1: The preparation stage for interviews

Firstly, the interview agenda was designed with an explanation of the research aims and research results; the diagram was included, which shows the main results of this research work.

Secondly, the developed interview agenda was shown to and confirmed by academic experts in design management; Mr. Ray Holland who is a course director for the MS/MSc in the Department of Design at Brunel University. During this step, the interview agenda was modified.

Finally, this interview agenda consisted of five main questions which were developed (see footnote[5], see appendix 10 further details)

Thirdly, the confirmed interview agenda was translated into Korean, too.

Fourthly, this interview agenda and an explanation of the research results with a diagram were sent by email before conducting the interview. It was also confirmed that interviewees had received this interview agenda and the visual diagram file (the framework model) before taking part in the interview. After that, convenient interview times were arranged.

3.2.7.3 Stage 2: The interview stage

Fifthly, two face-to-face interviews with the chief design manager at Hitachi and the senior design manager at Xerox Limited were conducted in a meeting room at each company. Fortunately, face-to-face interview was conducted with the chief design manager, Mr. Taisuke Kashima, at Hitachi, because he had been working at the Hitachi Home Electronics Europe Ltd. in the UK since 2000. These two interviews were also recorded using a cassette recorder to prevent any comments being misinterpreted. The other three interviews were conducted by phone because these the design departments of these three companies are located in South Korea.

The interviews consisted of four steps.

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[5] Question one: To what extent does this theoretical model support and challenge existing thinking in your organisation?
Question two: What areas in relation to CFC (Cross-Functional Collaboration) need to change in your company: Base your answers on the factors in the model?
Question three: Please comment on the relative values attributed to the other factors.
Question four: How can this theoretical model be used to improve practice in order to enhance CFC (Cross-Functional Collaboration) in design development?
Question five: Do you have any comments on these results, which are shown in the proposed new model of CFC?

First step, the aims and results of this research were explained. The information, which is included in the new framework model of CFC (diagram), was also explained

Second step, opportunities were given to interviewees to ask questions before starting the main part of the interview.

Third step, five main questions were posed, also the interviewee's answers were noted at the same time.

Finally, answers given by interviewees were confirmed after finishing the interview.

3.3.7.4 Stage 3: Evaluation and conclusion stage

As a final stage for the evaluation of the model of CFC, the contents of the interviews were summarised, and conclusions were drawn about the model of CFC.

3.3.8 Stage 8: Conclusion

As a conclusion, all research findings were reviewed and summarised.

Furthermore, finally, the new framework model for factors affecting CFC is proposed as a central result of this research work.

Also, future research work is recommended.

Chapter 4: Review the findings from literature search

Chapter 4: Review the findings from literature search

4.1 Introduction

This chapter presents the findings from the literature, regarding the issues of collaboration or cross-functional collaboration and the measurement items for design development performance and design management.

This chapter (Section 4.2) starts with a taxonomy of the previous research work, was related to the area of this research. Section 4.3 presents the contributory factors affecting collaboration from the existing NPD literature, and discuss difference between the existing research work, which discovered factors affecting collaboration, and this research work, which defines the factors affecting CFC for the design development of consumer electronics products. Section 4.4 explains the difficulties of evaluating design performance, the necessity of balance between quantitative and qualitative measures of design performance, and finally it presents the findings of evaluating items for design development performance from the literature search.

4.2 Taxonomy and characteristics of previous research works in this research area.

The related publications in the area of collaboration have not only been broadly cross searched in terms of collaboration/cross-functional collaboration, but also in terms of cooperation, interaction, integrated coordination, partnership, and alliance in NPD literature.

Through this literature search, a number of publications pertaining to cross-functional collaboration in NPD literature, particularly, collaboration between marketing departments and R&D departments were found. However, little information was found about cross-functional collaboration based on the NPDD (New Product Design Development) process.

As a result, fifty-four research works were found. These were publications related to collaboration or CFC (Cross-Functional Collaboration) in the NPD area of literature could be largely classified into four categories according to the main theme of the research. These are grouped as follows,

1) The significant collaboration/CFC in NPD and/or the performance between levels of collaboration/CFC and NPD success
2) Contributory factors affecting collaboration/CFC in NPD
3) Approach methods for collaboration/CFC in NPD
4) The analogous themes related to collaboration/CFC, for instance, integration, coordination, alliance, and interface among functional departments in NPD

Furthermore, each category can be further divided as follows:

2) Contributory factors affecting collaboration/CFC in NPD divided into two categories according to organisational limitation. Firstly, the contributory factors affecting collaboration in a general situation without any concrete limitations, the other category is the contributory factors affecting collaboration focused on a team organisation.

3) Approach methods for collaboration/CFC in NPD were divided into two areas according to the hardware approach method or the intangible managerial approach method. The hardware approach here means a method using a hardware system, such as a computer network or CAD system for collaboration or CFC in NPD. The intangible managerial approach method uses supporting theoretical information, for example, conceptual knowledge about conflict and conflict resolution between functional groups, emphasising the communication roles for a supporting collaboration etc.

4) The analogous themes related to collaboration or CFC can be divided into six sub-categories, these are Integration among functional departments in NPD, Interactions among functional departments in NPD, Coordination among functional departments in NPD, Alliance (partnerships) among functional departments in NPD, Interface functional departments in NPD, and Others. Table 8 shows details about research work and authors in the form of a taxonomy according to thematic area.

Table 8. Overview of literatures related to CFC

Themes (categories)		**Researchers**
1. The significant collaboration/CFC in NPD and/or the performance between levels of collaboration/CFC and NPD success.	The significant collaboration/CFC (cross-functional collaboration) in NPD	Slade (1989), Beckwith D. & Harris D. (1993), Faust W. (1993) , Walker D. (1993), Beckwith D. (1994), Littler D., Leverick F. and Bruce M. (1995), Rachel Cooper & Mike Press (1995), Jassawalla A. R., Dawson P. (1996), Kahn K. B. (1996) , Leonard D., Straus S. (1997), Herbruck D. & Umback S. (1997) Sashittal H. C. (2000)
	The performance between levels of collaboration/CFC and NPD success.	Soulder (1977, 1987) Littler D., Tjosvold (1988) Leverick F. and Bruce M. (1995), Kahn K. B. (1996), Song X. M., Montoya-Weiss M. M., Schmidt B. J. (1997)
2. Contributory factors affecting collaboration in NPD	Contributory factors affecting collaboration in general	Appley and Winder (1977), Soulder (1992), Song X. M., Montoya-Weiss M. M., Schmidt B. J. (1997), Kahn K. B. (1996), Schwartz and Davis (1981)

	Contributory factors affecting collaboration based on teams	Parker G. M. (1994), Littler D., Leverick F. and Bruce M. (1995), Shapiro B. (1995), Jassawalla A. R., Sashittal H. C. (1998), Jassawalla A. R., Sashittal H. C. (2000)
3. Approach methods for collaboration in NPD	using of hardware	Cook G. L. and Eining M. M. (1993), Favela J., Imai K. and Connor J. J. (1994)
	using of software	Olson E. M. (1993, 1994), Sonnenwald D. H. (1996)
4. The analogous themes related to collaboration	*Integration* among functional departments in NPD	Dean Tr. J. W., Rusinko. (1992), Dias W. P. S., Blockley D. I. (1994), Leonard-Barton D., Bowen H. K., Clark K. B., Holloway C. A., and Wheelwright W., (1994), Rafii F. and Perkins S. (1995), Shapiro B. (1995), Kahn K. B., McDnough E. F. (1997), Song X. M., Thieme R. J. and Xie J. (1998), Susman G. I., Liker J. K., Collins P. D., Hull F. M. (1999),
	Interactions among functional departments in NPD	Carlsson (1991), Griffin at el. (1992) Ruekert R. W. (1995)
	Coordination among functional departments in NPD	Klein M. (1995), Perry M. and Sanderson D. (1998)
	Alliance (partnerships) among functional departments in NPD	Larson A. (1991), Niederkofler M. (1991), Kahn K. B. (1996), Farr C. M. (1992)
	Interface among functional departments in NPD	Ellis S. R. (1994), Mukhopadhyay S. K. and Gupta A. V. (1998),
	Others.	Gorb P. and Dumas A. (1987), Herbruck D. & Umback S. (1997)

Other literature related to collaboration, integration, cooperation and alliance, outside of NPD has also been found, but the studies have not been detailed here because they are not within the scope of this research.

Over two thirds of the research works, which are presented above, were studied at the NPD (New product Development) level rather than NPDD (New Product Design Development) level. Only nine of the above fifty-four research works focused on the design area.

4.3 Contributory factors (issues) affecting collaboration from the NPD literature

To define contributory factors affecting CFC for the design development of consumer electronics products is one of the main aims of this research.

An extensive literature search, which investigated the contributory factors affecting collaboration and/or CFC, was conducted in order to understand and gather factors affecting collaboration. As a result, nine research works were found from this literature search. Four works illustrated contributory factors affecting collaboration in general. The other five works highlighted contributory factors affecting collaboration or CFC based on both 'a Team project' and 'a whole NPD process'. A summary of contributory factors affecting collaboration in general from the literature is shown in Table 9.

Table 9. Summary of factors affecting collaboration in general from the literature

Author(s)	Findings (attributers)
Appley and Winder (1977)	1) Share mutual aspirations and a common conceptual framework 2) Interaction
Schwartz and Davis (1981)	1) A dramatic change in organisational climate and culture 2) Lower levels of management to work with other departments, thereby decentralising authority 3) An unstructured, involved process
Soulder and Moenaert R. K. (1992)	1) Interaction 2) Information sharing 3) Coordination of activities
Kahn K. B. (1996)	1) Achieve goals collectively 2) Have a mutual understanding 3) Informally work together 4) Share idea, information, and resources 5) Work together as a team

The contributory factors, which have been discovered as being contributory factors affecting collaboration or CFC in the team organisation structure, from the other five papers have been summarised in Table 10.

Two papers are presented by the same researchers, Jassawalla & Sashittal (1998, 2000), and the other three are presented by Parker (1994), Littler et al. (1995), Shapiro (1995)

Shapiro' research work defined factors affecting CFC within the term 'integration'. In other words, the term 'integration' should also be compared with collaboration, as Kahn (1996) has pointed out. He has suggested that interdepartmental integration is a composite process comprising *interdepartmental interaction* and *interdepartmental collaboration*, as was noted in the previous section in chapter 1, 'philosophies underlying interaction and collaboration'. In line with this way of thinking, integration can be interpreted more widely meaning to include collaboration

Table 10. Contributory factors affecting collaboration in NPD focused on the team organisation from the literature

Author(s)	Findings (Contributory factors)	Research methods
Littler D., Leverick F. and Bruce M.	Littler et al have specified factors affecting outcomes of collaborative product development a) Collaborative 'input factors' - Choice of a suitable partner - Establishing clear objectives for collaboration - Allocating sufficient resources - Drawing up procedures for accountability and control b) Ongoing collaborative 'management factors' - Ensuring frequent communication between partners - Frequently monitoring progress - Building a climate of "trust" - Attempting to ensure equality of contribution and benefit	Questionnaire Total 106 companies in the UK Manufacturers within the information and communications technology industry.
Jassawalla A. R. and Sashittal H. C.	They have found two critical elements, which are 'information sharing' and 'mutual understanding' as contributory factors affecting human interaction in NPD. Their study also shows that 'equitable power', 'transparency' and 'mindfulness' are critical factors	Interviews 40 Managers from 10 firms

	for sponsoring higher levels of synergistic inter-functional interactions in a CFT (Cross Functional Team). Furthermore, the following factors were suggested as factors affecting collaboration in CFT in other research works. a) Implicitly acknowledge that all NP (New Product) participants are reciprocally interdependent; b) Feel a sense of belongingness and cohesion that they attribute to their involvement in NP activities; c) Feel a sense of ownership and personal stake in NP activities and its outcomes; and d) Participate in moving the NP activities purposefully forward	
Parker G. M.	Parker has also pointed out the factors the effectiveness of cross-functional teams as follows: a) Leadership b) Empowerment c) Shared goals d) Boundary management e) Performance appraisal f) Team rewards system rather than individual rewards system g) Interpersonal relationships h) Team size i) Managerial support	No mention in the papers about research methodology
Shapiro B.	Ben Shapiro has identified six approaches that can encourage efficient and effective cross-functional integration in NPD as follows; a) Unified strategy b) Integrative organisational systems c) Management process and systems d) Information systems and related electronic communication systems e) Informal social systems f) Appropriate skills, experiences and attitudes	No mention in the papers about research methodology

There are mainly two differences between the five studies above, which discovered the contributory factors affecting the cross functional collaboration, and this research.

Firstly, the five studies discovered the contributory factors affecting the CFC based on whole NPD rather than NPDD (New product *Design* Development), which is this research more focuses on.

The second difference is that the findings, which are contributory factors from the previous researches, were produced based on a cross-functional team and recommended

for the team in the research.

Katzenbach and Smith (1993) have defined a team as follows, which is the most frequently quoted definition of the term team in business literature.

"A team is a small number of people with complementary skills who are committed to a common purpose, performance goals and approach for which they hold themselves mutually accountable".

Karl and Steven (1995) underlined that a team is said to be one of the strongest organisational forms for collaborative work. By contrast, this research aims to discover and define the contributory factors affecting CFC by focusing on functional organisation, which is said to be the most difficult organisation types to create harmony among functional groups (Karl and Steven, 1995). Interestingly, almost all consumer electronics products are being developed under a functional organisational structure rather than a cross-functional team organisation. This fact has been proved by the results of the interview survey in this research which is great dealt with in the next chapter.

There might be a difference in motivation for a collaboration and attitude between a team based project and a non-team based project in NPDD (New product Design Development).

In the case of NPDD in a functional organisational structure, a designer carries out product design development as an owner in the design development stage of whole NPD with support from other functional experts as assistants who support information. Therefore, collaborative members who come from other functional departments do not normally share accountability for the results of the design output. In the case of NPDD in a cross-functional team based project, by contrast, all members who come from the other functional departments usually share accountability for product design output. So it is easily to imagine that there could be a difference in motivation for a collaboration and attitude between the two organisations

For this reason, there should be more attention focused on collaboration issue in a functional organisational structure in NPDD rather than in a cross-functional team. However, the existing research works related to this issue area were conducted focused on team project.

Therefore, this research has distinguished aims focused on a different research scope in comparison with the existing research. In other words, the purpose of this research is not only to identify factors affecting collaboration in team based projects and the whole NPD based process; but also this research more focuses on issues affecting CFC based on both NPDD and the functional organisation. The aims of this research can be seen as a further extension of previous work in this research area because it produces clearer and more precise information focused on product design development.

From a wide view point, the findings from the literature search could help to guide issues affecting CFC.

The contributory factors affecting collaboration from previous literature have been summarised in order to broadly understand them. As a result, forty-two factors were discovered as factors affecting collaboration/CFC. These are shown in Table 11 with references. Later, these forty-two factors are synthesised and analysed after being added to factors highlighted in the field interview survey using the 'affinity technique', which is a well known method gather large amounts of verbal data and organize it into groupings based on the relationships between the items.

Table 11 The factors affecting collaboration after analysis of the literature survey.

Factors (issues) [number of repeated]	Author(s)
- Management process and system [1] - Integrative organisational systems [1] - Unstructured, involved process [1] - Team size, in the case of team project [1] - Work together as a team [1] - Empowerment [1] - Equitable power [1] - Lower levels of management to work with other departments, (decentralising authority) [1]	Shapiro B.(1995), Schwartz H. and Davis S. (1981), Kahn K. B. (1996), Parker G. M. (1994).

- Managerial support [1] - Drawing up procedures for accountability and control [1] - Boundary management [1] - Coordination of activities [1] - Attempting to ensure equality of contribution and benefit [1] - Frequently monitoring progress [1] - Performance appraisal [1] - Team rewards system rather than individual rewards system and recognition [1]	Soulder and Moenaert R. K. (1992), Parker G. M. (1994), Leverick F. and Bruce M. (1995)
- Interaction [2] - Information sharing [2] - Sharing of ideas, information, and resources [1] - Ensuring frequent communication between partners [1]	Soulder and Moenaert R. K. (1992), Appley and Winder. (1977), Kahn K. B. (1996), Jassawalla A. R. and Sashittal H. C. (2000), Leverick F. and Bruce M. (1995)
- Feeling a sense of belonging and cohesion [1] - Participate in moving the NP activities purposefully forward [1] - Mindfulness [1] Feeling a sense of ownership and a personal stake in NP activities and their outcomes [1] - Achieve goals collectively [1] - Leadership [1]	Kahn K. B. (1996), Jassawalla A. R. and Sashittal H. C. (2000), Parker G. M. (1994).
- Choice of a suitable partner [1] - Appropriate skills, experiences and attitudes [1] - Interpersonal relationships [1] - Implicitly acknowledge that all NP (New Product) participants are reciprocally interdependent [1]	Parker G. M. (1994) Litter D., Leverick F. and Bruce M. (1995), Shapiro B. (1995).
- Establishing clear objectives [1] - Share mutual aspirations and a common conceptual framework [1] - Shared goals [1] - Unified strategy [1]	Appley and Winder. (1977), Sheth J. N. and Parvatiyar A. (1993), Shapiro B. (1995), Litter D., Leverick F. and Bruce M. (1995), Kahn K. B. (1996) Jassawalla A. R. and Sashittal H. C2000).
- A dramatic change in organisational climate and culture [1] - Building a climate of 'trust' [1] - Transparency [1]	Schwartz H. and Davis S. (1981), Litter D., Leverick F. and Bruce M. (1995), Jassawalla A. R. and Sashittal H. C. (2000)
- Have a mutual understanding between partners, [2]	Kahn K. B. (1996), Jassawalla A. R. and Sashittal H. C. (2000)
- Informally work together [1] - Informal social system [1]	Kahn K. B. (1996). Shapiro B. (1995).
- Allocating sufficient resources [1] - Information systems and related electronic communication systems [1]	Litter D., Leverick F. and Bruce M. (1995), Shapiro B. (1995).

4.4 Measurement items for product design development performance

4.4.1 Difficulties of evaluating design development performance

Although some studies have been carried out on the productivity of design (Potter S., Roy R., etc. al 1991, Walsh V. etc al. 1992) and there are schemes aimed at providing a benchmark for good design practice like the British Design Awards (Temple P. & Swann P. 1995), nevertheless "*there is a dearth of evidence on how to actually evaluate the design activity*" as Walton T. (1994), who is editor of the Design Management Journal, pointed out.

Four reasons why performance evaluation of design has received very little attention can be found as Nixon (1999) point out. Firstly, there are difficulties in measuring such a pervasive design activity. A major difficulty according to the report by the OECD (Organisation for Economic Co-operation and Development, 1994) is that design collaboration in many disciplines; an output measure like sales, profit margins, time to market or image change, may be commercially worthless unless it can be quickly translated into a working model. However, it is technically very difficult to apportion output to the respective input; besides, any such apportionment requires careful consideration of the potential dysfunctional behavioural consequences. A second difficulty is the nature of design which includes engineering and industrial design which has to be related to the form, function and ergonomics of products as well as the graphics, identity and communication design which creates powerful brands and corporate images (Bill N. 1999). A third difficulty in measuring the productivity and effectiveness of design is the protracted time period between the intensive design phase and commercialisation. A further obstacle to performance measurement of design is that such measurement is frequently perceived more as a constraint on the creativity that is the essence of good design than as a means of balancing customer value and cost needs with top management's need for cash flow and profitability. (Nixon B. & Innes J. 1997).

4.4.2 The balance between quantitative and qualitative measures of design performance

Bill Nixon (1999) suggests that the balance between quantitative and qualitative measures of design performance is needed depends on the following three factors, which he detailed after comparing both engineering design which is mostly concerned with product functionality and industrial design which focuses on product appearance, in two case studies:

a) *The nature of the design: for example, the objectives and measures for the engineering design project were much more quantitative than those for the industrial design project which related to product identify and were mostly qualitative;*
b) *Whether the design is innovative or more incremental; the greater the uncertainty the more qualitative the measures;*
c) *The stage in the product life cycle; a movement over time from relatively soft information and strategic criteria to more reliable and operational measures as uncertainty is reduced.*

Chung K. W. (1999) add another perspective,
"it is very dangerous that measuring the design performance depends on only quantitative ways because clear limitations exist to measure emotional qualitative factors such as an aesthetic, users' tastes, users' satisfaction, etc with quantitative methods".

4.4.3 Evaluating items for product design development performance

Perhaps, because of the above-mentioned reasons in the former section, '4.3.1 Difficulties of evaluating design performance', very little research work has been done about evaluating the performance of design development. In comparison, the literature review revealed that performance measurement research to date has been largely confined to manufacturing metrics (A. K. Kochhar 1994, B. Maskell 1991) and organisational measurement systems (M.J. Gregory 1993, S. Globerson 1985). Some research has been carried out into product development but the studies have focused on complexity, success and failure aspects (A. Griffin 1996) and strategy (B. Barczak 1995). R&D management examined in a couple of recent surveys (A. K. Gupta etc. 1996, Drongelen, etc.1996) offered some insight into the way R&D is being measured. There has been little interest in the measurement tools and methods to manage the product development process. Existing measurement tools focus very much on the strategic level with minimal involvement from the designers and developers of the products. Furthermore, there was extremely little evidence of work that examines performance in the context of product design and product design development, as Kulwant S. Pawar, etc. (1999) pointed out.

On the other hand, as Kaplan R. S. & Norton D. P. (1992) stated,

"there is a consensus within the literature on design performance measurement that effective metrics are, above all, well-integrated and balanced between strategy and operations and reflect accurately the objectives of the key perspectives."

Despite the extensive literature search related to measuring performance of product design and product design development, eventually, only two very recent research work (Kulwant S. Pawar, etc. 1999, and K. W. Chung 1999), which were related to some possible methods of evaluating design performance, were found. Both research works by Kulwant S. Pawar, Helen Driva (1999) and by K. W. Chung (1999) presented some

measurement items for evaluating the performance of product design or design team projects. Pawar and Driva (1999) presented five categories of measurement items from 30 possible measures for the performance of product design project teams as a result of their longitudinal case study (over a period of 18 months) through questionnaires, semi-structured interviews, observation and document searches in domestic appliances companies. They condensed and identified five measurement items for the performance of product design team projects as a conclusion to their research work. These five measurement items are

Time: Actual time against plan,

Cost: Cost comparisons (between competitive models),

Quality,

Flexibility, and

Management.

On the other hand, the criteria of selection principles for good design awards in nine countries were surveyed and presented by Chung K. W. (1999), who is the chairman of KIDP (Korea Industry Design Promotion), after investigating twelve countries (see Table 12). He (1999) also identified these surveyed criteria for good design awards after dividing them into eight categories based on affinity among criteria items as main factors for the evaluation of design output. These eight category groups are *'formative (good appearance)', 'fitness for function', 'economic, effectiveness of manufacturing', 'easy control', 'fitness for market and users', 'satisfaction for social trends and users' emotions', and 'familiarity with environment'.*

Table 12 shows the country the name of the award and the criteria of selection principles for good design awards in each country.

Table 12. The criteria of selection principles for good design award in twelve countries

Country	Name of award	Criteria of selection principles for good design award
England	British Design Award	Innovative ideas etc
USA	Industrial Design Excellence Awards	Innovation of design concept, proper materials, economical manufacturing process, easy to use,

		good appliance for users, useful for society, etc
Sweden	Utmarkt Svensk Form	Design, technology, function, quality
Finland	Pro Finish Design Award	High quality and innovative ideas in a manufacturing and a design
Yugoslavia	Biennial of Industrial Design	Economics, technology, Visually appealing (aesthetically pleasing), user friendly form
Norway	Good Design Award	New ideas, economical proper materials, high level of function for users, Visually appealing (aesthetically pleasing)
Taiwan	Selection of Good Design Products	Creativity, functionality, easy to use, Visually appealing (aesthetically pleasing), economics
Japan	Selection of Good Design Products	Visually appealing (aesthetically pleasing), functionality, quality of product, safety of product, etc (price, way to manufacture)
Korea	Good Design Products Selection	Visually appealing (aesthetically pleasing), functionality, safety of product, quality of product
	Korea industrial Design Awards	Innovation level, Visually appealing (aesthetically pleasing), quality of products

These findings from two research works related to evaluating design development performance or design output performance are analysed again with the items which were gathered from the interview survey to develop the measurement scale for measuring design development performance. This is dealt within the next chapter, which includes the results of the interview survey, and the analysis of the findings from both the literature survey and interview survey.

Chapter 5: The results of interview survey, and the analysis of the findings from both the literature survey and interview survey

Chapter5: The results of interview survey, and the analysis of the findings from both the literature survey and interview survey

5.1 Introduction

From the pilot interviews with four design managers before conducting the main interview survey, the aims of this research were positively assessed. All interviewees in the pilot interview survey stage agreed that this research work is worthwhile and the information produced from this research will be useful. Furthermore, valuable information, which was gathered during this stage, helped in the design of this research methodology.

This chapter presents the results of the interview survey and the analysis of the findings from both the literature survey and interview survey. Firstly, this chapter starts with an introduction to the interview survey aims. Section 5.2 briefly describes general

background information about contacted companies. Section 5.3 describes general background information about contacted interviewees. Sections 5.4 to 5.8 deal with the results of the interview survey and the analysis of the findings from both the literature survey and interview survey. Section 5.4 presents the number of projects, which a designer usually undertakes at the same time. Section 5.5 presents the general organisational structure of product designs development in CEI. Section 5.6 presents the percentage of organisation structures for a new product design development in CEI in detail. Section 5.7 presents factors affecting CFC after summarising both the findings from the literature survey and field interview survey. Section 5.8 presents developed measurements to assess the design development performance of consumer electronics products through summarising both the findings from the literature survey and field interview survey.

The aims of the interview survey were,

a) To discover and identify the empirical contributory factors affecting CFC in the design development process of consumer electronics products.
b) To discover the performance measurement items (criteria) for product design development and design management in practice.
c) To describe the design development circumstances of consumer electronics products, such as product design development types of organisational structure

5.2 General background information about contacted companies

(Data from: Interview question 1-3; see footnote[6])

Seven leading global consumer electronics firms were approached and in-depth interviews were conducted with fifteen chief and/or senior level managers who possess the widest knowledge about the NPDD (New Product Design Development) within their firms. These seven companies are Samsung Electronics, LG Electronics, Daewoo Electronics, Hitachi Home Electronics, Toshiba, Fuji Xerox, and Xerox Limited (Europe Xerox). All seven companies are large, top-level companies in the global consumer electronics industry, which is this research area.

These seven companies can be largely divided into two groups according to their business characteristics and products. Five companies, Hitachi Home Electronics, Toshiba, LG Electronics, Samsung Electronics, and Daewoo Electronics, can be seen as one group, which develops and produces a variety of products. For example, these companies produce and sell audio & video sets (TV sets, MP3 players, VTR, DVD, etc), computing products (monitors, notebook PCs, printers, Faxes etc), home appliances (microwave ovens, air conditioners, vacuum cleaners, refrigerators and washing machines), telecommunication products (Mobile phones, web video/screen phones, etc.). In contrast, Xerox, which can be placed in the other group, produces and sells only a few items, which are very high-tech mechanical products related to the documents industry. Xerox is divided into three companies: these are Xerox Corporation (America Xerox), Xerox Limited (Europe Xerox) and Fuji Xerox. These companies develop and produce electronic products mainly for the business sector market, such as copy machines and printers, but these kinds of products can be largely included in the consumer electronics products sector. For example, in the case of printers, these are

[6] Question 1. Name of company?
Question 2.Total number of employees?
Question 3. Total number of designers?

now commonly recognised and used as consumer products which are used by general consumers, even if these products originally began as business products.

On the other hand, Xerox Limited (Europe Xerox) and Fuji Xerox are dealt with as two companies in this survey, because these two companies not only develop and produce products for different contexts, they also have different process focus for different market places. In particular, Fuji Xerox Co., Ltd. (Fuji Xerox), which is an unconsolidated entity jointly owned by Xerox Limited and Fuji Photo Film Co., Ltd., are administrated differently within a different organisational structure, and different culture when compared to Xerox Limited (Europe Xerox). Moreover, Xerox Limited is located in Europe (in the UK) for the European market place, but Fuji Xerox is in Japan and the Pacific Rim. Approximately 90 percent of Fuji Xerox revenues are generated in Japan, with Australia, New Zealand, Singapore, Malaysia, Korea, Thailand, and the Philippines representing the remaining 10 percent (Annual report 1999[7]). For these reasons, Xerox Limited (Europe Xerox) and Fuji Xerox are dealt with as two companies in this survey.

During this research survey, three Korean companies, LG Electronics, Samsung Electronics, and Daewoo Electronics, were under a strong restructuring process. One of the main reasons was an outside economic force that the economy of Korea was being supported by the IMF (International Monetary Fund). Because of this economic situation, the employees in each Korean company cut down on a lot of staff including designers from early 1998. For example, both the Samsung and LG companies have cut down their industrial (product) designers by about one thirds compared to before the Korean economic crisis. Samsung reduced the number of designers from approximately 300 to 180 (total Samsung group employees from 267,000 to161,000). LG cut down the number of designers from approximately 300 to 220. In particular, Daewoo reduced the number of their designers by half from approximately 120 to 70. (This information was

[7] http:/ www.xerox.com/downloads 99annualrpt.pdf. p.31

given by each design manager, who was an interviewee in this research, or the home page of each company from September 2000 to October 2000.)

Table 13 summarises the general status of each of the contacted companies for interview survey, such as the main product items, the total number of employees, the total number of employees in the design department, the net sales, net profits and a summary of characteristics about each company. Details of the net sales and the net profits in 1999 were also given by interviewees and were investigated through the annual reports of each company.

Table 13. General background information about contacted companies

	Main product items	Total employees (approximately)	TOTAL EMPLOYEES IN DESIGN DEPARTMENT (approximately)	Net sales in 1999 (US $ Millions) (approximately)	Net profits in 1999 (US $ Million) (approximately)
Samsung Electronics[8]	Audio & Video sets, Business products, Computing products, home appliances, Semiconductors, Telecommunication Products,	40,000 (all Samsung group 161,000)	180	$ 22,810 (all Samsung group $93,500)[9]	$ 7,385
	Samsung Electronics considers the whole world as a customer base, with 25 worldwide production bases and 59 sales subsidiaries in 46 countries. Samsung Electronics currently has into four main business units, Digital Media, Semiconductors, Information & Communications and core component Businesses, producing the world's most innovative 21st century digital components.				

[8] Samsung Electronics Annual Report (1999), Seoul Korea p.78, http://samsungelectronics.com/corporateinfo/annual/1999/all.pdf

[9] http://www.samsung.com/about/financial/financial_data.html#Main_Financial_Indicators

LG Electronics Inc.[10]	Audio sets Refrigerators Computers TV sets, etc	56,215 (All LG group 10,000)	220	$ 9,587[11]	$ 2,352[12]
	LG Electronics is a major global company in electronics & telecommunications operating 60 subsidiaries in 34 countries LG is a US $ 54 billion business group which consists of 42 sisters companies with some 300 offices and subsidiaries in over 120 countries.				
Daewoo Electronics[13]	TV sets Audio sets Refrigerators Computers Video, etc	20,000	70	$ 4,699 (year 1998)	$ 11 (year 1998)
	Daewoo Electronics Co., Ltd. manufactures consumer electronics products and home appliances. The company now has 28manufacturing subsidiaries, 33sales subsidiaries, and 19 branches throughout the world. Daewoo Electronics holds the number one position in market share for 39 products in 24 countries around the world. Regarding TV sets, Daewoo Electronics exported over 12million units in 1998 becoming number one in the world; Daewoo Electronics is already the number one brand in Europe in terms of market share with regard to microwave ovens and washing machines				
Hitachi Home Electronics	Refrigerators, Washing machines, DVD players Camcorders Computers, TV sets, etc	70,000 (All Hitachi group 337,911)	160	$ 8,538[14]	$ 188[15]
	The turnover of Hitachi Ltd, the global leader, is approximately US $ 77 billion per annum (1999) Hitachi Ltd has 1,068 subsidiaries, including 332 overseas corporations				

[10] http://www.lg.co.kr/e_lg/about/m.html
[11] http://www.lge.co.kr:6666/korea/ir/announcements/performance/performance_1999_01.shtml
[12] http://www.lge.co.kr:6666/korea/ir/announcements/performance/performance_1999_01.shtml
[13] http://www.dwe.co.kr/korean
[14] http://global.hitachi.com/Int-e/AR/pdf/ar2000_04.pdf
[15] http://global.hitachi.com/Int-e/AR/pdf/ar2000_04.pdf

Toshiba[16]	Home entertainment and consumer electronics, Cameras, computers, copiers, fax and network printing, etc	57,000 (All Toshiba group 10,000)	150	$ 5,423[17]	$ 952[18]
Fuji Xerox[19]	Digital products, Light-lens copiers, printers, Paper and other products	15,000	30	$ 7,800	
	The total revenues of Xerox (US, Europe, Fuji, etc) was 19.2 billions and the net income was 1,424 million in 1999. Fuji Xerox Co., Ltd. (Fuji Xerox), an unconsolidated entity jointly owned by Xerox Limited and Fuji Photo Film Co., Ltd., develops, manufactures and distributes products in Japan and the Pacific Rim.				
Xerox Limited (Europe Xerox)	Digital products, Light-lens copiers, printers, Paper and other products	15,000 (All Xerox group 85,000)	3	$ 5,300	

[16] http://www.toshiba.com
[17] Toshiba Annual Report(2000), Toshiba, Japan p.1
[18] Toshiba Annual Report(2000), Toshiba, Japan p.1
[19] http://www.xerox.com downloads 99annualrpt.pdf

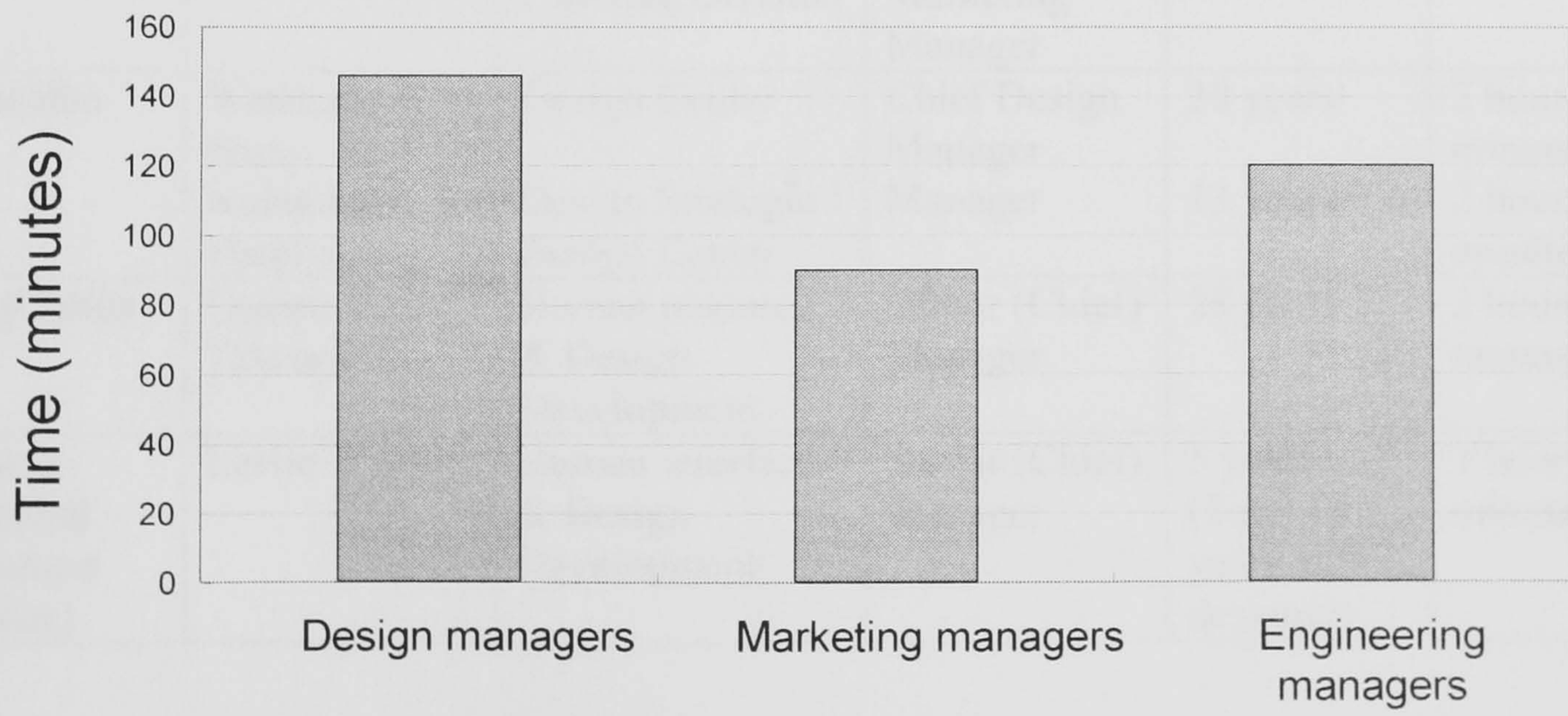
5.3 General background information about contacted interviewees

(Data from: Interview question 4-6; see footnote [20])

In total fifteen senior managers were interviewed. These were ten senior design managers, including four chief design managers, two marketing managers, two mechanical engineering managers, and one technical programme manager (Andrew Houston) at Xerox who has thirty-four year engineering background in the consumer electronics industry (He was also a chief manager in the engineering group at Philips in Holland and ITT, International Telegraph Telecommunication, in the USA). All interviews were conducted in a meeting room at each company.

Almost all the interviews took over 2 hours (average time was 2 hours 13 minutes – see Figure 23). Particularly, those with the design managers took longer.
The average interview time with the ten design managers was 2 hours 23 minutes.
The average interview time with the two marketing (planning) managers was 1 hour 30 minutes, and the average interview time with the two engineering managers was 1-hour 40minutes.

Figure 23 The interview time



[20] Question 4.What is your job title ? Question 5. What is the name of your department?
Question 6.How long have you been working for this company as a designer (or as a engineer or,..)?
Also, How long have you been working as a designer (or as a engineer or,..) in you life?

Table 14 illustrates more background information about contacted interviewees.

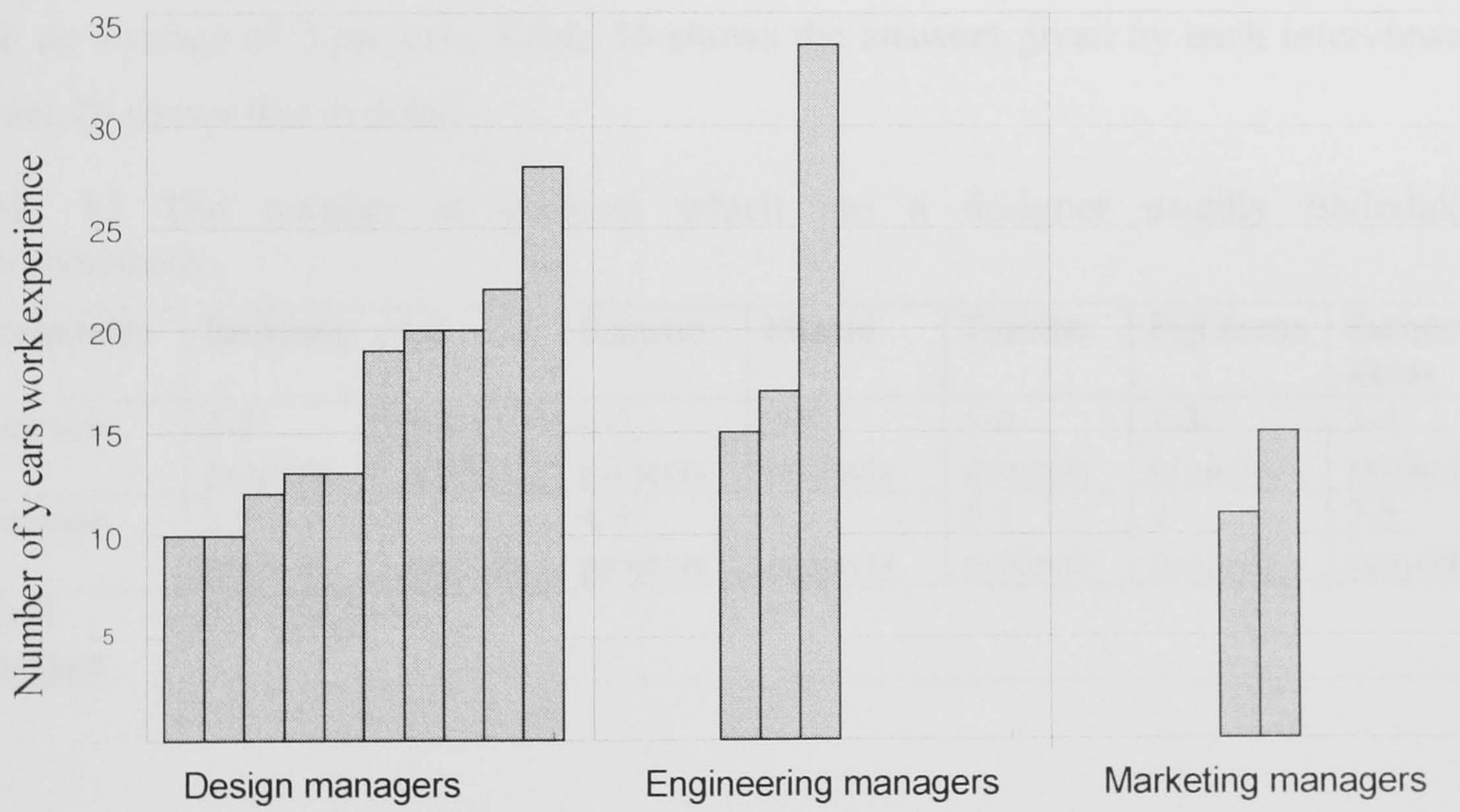
Table 14. General background information about contacted interviewees

	Name of interviewee	**Department interviewee works in**	**Job title**	**Working years**	**Length of time for Interview**
Samsung Electronics	Byeong Young Song	Design group	Manager	13 years	2 hours 40 minutes
	Jun Hee Lee	Strategic Marketing group	Manager	15 years	2 hours
	Sunny Bang	Mechanical R&D group	Senior Manager	17 years	2 hours
LG Electronics	Woo Young Oh	Design Center	Chief Design Manager	22 years	1 hour 50 minutes
	Hyung Ki Lee	Design Center	Manager	10 years	3 hours
Daewoo Electronics	Hyung-Lock Lee	Design Center	Senior Design Manager	12 years	2 hours 20 minutes
	Hyun Ho Lee	Design Center	Design Manager	10 years	2 hours 20 minutes
	Kwang Ho Choi	Mechanical Center	Senior Manager	15 years	2 hours
Hitachi Home Electronics	Taisuke Kashima	Business Planning Division	Chief Design Manager	20 years	2 hours 40 minutes
	Peter Johnson	Business Planning Division	Product Marketing Manager		1 hour
Toshiba	Watanabe Shinji	Design Center	Chief Design Manager	20 years	2 hours 30 minutes
	Nobuhiro Fushiya	Design Strategic / Design Center	Manager	13 years	2 hours 30 minutes
Fuji Xerox	Osamu Takeuchi	Human resource & Design Development	Senior (Chief) Manager	28 years	2 hours 10 minutes
Xerox Limited (Europe Xerox)	Leslie Wynn	Human interface & Design Development	Senior (Chief) Manager	5 years (Total 19 years as a designer)	1 hour 50 minutes

	Eur Ing Andrew Houston	Technical Centre	Technical Senior manager	13 years (Total 34 years including work for Philips and ITT	1 hour10 minutes

All the interviewees' work experience spanned at least over 10 years each. Five people had more than twenty years work experience. Figure 24 shows the number of years of work experience of the interviewees in their professional area in detail.

Figure 24 The work experience years of interviewees in their specialist domain



5.4 The number of projects, which a designer usually undertakes simultaneously.

(Data from: Interview question 8; see footnote[21])

This question (see footnote 21) was posed in order to describe the circumstances of design development in the CEI (Consumer Electronics Industry).

The result of this investigation revealed that a designer in the CEI sector usually undertakes several project simultaneously. According to the results of this survey, a designer in the CEI usually undertakes 3.85 projects at the same time on average.

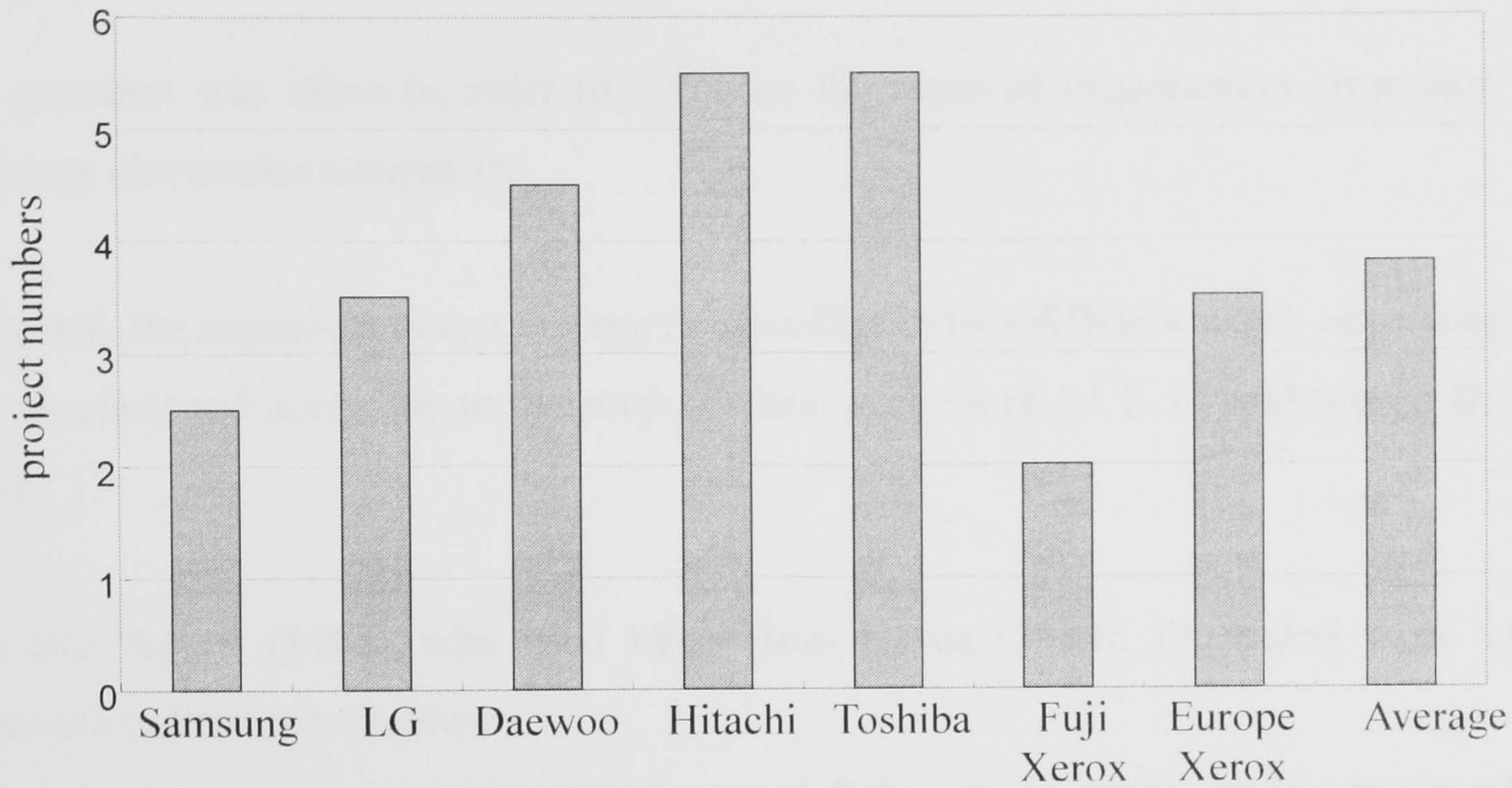
The highest number of projects that a designer usually undertakes simultaneously includes 5.5 projects at Hitachi and Toshiba. A designer in these two companies usually undertakes on average 5.5 projects at the same time. Fuji Xerox has the lowest number with an average of 2 projects. Table 15 shows the answers given by each interviewee. Figure 25 shows this in detail.

Table 15 The number of projects which are a designer usually undertakes simultaneously.

Companies	Samsung	LG	Daewoo	Hitachi	Toshiba	Fuji Xerox	Europe Xerox
Answers	2-3 projects	3-4 projects	4-5 projects	3-8 projects	5-6 projects	1-3 projects	3-4 projects
Average	2.5 projects	3.5 projects	4.5 projects	5.5 projects	5.5 projects	2 projects	3.5 projects
Total Average	3.85 projects						

[21] Question 8. How many projects does a designer usually undertake at the same time?

Figure 25 The number of projects, which are a designer usually, undertakes simultaneously.



5.5 The organisational structure in the CEI (Consumer Electronics Industry)

(Data from: Question 9; see footnote[22])

This question was taken in order to delineate the types of organisation structures in consumer electronics companies.

In general, the organisation can be largely classified in two different ways: according to their *function* and according to the *projects* they work on (Karl T. U. and Steven D. E. 1995).

Karl and Steven (1995), who used ideas from Hayes (1988), illustrated these two organisational types as follows:

In *functional organisations*, the organisational links are primarily among those who perform similar functions. By contrast, in *project organisation*, the organisational links are primarily among those who work on the same project. For example, a strict functional organisation might include a group of design professionals, all sharing similar training and expertise. These would all report to the same manager who evaluates them and sets their salaries. The group would have its own budget and the people would sit in the same part of a building. This design group would be involved in many different projects, but there would be no strong organisational links to the other members of each project team. There would be similarly arranged groups corresponding to marketing and to manufacturing. A strict project organisation would be made up of groups of people from several different functions, with each group focused on the development of a specific product. These groups would each report to an experienced project manager, who might be drawn from any of the functional areas. Performance evaluation would be handled by the project manager, and the team would typically be

[22] Question 9. If an organisational structure can be divided into the following four categories, which type of organisational structures does product design development usually take in your company?
a) Functional organisation, b) Project organisation, c) Lightweight project Matrix Organisation, d) Heavyweight project Matrix Organisation

co-located as much as possible so that they all work in the same office or part of a building.

Karl and Steven (1995) further explained about the matrix organisation, which was conceived as a hybrid of functional and project organisations. In the matrix organisation, each individual is linked to others according to both the project they work on and their function. Typically each individual has two supervisors, a project manager and a functional manager. The practical reality is that either the project or the function tends to have stronger links. This is because, for example, both functional and project managers cannot have independent budget authority, they cannot independently evaluate and determine the salaries of their subordinates, and both functional and project organisations cannot easily be grouped together physically. As a result, either functional or project organisation tends to dominate.

Two variants of the matrix organisation are divided and called the heavyweight project organisation and the lightweight project organisation by Hayes et al (1988). A heavyweight project organisation contains strong project links. The heavyweight project manager has complete budget authority, is heavily involved in performance evaluation of the team members, and makes most of the major resource allocation decisions. Although each participant in a project also belongs to functional organisation, the functional managers have relatively little authority and control. A lightweight project organisation contains weaker project links and relatively stronger functional links. In this scheme, the project manager is more of a coordinator and administrator. The lightweight project manger updates schedules, arranges meetings, and facilitates coordination, but the manager has no real authority and control in the project organisation. The functional managers are responsible for budgets, hiring and firing, and performance evaluation.

Therefore, the organisation can be divided into four categories; these are the functional organisation, the project organisation, the heavyweight project organisation and the lightweight organisation. These organisations were also adapted by many researchers

such as Hayes, Robert H., Steven C. Wheelwright, and Kim B. Clark (Karl and Steven 1995). Table 15 further explains the characteristics, strengths and weaknesses of each organisation, and the major issues in each organisation in detail.

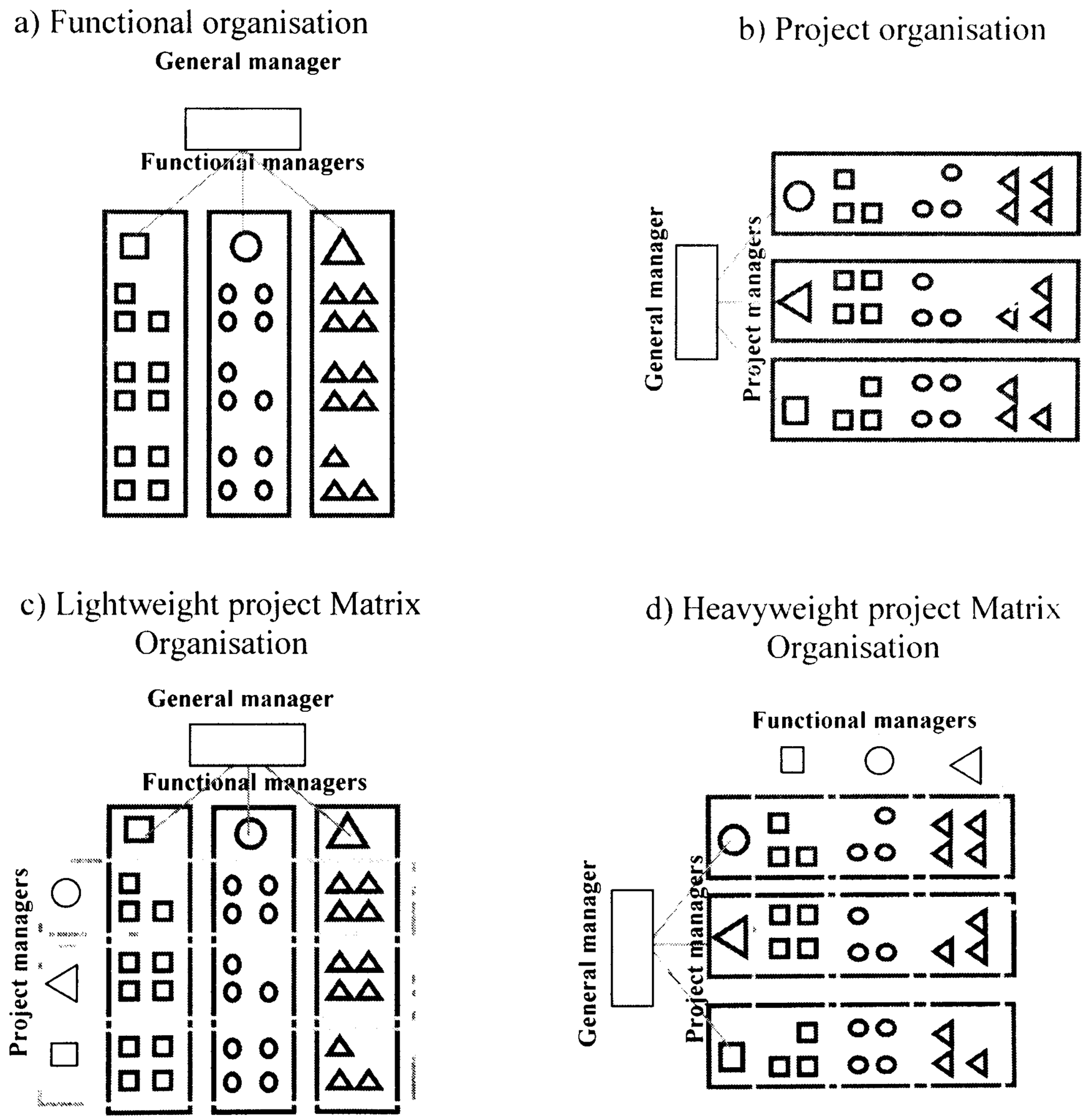
Four diagrams in Figure 26, adapted from the book by Karl and Steven (1995), also help to understand idea of the pure functional and project organisation, along with the lightweight and heavyweight matrix organisation.

Table 16 Characteristics of different organisational structures 2 (Karl & Steven 1995)

	Functional Organisation	Matrix Organisation		Project Organisation
		Lightweight Project Organisation	Heavyweight Project Organisation	
Strengths	Fosters development of deep specialisation and expertise.	Coordination and administration of projects is explicitly assigned to a single project manager	Provides integration and speed benefits of the project organization.	Resources can be optimally allocated within the project team.
Weaknesses	***Coordination among different functional groups can be slow and bureaucratic***	Requires more managers and administrators than a non-matrix organization		Individuals may have difficulty maintaining "cutting edge" functional capabilities
Major issues	***How to integrate different functions (e.g. marketing and design) to achieve a common goal.***	How to balance functions and projects. How to evaluate simultaneously project and functional performance.		How to maintain functional specialization over product generations. How to share technical learning from one project to another.

Interview question 9 was used based on the above four organisational types which had been adopted by several researchers in order to categorise organisational type in the CEI. The four diagrams in Figure 26, adapted from ideas by Karl and Steven (1995) were shown and used to explain these organisational structures to interviewees during the interviews.

Figure 26 The types of NPD organisation structures. For simplicity, three functions and three projects are shown.

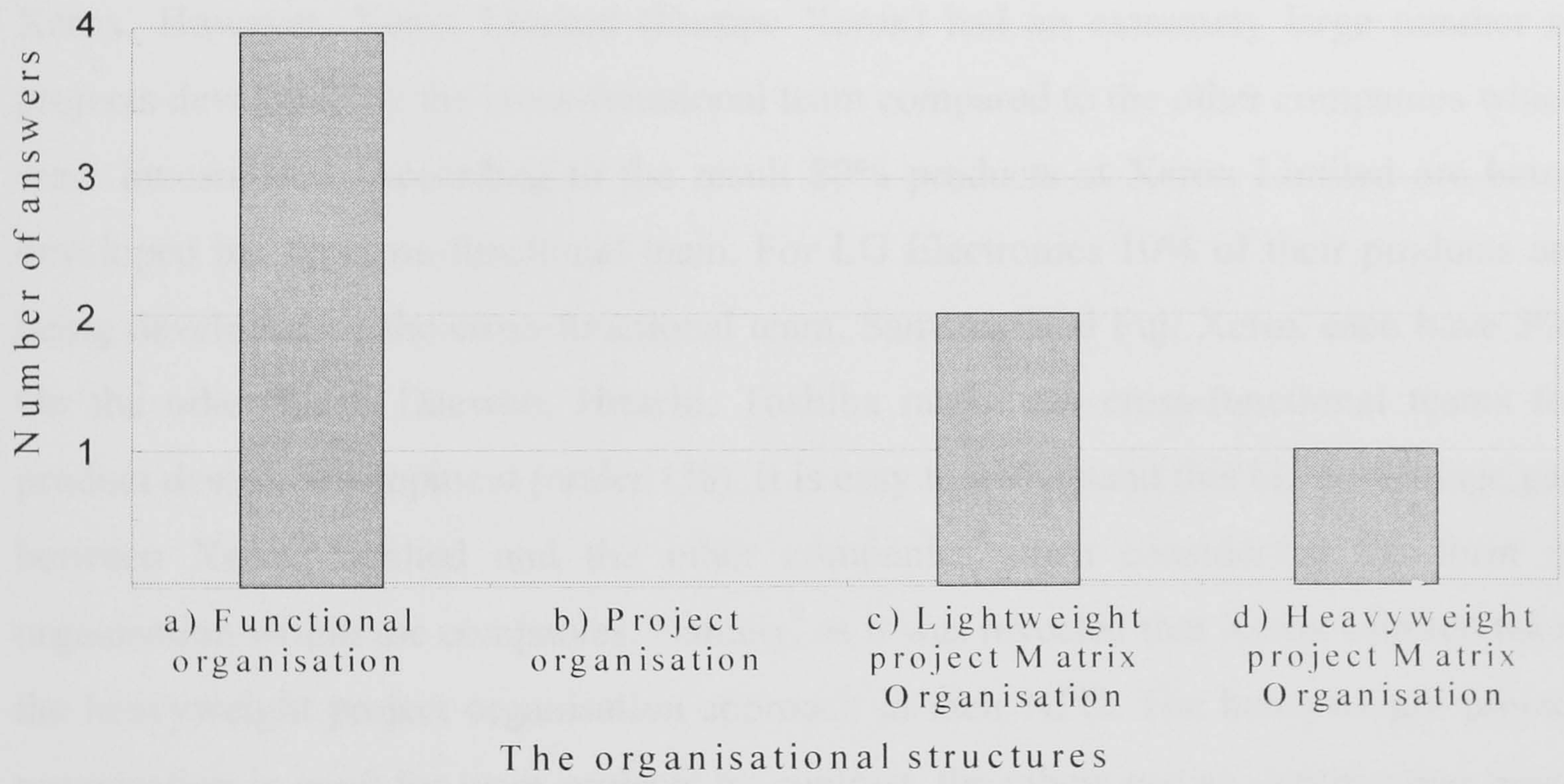


As a result, four of the seven companies had the functional organisational structure, and two companies had the lightweight project matrix organisational structure, and one company (Europe Xerox), had the heavyweight project matrix organisation structure. Table 17 and Figure 27 show the results of question 9.

Table 17 The types of NPD organisational structures in the CEI (Consumer Electronics Industry)

	Samsung	**LG**	**Daewoo**	**Hitachi**	**Toshiba**	**Fuji Xerox**	**Europe Xerox**
Answer	a	c	a	a	a	c	d

Figure 27 The type of NPD organisational structures in the CEI (Consumer Electronics Industry)



5.6 The percentage of organisational structures for a new product design development in the CEI

(Interview question 10: see footnote[23])

This question 10 was posed in order to explain and identify the organisational forms in the CEI for a new product development, similar to question 9.

Table 18, and figures 28 and 29 show the results obtained from this question. Within the companies surveyed over 90% of consumer electronics products projects are being developed under the in-house design department (see Table 18 and Figure 28). On the other hand, only 6.5% of projects are being developed by outside design consultants. Furthermore, the number of projects being developed through the cross-functional team is also very low, being an average of 3.6% of the total projects, if excluding Europe Xerox. However, Xerox Limited (Europe Xerox) had an extremely large number of projects developed by the cross-functional team compared to the other companies which were investigated, According to the result 80% products at Xerox Limited are being developed by the cross-functional team. For LG Electronics 10% of their products are being developed by the cross-functional team. Samsung and Fuji Xerox each have 5%. On the other hand, Daewoo, Hitachi, Toshiba rarely use cross-functional teams for product design development (under 1%). It is easy to understand this big percentage gap between Xerox Limited and the other companies when considering the form of organisation within the companies. Namely, as it was revealed that Xerox Limited takes the heavyweight project organisation approach in their NPD. The heavyweight project organisation is good for team projects by contrast, the others use an organisation based on function. Interestingly, in the case of Fuji Xerox, only approximately 5% of products are being developed by cross-functional teams. This reflects a big difference between Fuji Xerox and Xerox Limited (Europe Xerox), even though both companies are under

[23] Question 13. What percentage of new product design development is conducted in each of the following organisation categories in your company?

the same Xerox company name. The reason is, as explained before, that products are developed under a completely different administration, organisation, and culture etc. In the case of Samsung Electronics, the computer business division occupies almost 5% of the total. In fact, the other divisions hardly use cross-functional teams for product design development according to the statement by the design manager in the computer division who was an interviewee for this survey.

Table 18 The percentage of organisational forms of new product design development

	In-house design		From design consultant	Others.
	Using cross-functional teams	Using functional organisational form		
Samsung	5%	85%	10%	0%
LG	10%	70%	20%	0%
Daewoo	0%	99.5%	0.5%	0%
Hitachi	1%	89%	10%	0%
Toshiba	1%	98.8%	0.2%	0%
Fuji Xerox	5%	90%	5%	0%
Europe Xerox	80%	0%	0%	20%
	14.5% (3.6% if excluding Europe Xerox)	76.0% (90.5% if excluding Europe Xerox)	6.5% (5.9% if excluding Europe Xerox)	3% (0% if excluding Europe Xerox)
Average	90.5%		6.5%	3%

Figure 28 The percentage of project forms of new product design development within the In-house design department (using the cross-functional team & using the functional organisation form), Design by consultants and Others

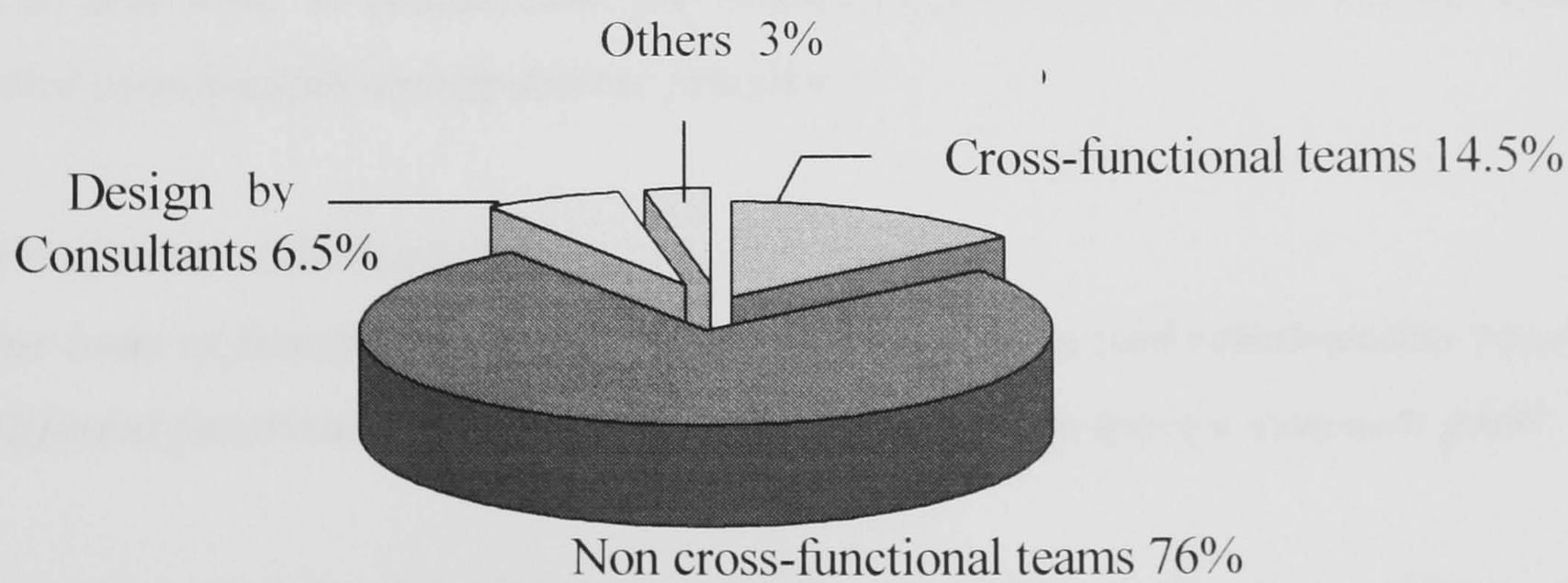
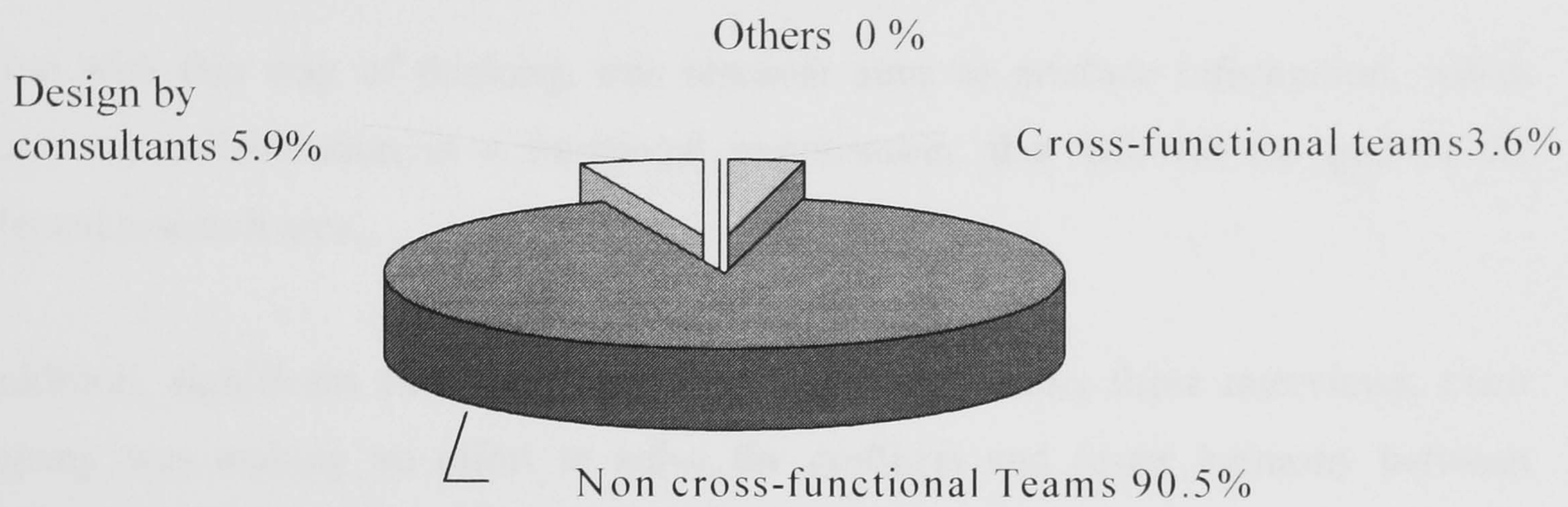


Figure 29 The percentage of project forms of new product design development among In-house design (by the cross-functional team & by the functional organisation form), Design from consultants and Others excluding Europe Xerox



The results from the both question 9 and 10 indicate that many of consumer electronics products are being developed under the functional organisational structure. In other words, it can be interpreted that many of the consumer electronics products are being developed in difficult contexts of collaboration and coordination among different functional groups, because of the nature of functional organisation (Karl T. U., Steven D. E., 1995).

Karl T. U., Steven D. E. (1995) also illustrated,

"the functional organisation tends to breed specialisation and deep expertise in the functional area, but collaboration and integration among different functional groups are difficult and slow. In comparison, the project organisations tend to enable rapid and effective coordination among diverse functions."

They (1995) further underlined that

"the major issue of functional organisation is the integration and collaboration issues among different functions (e.g. marketing and design,..) to achieve a common goal".

Despite the fact that the functional organisation has this weakness in relation to collaboration among other functional groups compared to team based organisation.

Almost all the existing research, which aimed to encourage collaboration among functional people, carried out focused on cross-functional team projects, which is the easiest organisation to encourage collaborate among other functional groups.

In line with this way of thinking, this research aims to produce information, which focuses on collaboration in a functional organisation, that will fill the gap in the neglected research area.

In addition, significant extra information was obtained during these interviews. Each company was making an effort to solve the conflicts and foster harmony between functional groups for successful product design development. For example, at Samsung (computer division), the mechanical engineering department sent one engineer into the design department informally even though the both departments are located in different cities. The engineer who was sent to the design group resolves conflicts that might occur between the design group and the engineering group. He/she does this by giving the basic knowledge about mechanical engineering information to designers and giving opportunities to discuss problems, which come from the engineering area, with designers. In the case of the Hitachi design centre, they employ designers who have other backgrounds, for instance, an engineer, a scientist, a marketer, a psychologist, etc in order to reduce the functional barriers between functional groups. In the case of the Design Lab at Daewoo, they emphasise frequent meetings with functional department partners, particularly, during the early design development stage, in order to break down the barriers among the functional groups.

5.7 Contributory factors affecting CFC (Cross-Functional Collaboration)

(From: Interview question 7.1 - 7.3: see footnote[24])

Extensive contributory factors affecting CFC in practice were discovered through the interview questions 7.1-7.3.

During the interviews with fifteen senior mangers, many managers admitted to the difficulties of collaboration with other functional groups. Furthermore, four of the design managers state,

"we (designers) usually fight with engineers during the design development process"

when they explain their relationship with the mechanical engineering group.

In order not only to solve these kinds of conflicts but also to consolidate their collaborative relationship with other functional group people, each interviewee gave many ideas based on their longitudinal experience. Table 19 shows all the summarised factors affecting cross-functional collaboration indicated by each interviewee.

Table 19 Contributory factors affecting CFC (Cross-Functional Collaboration) from each interviewee.

	Names of interviewee	**Issues (factors)**
Sam-sung	**Manager in Design department** (Byeong Young Song)	Coordination of activities from senior managers Having a mutual understanding about partners' groups Having good communication based on logic Feeling of belonging and cohesion Rewards system based on groups rather than individual systems

[24] Question 7-1. What are the contributory factors affecting a level of CFC (Cross Functional Collaboration) for product design development in general?
Question 7-2. Why do you think these contributory factors you mentioned are important?
Question 7-3. What are the obstacles affecting each of the above contributory factors affecting CFC?

	Manager in Marketing department (Jun Hee Lee)	Well planned schedule for product development (e.g. having a proper schedule for product development) Mutual understanding of the roles of partners' departments Frequent sharing of information and ideas Sharing unified goals of the project Having appropriate data and the right information about partners' groups Co-location Trust level
	Manager in Engineering department (Sunny Bang)	Mutual understanding of roles and knowledge of partners' departments Well planned schedule for product development Keep to the schedule Appropriate knowledge, skills about the job Trust level
LG	**Manager in Design department** (Woo Young Oh, Hyung Ki Lee)	Unified strategy between partners Mutual understanding Give and take relationship Frequent communications Communications based on trust Shared vision of corporation Understanding partners' job characteristics Frequent interaction (relationship) Choosing a suitable partner Appropriate skills for job Working rationally Informal social meetings between partners and/or groups Management and coordination of activities from senior manager Joint rewards system
Daewoo	**Manager in Design department** (Hyung-Lock Lee)	Establishing and understanding clear objectives of the project (particularly in the early stages of design development) Sharing information Having a unified culture Co-location (Working in the same place with a partner) Choosing suitable partners To be open minded Flexible organisational culture

	Manager in Marketing department (Hyun Ho Lee)	Evaluation and rewards to encourage collaboration Training about collaboration techniques Understanding of characteristics of other functional departments Having a sense of partnership Sharing reliable information Choosing partners who have a good interpersonal relationship Informal social relationships (Frequent informal social meetings)
	Manager in Engineering department (Kwang Ho Choi)	Mutual understanding of the role of partners' department Trust level between partners Shared goals Give and take relationship among departments Previous good experience of collaboration Level of goodwill Having responsibilities
Hitachi	**Manager in Design department** (Taisuke Kashima)	A well organised logical product design process (e.g. preparing design album (see footnote [25]) Communication with right information and logic (particularly designers). Appropriate design knowledge and skills as a designer Explaining design background (design album) in a logical way to other functional departments. Having clear and mutual objectives (aims & goals of project level) Sharing valuable information between functional groups (e.g. competitor information, market information) Having unified strategy and policy upstream to down stream Good communication between functional groups Close location (because face to face communication is best) Good skills for using communication systems (e.g. email-lack of skill makes for inefficient communication) Having a mutual understanding about basic knowledge of product and product development process Having a mutual understanding of each other's role within functional departments Sharing a vision of the company's future

[25] 'Album' was used by Taisuke Kashima, who is a chief design manager in Hitachi, as a term that explained a logical and historical design process. In contrast a design process without logic and historic background; for example design out-put comes suddenly from a designer's inspiration. He pointed out that making design logic and logical design processes contributes to cross-functional collaboration, rather than doing design development based on just a designer's inspiration

	Manager in Marketing department (Peter Johnson)	Good communication between functional groups Regular meetings between functional groups Having a physical co-location (to have face to face meetings easily) Sharing ideas with other departments Frequent informal meetings between functional groups A mutual understanding of roles in NPD Appropriate skills (e.g. drawing skills of designers) and knowledge Sharing information Regular meetings Having a common language between partners Trust level Show the appropriate skills and capability to partners Work rationally Good experience of collaboration
Toshiba	**Manager in Design department** (Watanabe Shinji, Nobuhiro Fushiya)	A well defined design process Well defined roles of each functional group Having responsibility for a project. Concern and commitment from senior management level Sharing common vision & values Having the same location (face to face) Appropriate knowledge, skills and experiences The right information sharing Goodwill (Giving his/her favour) Frequent communication
Fuji Xerox	**Manager in Design department** Osamu Takeuchi	Having a mutual understanding about partners' roles Having a unified strategy with other functional departments Sharing vision and values Managerial support during the development process Coordination from senior managers (or/and senior management committees) Appropriate skills, experiences and attitudes Having the same goals Sharing valuable information Co-location (for face to face communication) Frequent and rapid monitoring progress Clear decision making process Decentralisation of NPD process Trust level

Xerox Limited (Europe Xerox)	**Manager in Design department** (Leslie Wynn)	Having common goals for the project Having a common culture (e.g. geographical, ethnological culture and language matters) Choosing a suitable partner who has a good personality (personal relationship) Having a physical co-location (geographical, neutral area) Level of partners' experience of cross-functional collaboration Having a common process (One process) between partners who come from other departments Optimum level of bureaucracy (e.g. Choice of a suitable amount of bureaucracy makes for good collaboration) Sharing information rapidly Understanding the level of other functional groups' knowledge Internal competition system based on a project team Trust level Suitable organisational type
	Technical programme manager (Eur Ing Andrew Houston)	Co-location Management and coordination of activities from senior manager (for example, by the changing control process) Having a well organised product (design) development process Having common goals for a project Understanding the level of other functional groups' fundamental knowledge

Table 19 shows factors affecting CFC indicated during the interview survey. However, many factors were repeated several times by different interviewees (managers), for instance, 'Having a mutual understanding of roles and knowledge of partners' groups' was repeated twelve times, 'Having a close physical co-location' was repeated eight times, and 'Trust levels of partners' was repeated six times. In total one hundred and nineteen factors were gathered from the interview survey, if the same factors (duplicated factors) are repeatedly counted. However the factors that had exactly the same meaning should be counted as one factor. Therefore, it can be said that actually fifty-two factors affecting cross-functional collaboration were found from this interview survey.

Besides, if we add forty-two factors, which were discovered from the literature survey, as factors affecting CFC, a total of ninety-four factors were collected from both the field interview survey (52 factors) and the literature survey (42 factors).

However, many factors from the verbal data (52+42=94 factors) were still duplicated or had a similar meaning to the factors from the literature survey and the factors from the interview survey. In order to condense and identify these qualitative factors based on the similarity among the factors, the *'affinity diagram technique'* with a brain group (focus group) that consisted of experts in the design management and/or product design field was used.

Schweiker M. (1999) stated.
"The affinity diagram is the typical technique to put large amounts of verbal data into groupings based on the relationships between the items".

He (1999) also emphasised that
"the process of the affinity diagram technique is a creative process rather than a logical process".

The focus group meeting followed the 'affinity technique' as follows;
As a first step when the group met, the aim of the meeting was explained to all the members of the focus group. They also had some simple practice before beginning the main meeting.
Secondly, all contributory factors affecting CFC, which had been found from both the literature survey and the interview survey, were printed on cards (papers) in the same letters and the same size. In total ninety-four factors, which came from both the practical field interview survey (52 factors) and the literature survey (42 factors), were indicated on each card.
Thirdly, these cards were laid on a very big board (A0 plus 2/1 A0 size), which had been prepared for this special focus group meeting.

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Fourthly, the members of the group then silently moved these cards into each affinity cluster that appeared to share similar ideas. These cards were moved as many times as were necessary until the group was satisfied with the clusters.

Finally, the group then clarified and discussed the relationship between the items and assigned a title for each cluster. The focus group generated a suitable title and placed it over the cluster after discussion and agreement was made by all the members. They also considered that the cards, which were repeated many times within the cluster, served as potential titles for the entire cluster. Figure 30 shows the final actual process of the focus group activities using the affinity diagram technique and Figure 31 displays this final output in a diagram.

Figure 30 Process of the focus group activity using affinity technique 1 (actual photo).

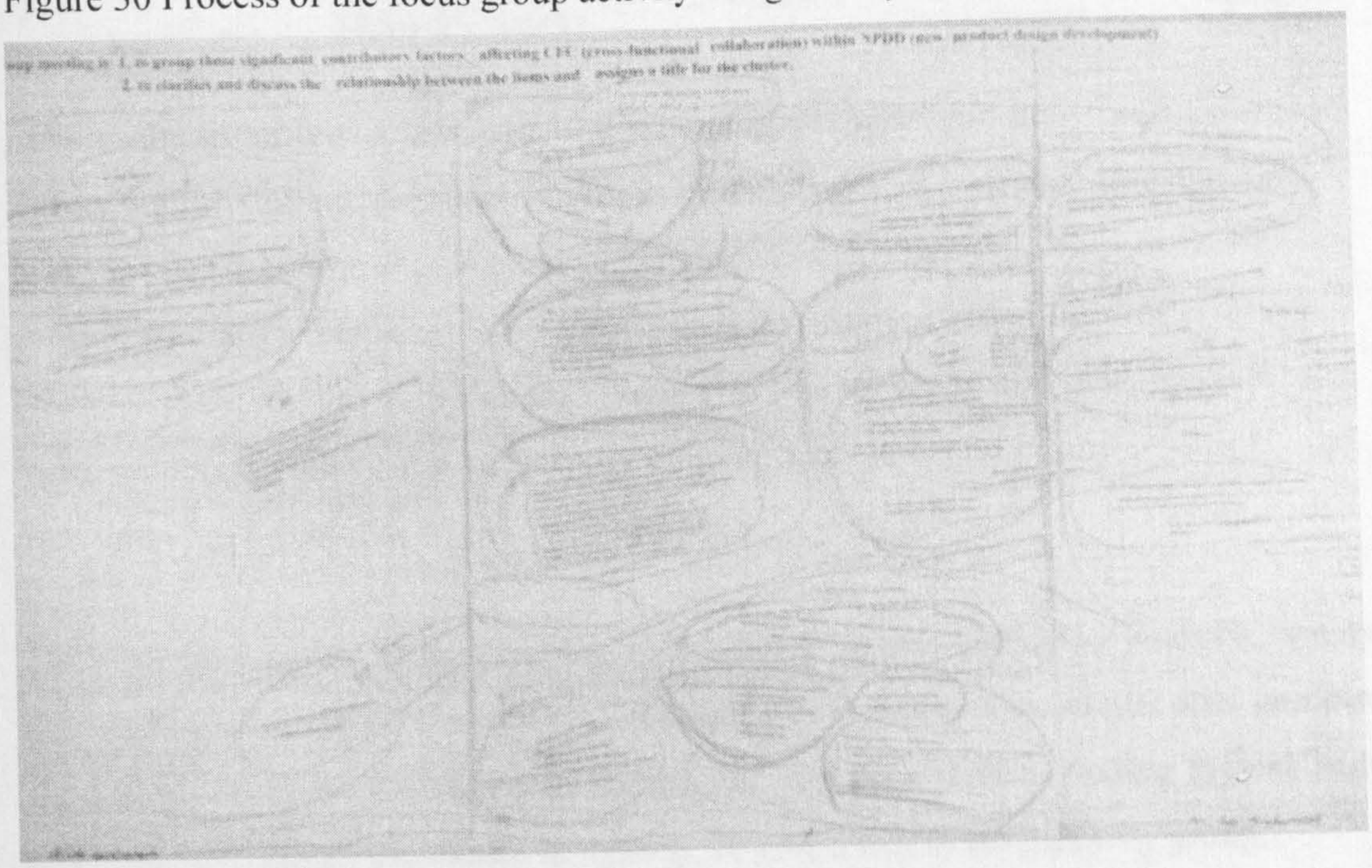
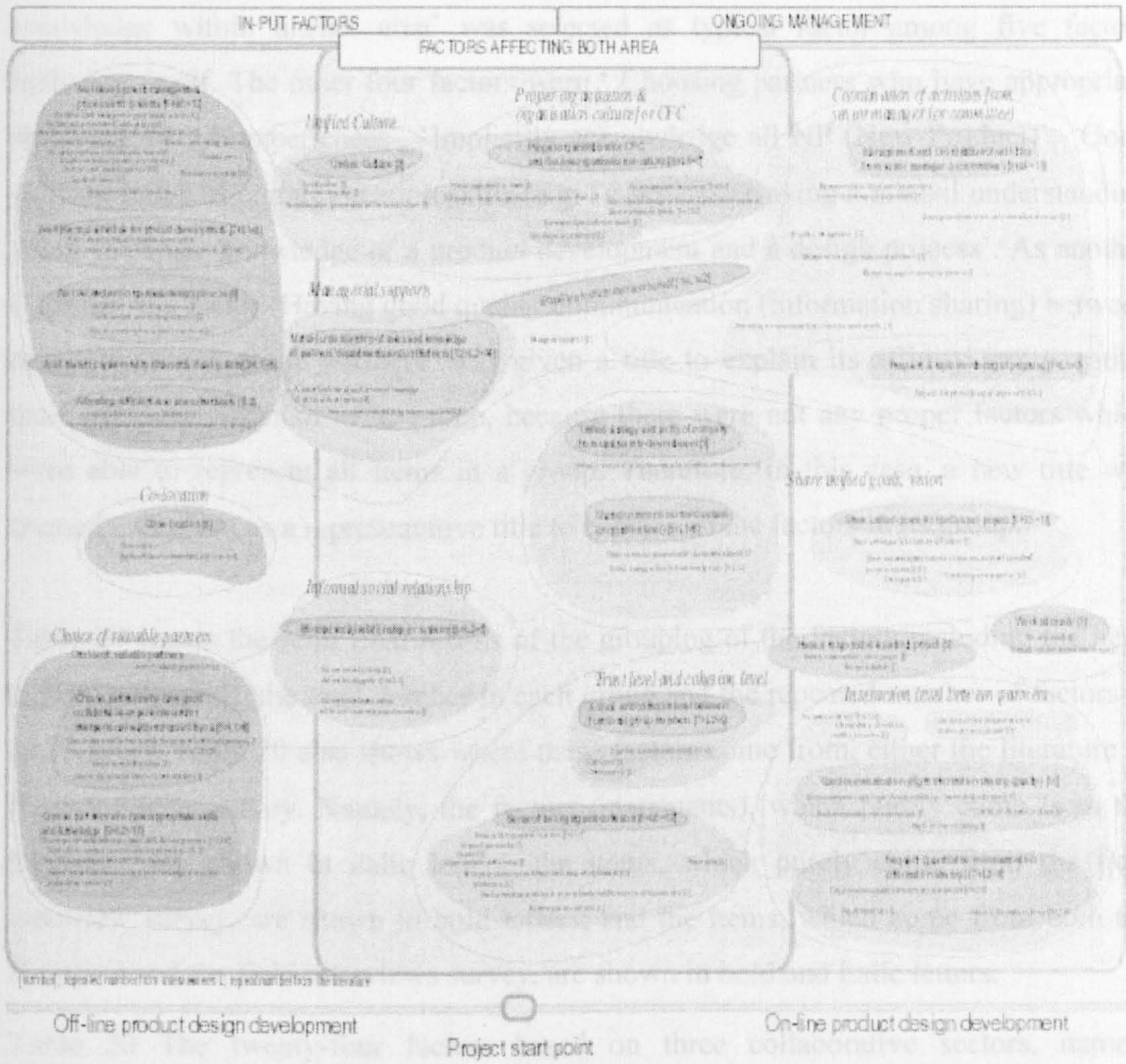


Figure 31 Process of the focus group activity with affinity technique 2.



The semi final results of the grouping of the factors in this qualitative analysis, twenty-four factors affecting CFC could been identified from ninety four factors after grouping the factors based on the similarity among the factors, and then finding typical items which can explain all the factors in a group, or give a title to each affinity group.

For example, 'Common culture (common language, common geographic and ethnological culture)' was generated after being merged with another factor in group as a representative factor to explain all the factors in its group; the other factors in this group were 'using a common language' and 'common geographic and ethnological

culture'. As another example, 'Choosing partners who have professional skills and knowledge within his/her area' was selected as typical factor among five factors including itself. The other four factors were ' Choosing partners who have appropriate skills and/or job experiences', 'Implicitly acknowledge all NP (New Product)', 'Good skill for using of communication skills (e.g. IT skills)', 'Having a mutual understanding about the basic knowledge of a product development and a design process'. As another example, the factor 'Having good quality communication (information sharing) between other functional group partners' was given a title to explain its affinity group, rather than selecting one item in its group, because there were not any proper factors which were able to represent all items in a group. Therefore, in this case, a new title was created and given as a representative title to explain all the factors in its group.

Table 20 shows the semi final results of the grouping of the factors including the head factor (statement), the total number in each group and the repeated number of factors in each group. Table 20 also shows where these factors come from, either the literature or the interviews survey. Namely, the factors (statements), which purely come from the literature, are shown in italic letters; the items, which purely come from the field interview survey, are shown in bold letters; and the items, which come from both the literature and the field interviews survey, are shown in bold and italic letters.

Table 20 The twenty-four factors based on three collaborative sectors, namely 'collaborative input factors', 'collaborative ongoing management factors' and 'collaborative factors affecting both areas'

A. Collaborative factors affecting both areas	
Header statements [total repeated Number]	The other statements [repeated Number] (* L mean the repeated number comes from literature survey)
1. **Having a common culture (common language, common geographic and ethnological culture)[3]**	- **Unified Culture [1]** - **Using a common language [1]** - **Common geographic and ethnological culture [1]**
2. ***Proper organisation and flexible organisational culture for cross-functional collaboration [3+L4=7]***	- **Proper Organisational system [1]** - ***Lower levels of management to work with other departments, (decentralising authority) [1+L1=2]*** - **Flexible organisational climate [1]** - *A dramatic change in organisational climate and culture [L1]* - *Team size, in the case of team project [L1]* - *Work together as a team [L1]*

3. ***Equality of contribution and benefit [1+L1=2]***	- ***Equality of contribution and benefit [1+L1=2]***
4. ***A mutual understanding of role and knowledge of partners' departments and/or partners [12+L2=14]***	- **A mutual understanding of role and knowledge of partners' departments [12]** - *Have a mutual understanding between partners [L2]*
5.**Unified strategy and policy upstream and down stream [1]**	- **Unified strategy and policy upstream and down stream [1]**
6. ***Sharing a common vision and values (corporate level) [5+L1=6]***	- **Sharing a common vision and values (corporate level) [4]** - ***Having a unified strategy with other functional groups [1+L1]***
7. ***Informal social relationship (or system) with other functional group members [3+L2=5]***	- ***Informally work together [1+L1=2]*** - *Informal social system [L1]* - **Informal social relationship with other functional group members [2]**
8.***Trust level between functional group members [7+L2=9]***	- ***A trust level between functional group members [6+L1=7]*** - **Open mind [1]** - *Transparency [L1]*
9. **Having a *sense of belonging and cohesion [6+L6=12]***	- ***Feeling a sense of belonging and cohesion [1+L1=2]*** - **Sense of partnership [2]** - **Goodwill [2]** - **A give and take relationship [1]** - *Participants in moving the NP activities purposefully forward [L1]* - *Mindfulness [L1]* - *Feeling a sense of ownership and a personal stake in NP activities and its outcomes [L1]* - *Achieve goals collectively [L1]* - *Leadership [L1]*
B. Collaborative input factors	
10.***Well developed management process and systems [6+L6=12]***	- *Well developed management processes and systems [L1]* - *Integrative organisational systems [L1]* - *Unstructured, involved process [L1]* - *Empowerment [L1]* - *Equitable power [L1]* - *Performance appraisal [L1]* - **Well defined role of each functional group [1]** - **Optimum level of bureaucracy [1]** - **Internal competition system based on team [1]** - **Education about collaboration techniques [1]** - **Evaluation and rewards about efforts to make collaboration [1]** - **Clear decision making process [1]**
11. ***Well planned schedule for product development [2+L1=3]***	- ***Well planned schedule for product development (e.g. have proper schedule for product development) [2+L1=3]***
12.**Well defined and organised design process [4]**	- **Well defined design process [2]** - **Well organised design process [1]** - **Have a common process between partners [1]**
13. ***Joint rewards system rather than individual rewards system [2+L1=3]***	- ***Joint rewards system rather than individual rewards system [2+L1=3]***

14. *Communication & information systems level (Support sufficient resource: hardware) [L2]*	- *Information systems and related electronic communication systems (hardware) [L1]* - *Support sufficient resources [L1]*
15. **Close physical location between functional partners [8]**	- **Close physical location between functional partners (e.g. face to face communication is best) [8]**
16. ***Choosing partners who have good collaborative experience and/or interpersonal relationships with you [5+L2=6]***	- **Choosing partners who have a good interpersonal relationship with you [1]** - *Interpersonal relationship [L1]* - *Appropriate attitude [L1]* - **Choosing partners who have corporate attitudes [1]** - **Choosing partners who have a good experience of cross-functional collaboration [3]**
17.***Choosing partners who have professional skills and knowledge about his/her area [9+L2=11]***	- ***Appropriate skills, job experiences [7+L1=8]*** - *Implicitly acknowledge all NP (New Product) [L1]* - **Good skills for using communication systems (e.g. IT skill) [1]** - **Having a mutual understanding about basic knowledge of a product and a design process [1]**
C. Collaborative ongoing management factors	
18.***Sharing unified goals & objectives of project [8+L4=11]***	- ***Sharing unified goals & objectives of project [8+L1=9]*** - *Establishing clear objectives [L1]* - *Share mutual aspirations and a common conceptual framework [L1]* - *Shared goals [L1]*
19. ***Management and coordination of activities from senior manager) [6+L4=10]***	- **Management and coordination of activities from senior manager [5]** - *Drawing up procedures for accountability and control [L1]* - *Boundary management [L1]* - *Coordination of activities [L1]* - *Attempting to ensure equality of contribution and benefit [L1]* - **Managerial support during the process [1]**
20. ***Frequent & rapid monitoring of progress [1+L1=2]***	- ***Frequent & rapid monitoring of progress [1+L1=2]***
21. **Good quality communication (information sharing) between other functional group partners [10]**	- **Good communication with right information and logic (particularly, a designer [3]** - **Qualitative information sharing [3]** - **Good communication based on trust [1]** - **Right information sharing [3]**
22. ***Frequent (quantitative) communication (information sharing) between other functional group partners [7+L1=8]***	- **Frequent communication between partners' groups [3]** - ***Frequent information sharing [2+L1=3]*** - **Regular meetings [2]**
23. **Work rationally and logically [3]**	- **Work rationally [2]** - **Explain design background logically [1]**
24. **Having responsibility a project [3]**	- **Have responsibility a project [2]** - **Keep a schedule [1]**

Interestingly, the items that come from the field interview survey largely covered all factors which came from the literature survey apart from one factor, which was

'Allocating sufficient resources'. In other words, twenty-three of the identified twenty-four factors were discovered from the interview survey. Sixteen of the twenty-four factors affecting CFC were discovered from both the literature and the interview survey. Therefore, eight more items were more discovered from the findings of the interview survey; by contrast, only one of the twenty-four items was discovered from literature survey.

On the other hand, the focus group panel tried to divide the factors affecting CFC into largely three categories, namely 'collaborative input factors', 'collaborative ongoing management factors' and 'collaborative factors affecting both areas' from the idea, as Sauter, M. A. & Enkawa, T. (1998) also emphasised, that the environment for cross-functional collaboration should be established before starting product development. By contrast, the research work by Littler D., al. (1995) divided factors affecting outcomes of collaborative product development into two areas, 'collaborative input factors' and 'ongoing collaborative management factors'. .

Table 20 shows the twenty-four items based on these three collaborative categories, namely 'collaborative input factors', 'collaborative ongoing management factors' and 'collaborative factors affecting both areas'. Sauter, M. A. & Enkawa, T. (1998) called the period before starting product development as *'off-line product development'*, by contrast, the procedure period for product development was called *'on-line product development'*.

As a result, eight of the twenty-four factors were located as 'collaborative input factors' which belong to the area of off-line product design development; seven of them were located as 'collaborative ongoing management factors', which belong to the area of on-line product design development. The remainder (nine factors) were put in the middle area, which means these collaborative factors affect both areas, from off-line product development to on-line product design development.

In the next and final step, the panel identified eleven compressed factors from the twenty-four factor groups based on principle affinity relationship (these final factor groups are shown with grouped lines in Figure 31). These eleven factors affecting CFC were finally grouped by the focus group. The results of the grouping are shown in Table 21 in detail.

Table 21 Eleven factors affecting CFC using affinity analysis by a focus group

Header statements	The other statements
***1. Having a common culture* (common language, common geographic and ethnological culture)**	- Having a common culture (common language, common geographic and ethnological culture)
2. Proper organisation and flexible organisational culture for cross-functional collaboration	- Proper organisation and flexible organisational culture for cross-functional collaboration
3. Managerial support	- Well developed management process and systems - Well planned schedule for product development - Well defined and organised design process - Joint rewards system rather than individual rewards system - Allocating sufficient resources - A mutual understanding of role and knowledge of partners' departments and/or partner - Frequent & rapid monitoring of progress - Equality of contribution and benefit
4. Sharing unified goals, vision at both corporate level and project level	- Unified strategy and policy upstream and down stream - Sharing a common vision and values (corporate level) - Sharing unified goals & objectives for a project
5. Informal social relationship (or system) with other functional group members	- Informal social relationship (or system) with other functional group members
6. Trust level between functional group members	- A trust level between functional group members - Sense of belonging and cohesion - Have responsibility for a project
7. Choosing suitable partners	- Choosing partners who have a good interpersonal relationship with you and good experience of cross-functional collaboration - Choosing partners who have professional skills and knowledge about his/her area
8. Close physical location between functional partners	- Close physical location between functional partners
9. Management and coordination of activities from senior manager	- Management and coordination of activities from senior manager (or committee)
10. Work logically and rationally	- Work logically and rationally

11. Interaction between partners	- Good quality communication (information sharing) between other functional group partners - Frequent (quantitative) communication (information sharing) between other functional group partners

All members of the panel agreed that these eleven factors were quite clearly grouped and titled. However, some of the panel group suggested that three of the eleven factors, these are 'a common culture (common language, common geographic and ethnological culture)', 'Proper organisation and organisation culture for CFC'; and 'Managerial support', have a very broad meaning, which might be interpreted as an umbrella term which may have an impact on other factors.

In addition, for this reason, some of the panel members suggested that twenty-four factors may be better than the finally defined eleven factors affecting CFC as measuring items for the questionnaire survey work in this research.

5.8 Development of measurement items for measuring design development performance of consumer electronics products.

(From: Question 10; see footnote[26])

In order to develop the measurement items (scale) for design development performance of consumer electronics products, both the findings from the literature survey and the practical field survey are summarised and reproduced in this section.

As a result of the literature search related to assessment tools for product design development performance or product design output performance, two research works were discovered, as has been noted in the previous chapter. From these research works, five measurement items were discovered from the research by Kulwant S. Pawar and Helen Driva (1999), and another eight items, which include criteria to assess product design output, were also found from the research work by Chung K. W. (1999).

But these thirteen items, which were presented by both Pawar & Driva (1999) and Chung (1999), could not be used directly as measurement items for design performance of consumer electronics products in this research. This is because, in the case of five items from the research by Pawar and Driva (1999), these were actually developed in order to measure product design team performance, but this research requires the tools to measure the total design development performance itself, not team performance. In addition, in the case of the eight items that were presented as criteria for the selection of good design awards by Chung K. W. (1999), these cannot to measure the total design development performance, because these items can be used as a scale to assess design output, they do not assess design development process performance, such as time, and development cost.

[26] Question 10. Does your company have any criteria or/and scales in order to measure the performance of product design development and design management?

Therefore, in order to develop appropriate performance measurement tools (items) for the total design development of consumer electronics products, interview question 10 was posed. Table 22 shows the results from this question.

Table 22 The results from the field survey about measurement items for design development performance.

Companies	Measurement items for total design development performance
Europe Xerox	Time: actual time against plan Cost: actual cost against plan Quality: total quality of product design (e.g. Innovation level, user friendly, a fine view (aesthetic aspects), reliability, etc.
Fuji Xerox	Time: Actual time against plan Cost: Actual cost against plan Quality: total quality of product design (e.g. Innovation level, user friendly, visually appealing (aesthetically pleasing), Reliability, etc.
Toshiba	No particular official measurement tools (They used to have a Self-evaluation system, in which a designer evaluates his/her total design development & design output quality based on his/her own satisfaction. They have stopped this measuring system recently, because they think that it is an objective enough method)
Hitachi	No particular official measurement tools
Samsung	No particular official measurement tools
LG	No particular official measurement tools
Daewoo	No particular official measurement tools

As the results of this survey show on a practical level, only two of the seven consumer electronics companies have clear performance measurement tools. Many respondents (design managers) confessed that it was very difficult to have common and official performance measurement criteria for product design development and design management. This is because of the nature of design activities, as was discussed in the previous section, 4.4.1 Difficulties of evaluating design development.

However, two companies, Europe Xerox and Fuji Xerox, have clear items (scales) for measuring design development performance.

Through summarising all the findings from both the literature survey, that is investigating measurement scales through previous research works, and the results from the field interview survey, it is deduced that there are four principles surrounding design performance measurements. In short, all the measurement items discovered through this research survey were largely divided into four measurement items. These are 'time', 'cost', 'quality of design output' and 'effectiveness and efficiency of design management'. These four measurement items mainly incorporate all the measurement items which were found from both the literature survey and practical field survey in CEI. Table 23 shows the references for each of the four developed item categories.

Table 23 References for each of the four developed items.

	Items from literature survey		Items from field survey
	Items were developed from research by Kulwant S. Pawar & Helen Driva (1999).	Items were developed from research by K. W. Chung (1999).	
Time	- Time		- Time (Europe Xerox) - Time (Fuji Xerox)
Cost	- Cost		- Cost (Europe Xerox) - Cost (Fuji Xerox)
Total Design output Quality	- Quality	Visually appealing (aesthetically pleasing), Fitness for function, Fitness for economic, Effectiveness of manufacturing, Easy control, Fitness for market and users, Satisfaction for social trend and users' emotion, A level of familiarity with the environment	- Quality (Europe Xerox) - Quality (Fuji Xerox)
Effectiveness and efficiency of design management.	- Flexibility - Management		

These four measurement items were applied as a scale for the measuring of design development performance of consumer electronics products in the questionnaire for the next survey in this research.

To enable the questionnaire to achieve the purpose of this research, the weight of importance of these four measurement items was also asked about based on the design development project. This is because, as Kaplan R. S. & Norton D. P. (1992) pointed out, the weight of importance of assessment items for product design development performance can be very different according to different design development contexts, such as, product items, company size, company strategy, etc, and in particular, product design development objectives. Therefore, in order to include not only these kinds of complicated product design development situations but also to try to accurately measure total design development performance, the weight of importance of these four measurement items is also considered in this research rather than just using these four items uniformly.

Consequently, the metrics for measuring total design development performance of consumer electronics products was developed, using the semantic differential scale developed by Osgood (1967), in the questionnaire in the next of this research step. Table 24 shows the developed metrics for total design development performance in this research.

Table 24 The metrics for measuring for total design development performance.

Measurement items	Weight of importance (the total sum should be 100)	Measurement scale (degree of satisfaction)
Time: (Actual time against plan)		1 (Very dissatisfied) 2 3 4 5 6 7 (Very satisfied)
Cost: (Actual cost against plan, Cost comparisons between competitive models)		1 (Very dissatisfied) 2 3 4 5 6 7 (Very satisfied)
Effectiveness and efficiency of design management.		1 (Very dissatisfied) 2 3 4 5 6 7 (Very satisfied)
Total Design output Quality (e.g. A fitness for objectives, Good appearance, Effectiveness of manufacturing, How much		1 (Very dissatisfied) 2 3 4 5 6 7 (Very satisfied)

easy to use, etc.)		

These items and these designed metrics for measuring total design development performance were tested before being used in the actual questionnaire survey.

Chapter 6: The analysis & results of questionnaire survey, and development of new conceptual framework for CFC for new product design development

Chapter 6: The analysis & results of Questionnaire survey, and development of new conceptual framework of CFC for new product design development

6.1 Introduction

This chapter presents the findings from the questionnaire survey as main body of this research.

This chapter starts with an introduction which restates the aims of the questionnaire survey. Section 6.2 describes the overall characteristics of the respondents and respondent groups in questionnaire survey of this research. Section 6.3 explains the characteristics of both the 24-factor dataset and the 11-factor dataset, which are identified as factors affecting CFC, and the reasons why a particular dataset was chosen for particular aims. Section 6.4 and Section 6.5 present the major findings of this questionnaire survey. The results of the priority of importance given to the both twenty-four factors and eleven factors affecting CFC are presented in Section 6.4. Section 6.5

offers an interpretation of the output data of SPSS. The correlation between the level of CFC and the performance of product design development is presented, after the performance of product design development has been divided into five categories. These are noted in the explanations of aims below. Also, substantial factors affecting the performance of design development based on the above same performance categories are presented in Section 6.5. Finally, and to conclude, the conceptual model of CFC, which includes main information produced from the research findings, was developed and explained in Section 6.6.

The aims of the questionnaire are as follows;

1) To define the priority of importance among the contributory factors affecting CFC for the design development of consumer electronics products.

In addition, the difference in opinion about the degree of importance of each contributory factor affecting CFC for product design development is described in relation to the following:

1.1) The difference in opinion about the degree of importance of each factor affecting CFC between the designers group and non-designers group.

1.2) The difference in opinion about the degree of importance of each factors affecting CFC between the less experienced specialists (career under 5 years) group and the more experienced specialists (career over 6 years) group.

2) To define the correlation between the level of CFC and the performance of product design development.

2.1) To define the correlation between the level of CFC and the total performance of product design development

2.2) To define substantial factors affecting the total design development performance

2.3) To define the correlation between CFC and each performance item of product design development in this research. Namely, a) the correlation between the

level of CFC and *the time performance* of product design development, b) the correlation between the level of CFC and *the cost performance* of product design development, c) the correlation between the level of CFC and *the quality performance* of product design output, d) the correlation between the level of CFC and *the effectiveness and efficiency of design management performance*.

2.4) To define substantial factors affecting each performance item of design development

6.2 The characteristics of the respondents and respondent groups

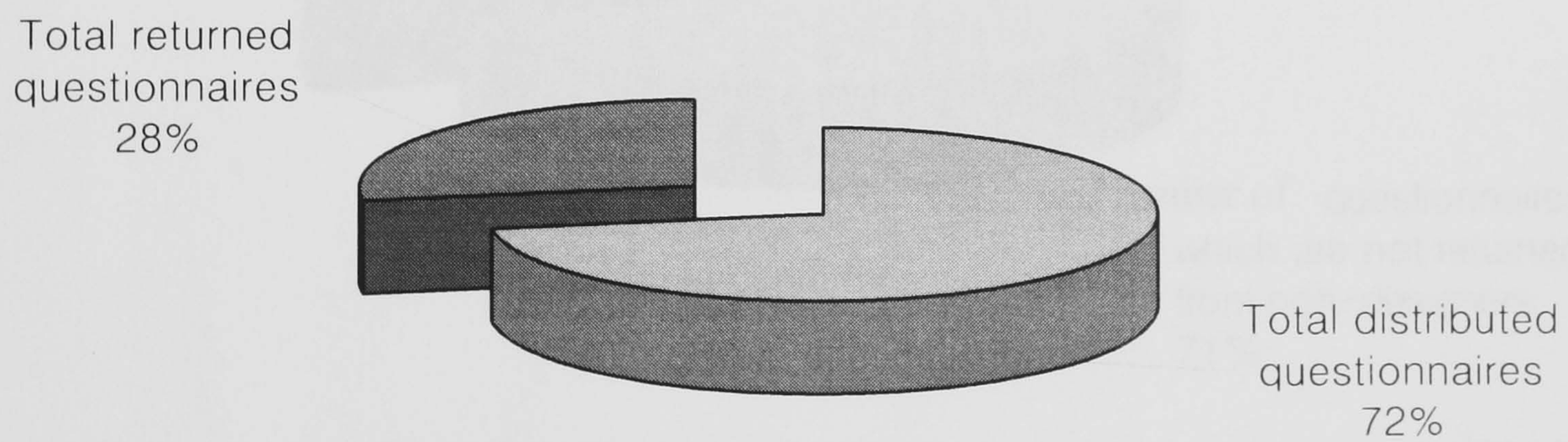
This section presents the characteristics of respondents and general findings from the questions in section A in the questionnaire.

The questionnaires were distributed and collected over a period of three months between early December 2000 and the end of February 2001.

About six hundred and forty questionnaires were distributed to the eight global consumer electronic companies in three countries, which were located in Korea, Japan, and the UK. These were Samsung Electronics, Hitachi Home Electronics, Toshiba, LG Electronics, Daewoo Electronics, Xerox Limited (Europe Xerox) and Fuji Xerox and KEC (Korea Electronic Co.). One company, that is KEC, was added to the group of previously researched companies in the in-depth interview survey of this research.

In total, eighty questionnaires (40 version one questionnaires and 40 version two questionnaires) were distributed to each company through design managers in each company. Two hundred and forty three questionnaires were returned. 28% of the questionnaires were collected (see Figure 32)

Figure 32 The ratio of returned questionnaires



On the other hand, eight questionnaires of the total returned questionnaires had some missing data. The missing data was treated as missing values in the SPSS process.

In the case of the version one questionnaire for designers, One hundred and ten questionnaires were collected (26% of the questionnaires were returned). In the case of the version for a non-designer, one hundred and thirty three questionnaires were returned (29% of the questionnaires were returned).

Figure 33 Ratio of returned questionnaires from designers (version one)

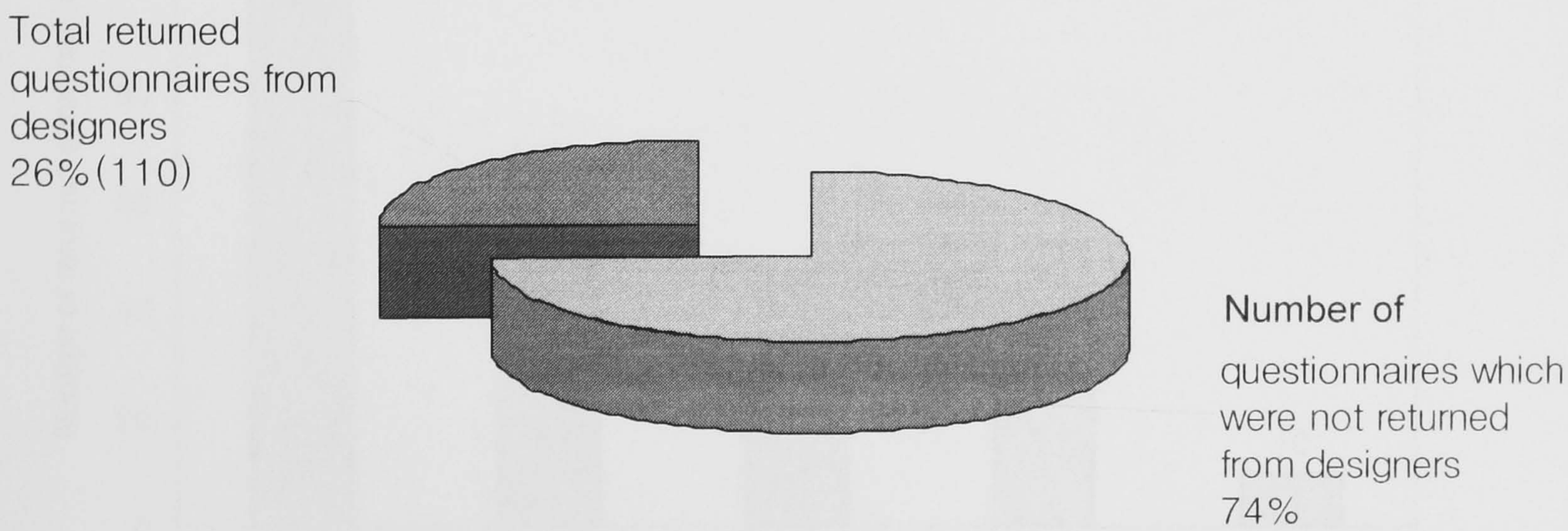
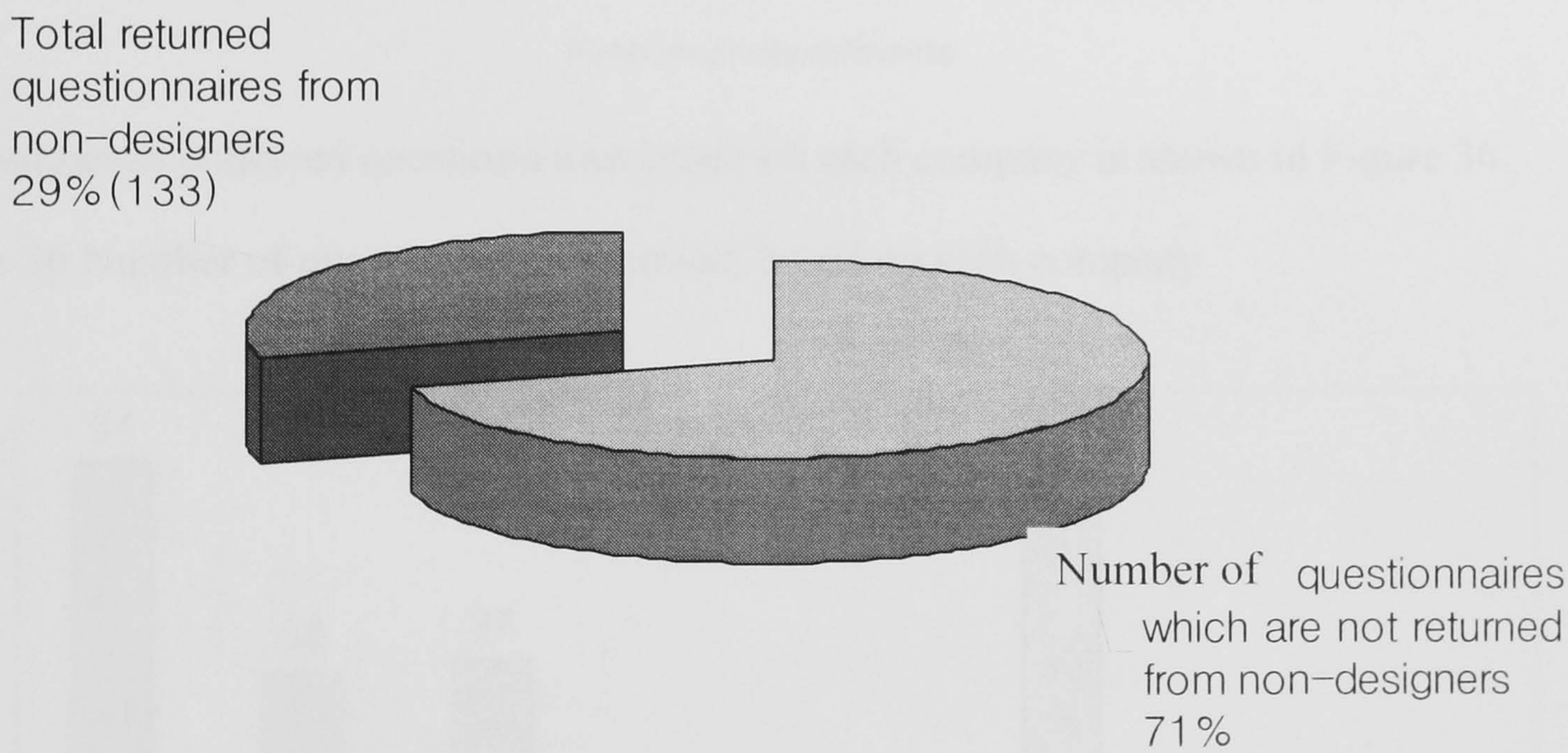


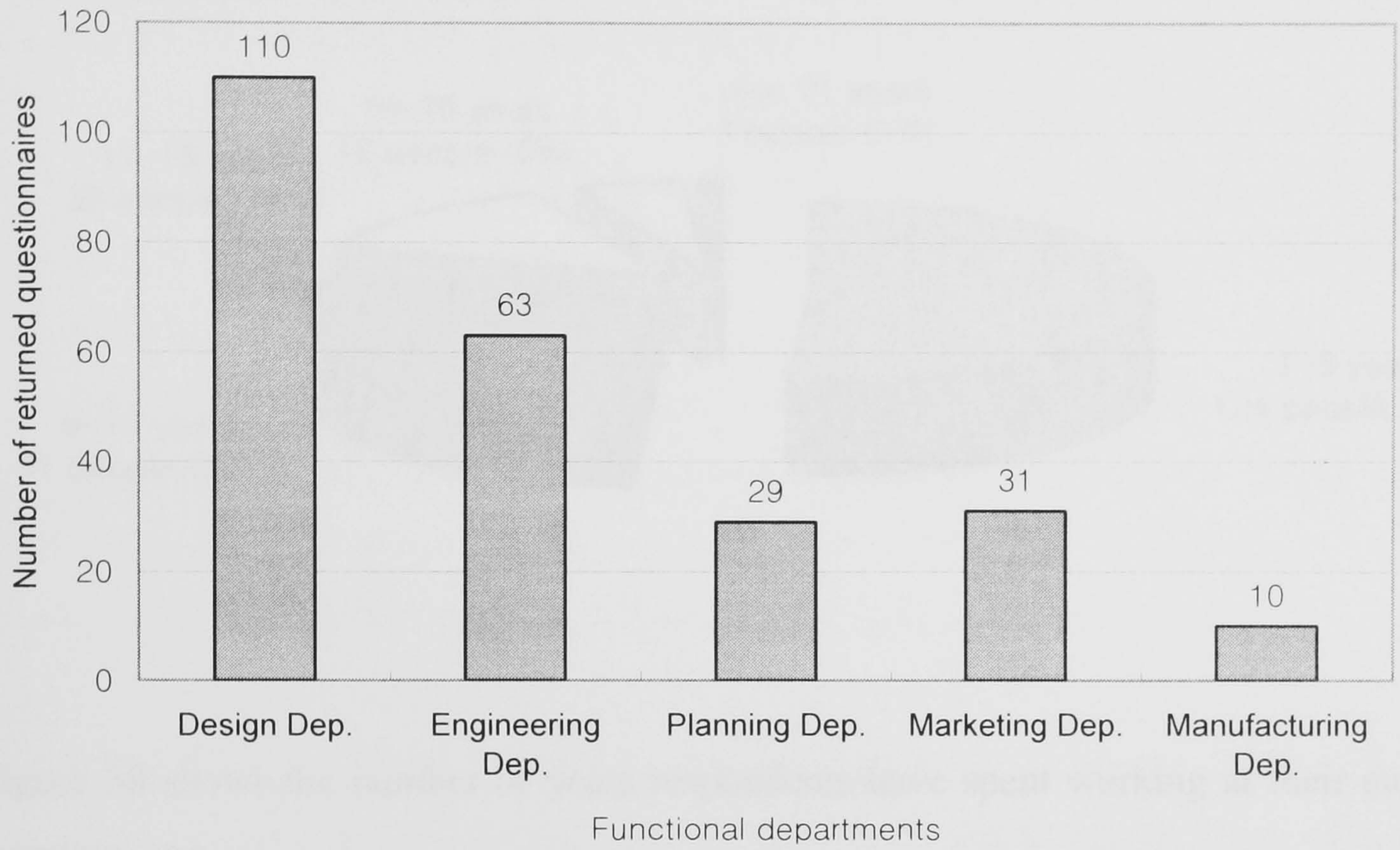
Figure 34 The ratio of returned questionnaires from non-designers (version two)



Considering the number of collected questionnaires based on each functional department, one hundred and ten questionnaires were returned from the design department, sixty-three questionnaires from the engineering department, twenty-nine questionnaires from the planning department, thirty-one questionnaires from the

marketing department, and ten questionnaires from the manufacturing department as Figure 35 shows below.

Figure 35 Number of questionnaires returned from each functional department.



The number of collected questionnaires based on each company is shown in Figure 36.

Figure 36 Number of questionnaires returned, based on each company

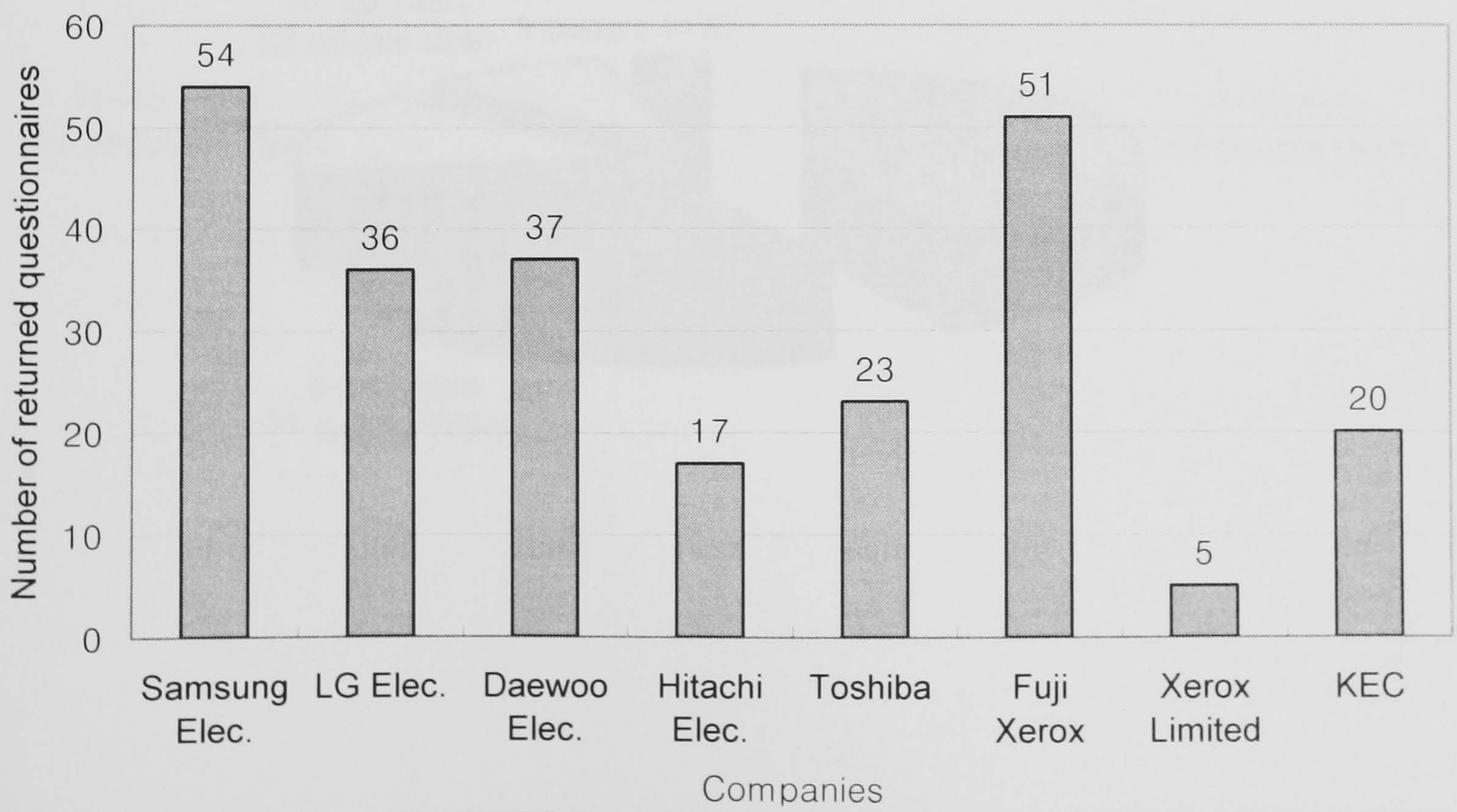


Figure 37 shows the number of years respondents have spent working as specialists in his/her professional area.

Figure 37 The number of years respondents have spent working as specialists in his/her professional area.

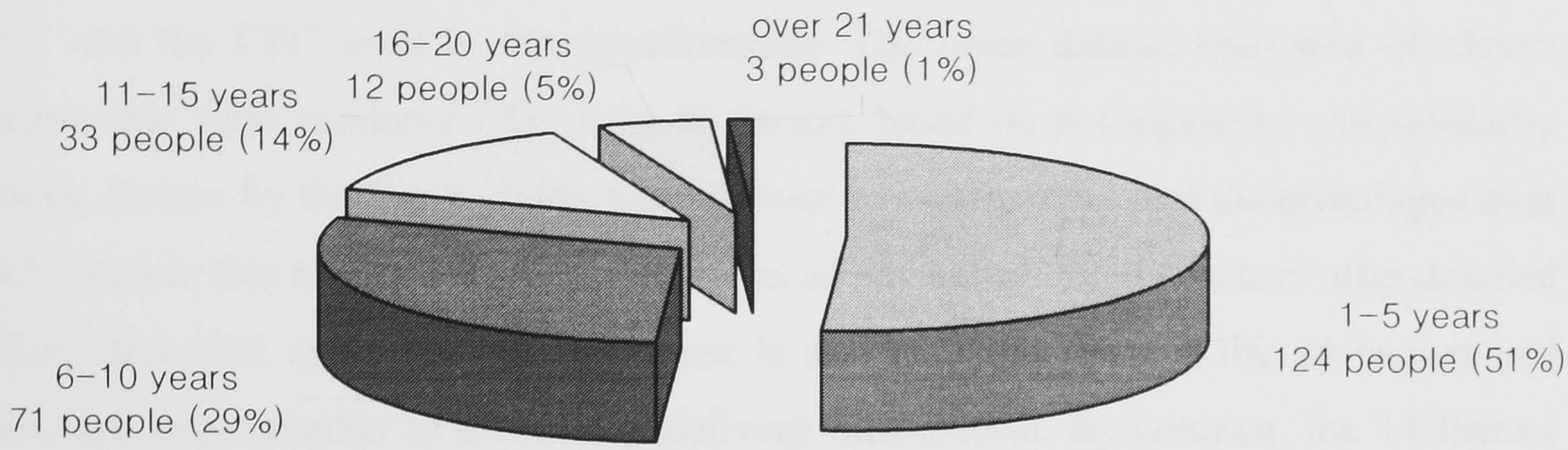
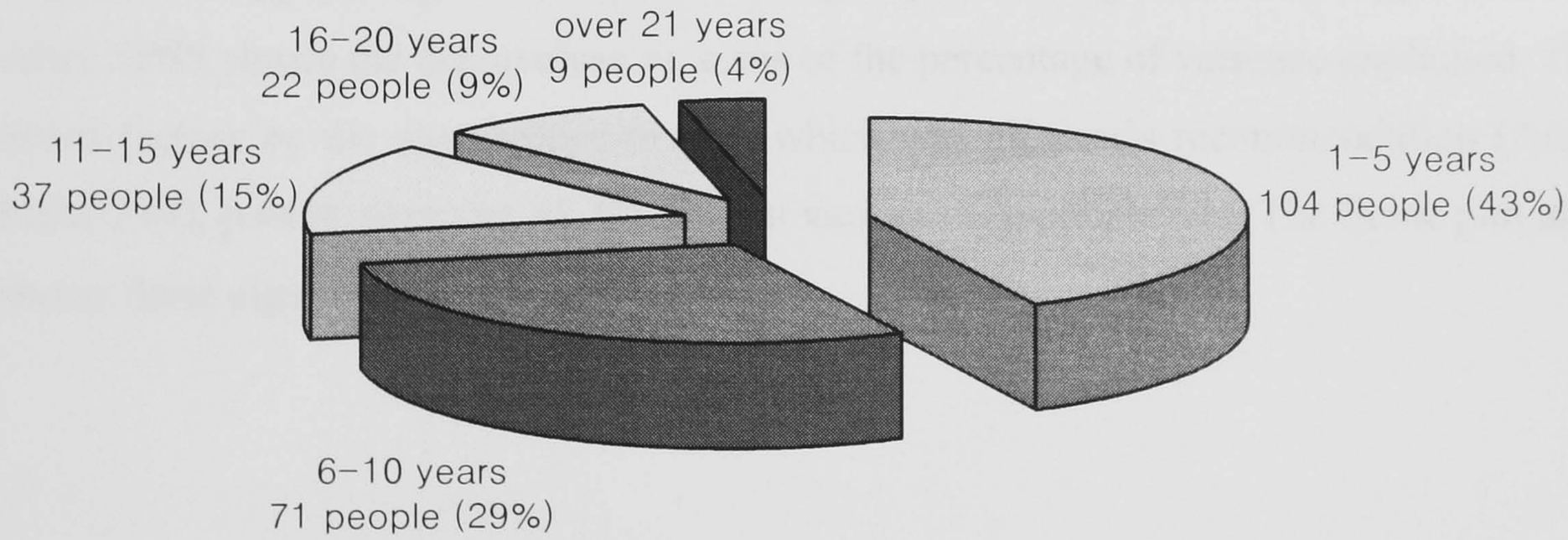


Figure 38 shows the number of years respondents have spent working at their current company, too.

Figure 38 The number of years respondents have worked at their current company.

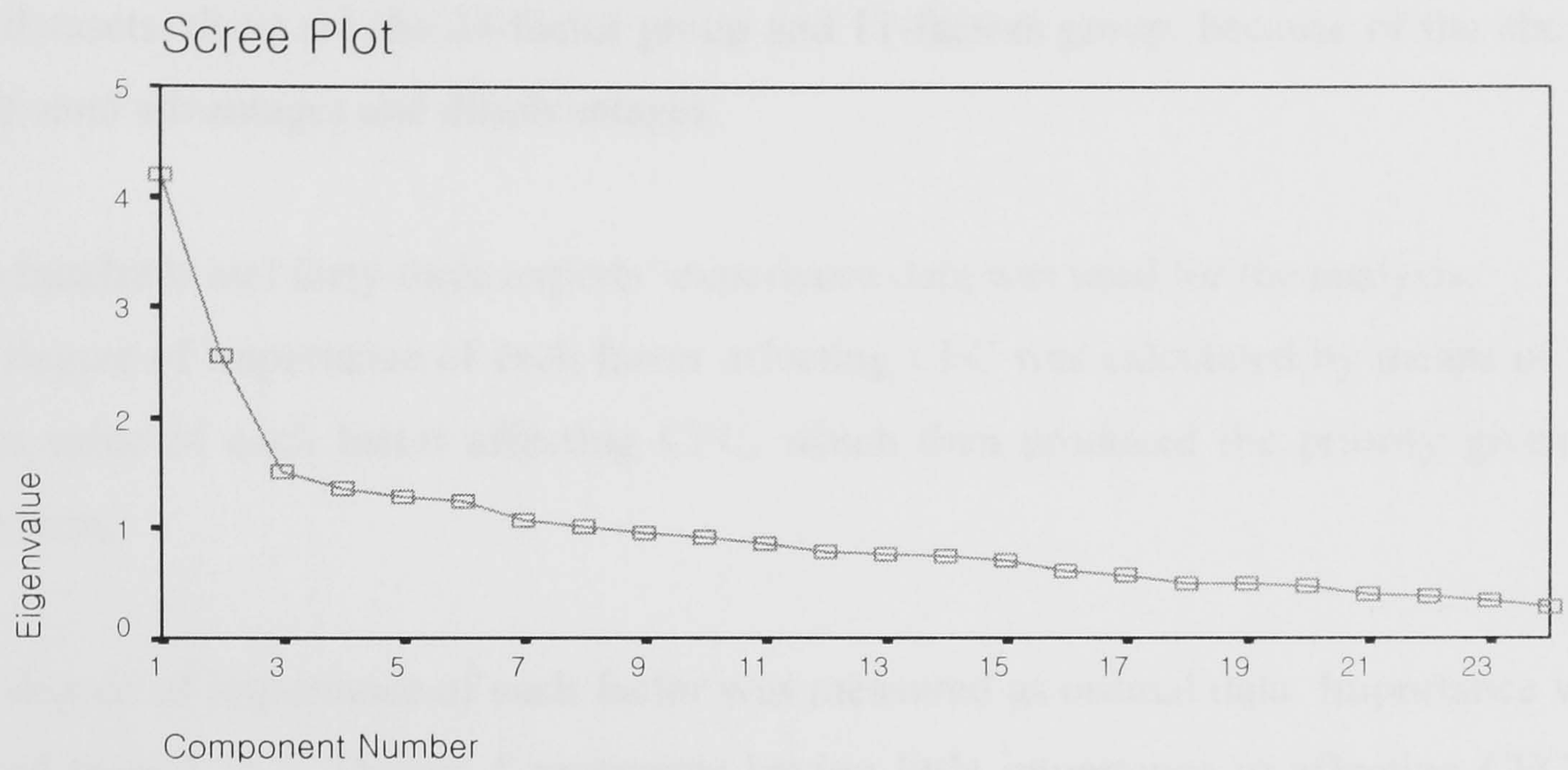


6.3 The data set of factors affecting CFC

Before producing the results of this questionnaire survey, the dataset of factors affecting CFC were divided into two groups. The first dataset consisted of the 24-factors, which are original factors used to measure the degree of importance of each item affecting CFC and the CFC level in the questionnaire. The other dataset consisted of eleven factors that were condensed from the 24 factors based on homogeneity and similarity among factors by the focus group. Each dataset has advantages and disadvantages over each other in this research work. Namely, as an advantage, the 24-factors offer detailed information, but as a disadvantage, these is still similarity among the 24-factors and these are large number to effectively delivery information. By contrast, the 11-factors dataset, after being condensed from the 24-factors, is that there is not much similarity among the factors, also it is better to communicate information effectively

In order to reduce the factor based on homogeneity and similarity among the factors as the other method, Factor Analysis was undertaken to compress the large of amount factors (24-factors) which still had a strong relationship with each other. The result by Factor Analysis (Extraction method: Principal Component Analysis) suggested seven factors as being the most reasonable factor groups affecting CFC. (see Appendix 10). Also, SPSS shows the eigenvaluse in terms of the percentage of varience explained. The seven factors by the eigenvalues over 1, which was aKaiser's recommendation (Andy Field 2000, p.449), explains 55.7% of total varience (Appendix 11). The Scree plot also shows these eigenvaluse in Figure 39.

Figure 39 The results of the Factor Analysis (Scree plot).



However, it was decided that the results from the Factor Analysis would not be used in this research, because of the following two reasons. Firstly, there were not similarity among the factors in the group of each seven factors (see Appendix 10), in comparison to the 11-factors grouped by focus group produced. The other reason is that this research would focus on qualitative data rather than quantitative data because of the nature of this research subject, as mentioned in the previous methodology chapter. For these reasons, the eleven factors, which were already developed by focus group, were preferred rather than the seven factors which was suggested by the result of factor analysis.

6.4 The priority of importance among the factors affecting CFC

The degree of importance attached to each factor affecting CFC was produced by using two datasets, these are the 24-factor group and 11-factors group, because of the above-mentioned advantages and disadvantages.

Two hundreds and forty-three experts' experience data was used for the analysis.
The degree of importance of each factor affecting CFC was calculated by means of the mean value of each factor affecting CFC, which then produced the priority given to each item.

The degree of importance of each factor was measured as ordinal data. Importance was ranked from 1 to 7. Degree 1 represents having little importance in affecting CFC in design development, and degree 7 represents being an extremely important factor. Degrees 1 to 7 are also divided into 6 intervals, namely, from 1 (little importance) to 7 (extreme importance). The reason why these factors were asked to mark the degree of importance from a little importance is that they had already been discovered to be important factors affecting CFC within both the previous literature and the interview survey stage of this research.

The average total degree of importance was 5.0. Also, all twenty-four factors were marked between 4.12 and 5.78. It can be deduced that all twenty-four factors affecting CFC, which were identified throughout both the previous literature survey and the interview survey, were verified again as being important factors by quantitative data.

Figure 40 shows the total average degree of importance of each factor affecting CFC in design development from the results of the questionnaire survey. These findings were produced from section B (see footnote[27]) in the questionnaire.

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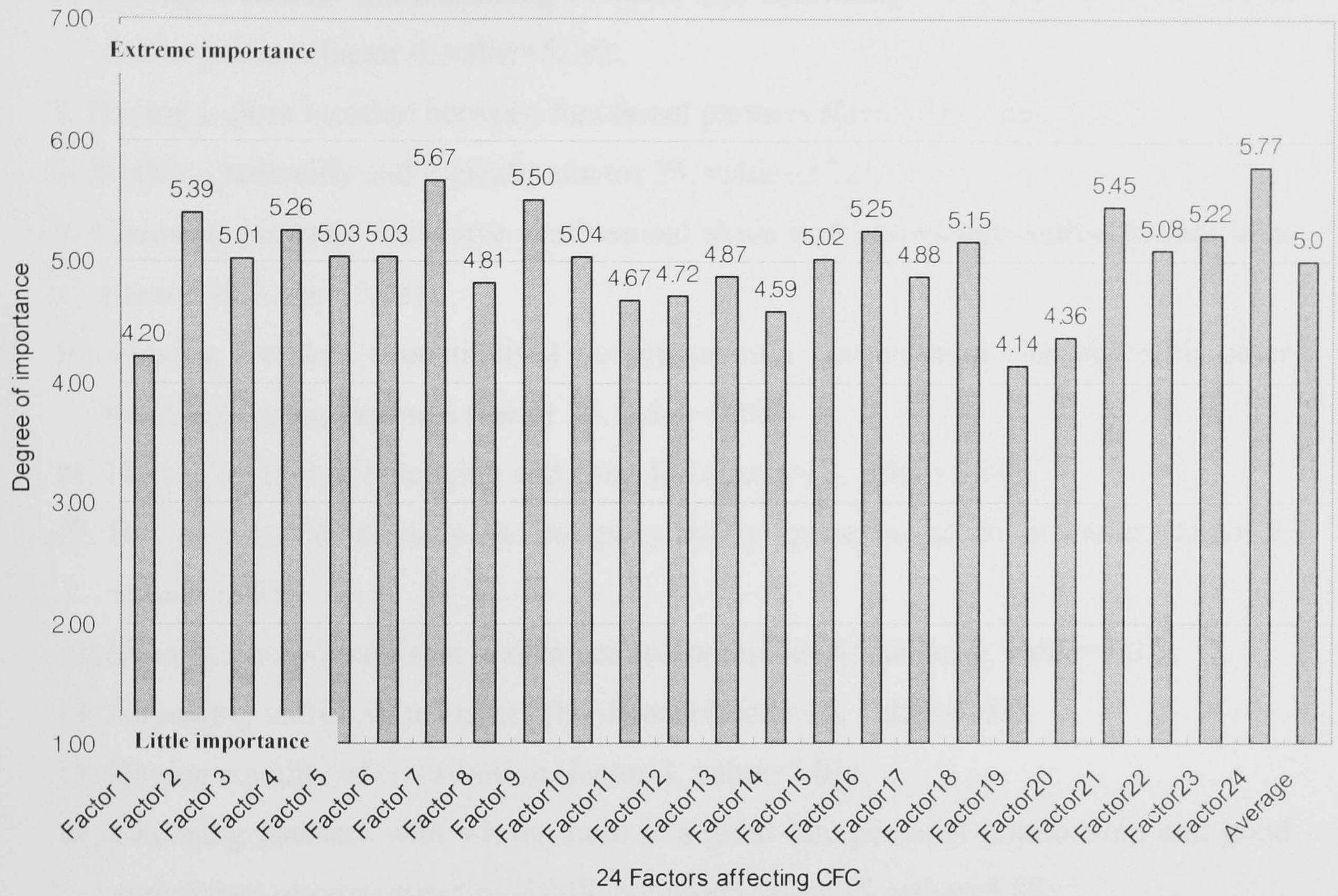
27 Section B: From your experience, please give your grading about the degree of importance of each factor affecting cross-functional collaboration. * Partner in this questionnaire means someone who not

Figure 40 Degree of importance of each factor affecting CFC (24-factors)



As a result of this one-dimensional analysis, the grade of importance among the factors affecting CFC is prioritised below.

1. Taking collective responsibility for a project (factor 24, value=5.77).
2. Sharing unified goals & objectives (project level) (factor 7, value=5.67).
3. Building trust between functional group partners (factor 9, value=5.50).
4. Having good quality communication (information sharing) with other functional group partners (factor 21, value=5.45).

only belongs to other functional departments (groups) but also works jointly, especially in an intellectual capacity for a special purpose (For example, in the case of a designer, a marketer, an engineer, a manufacturer etc).

5. Having a proper organisation and a flexible organisational culture for CFC (factor 2, value=5.39).
6. Having a mutual understanding of roles and knowledge of partners' departments and/or partner (factor 4, value=5.26).
7. Having a close location between functional partners (factor 16, value=5.25).
8. Working rationally and logically (factor 23, value=5.22).
9. Choosing partners who have professional skills and knowledge within his/her area (factor 18, value=5.15).
10. Having frequent (quantitative) communication (information sharing) with other functional group partners (factor 22, value=5.08).
11. Having a sense of belonging and cohesion (factor 10, value=5.04).
12. Having a unified strategy and company policy upstream and down stream (factor 5, value=5.03).
12. Sharing a common vision and values (corporate level) (factor 6, value=5.03).
14. Allocating sufficient resources (hardware) (factor 15, value=5.02).
15. Having equality of contribution (factor 3, value=5.01).
16. Choosing partners with whom there is a good interpersonal relationship and good experience of cross-functional collaboration (factor 17, value=4.88).
17. Having a well-defined and organised design process (factor 13, value=4.87).
18. Having an informal social relationship (or system) with other functional group members (factor 8, value=4.81).
19. Having a well-planned schedule for product development (factor 12, value=4.72).
20. Having well-developed management processes and systems (factor 11, value=4.67).
21. Having a joint rewards system rather than individual rewards system (factor 14, value=4.59).
22. Monitoring progress frequently and rapidly (factor 20, value=4.36).
23. Having a common culture (common language, common geographic and ethnological culture) (factor 1, value=4.20).
24. Managing and coordinating activities by senior manager (factor 19, value=4.14).

On the other hand, Figure 41 shows the degree of importance of eleven-factors affecting CFC in design development after calculating the mean value of its group factor from the 24-factor dataset. These eleven factors can be seen as compressed factors from the 24 factors based on the homogeneity and similarity among factors.

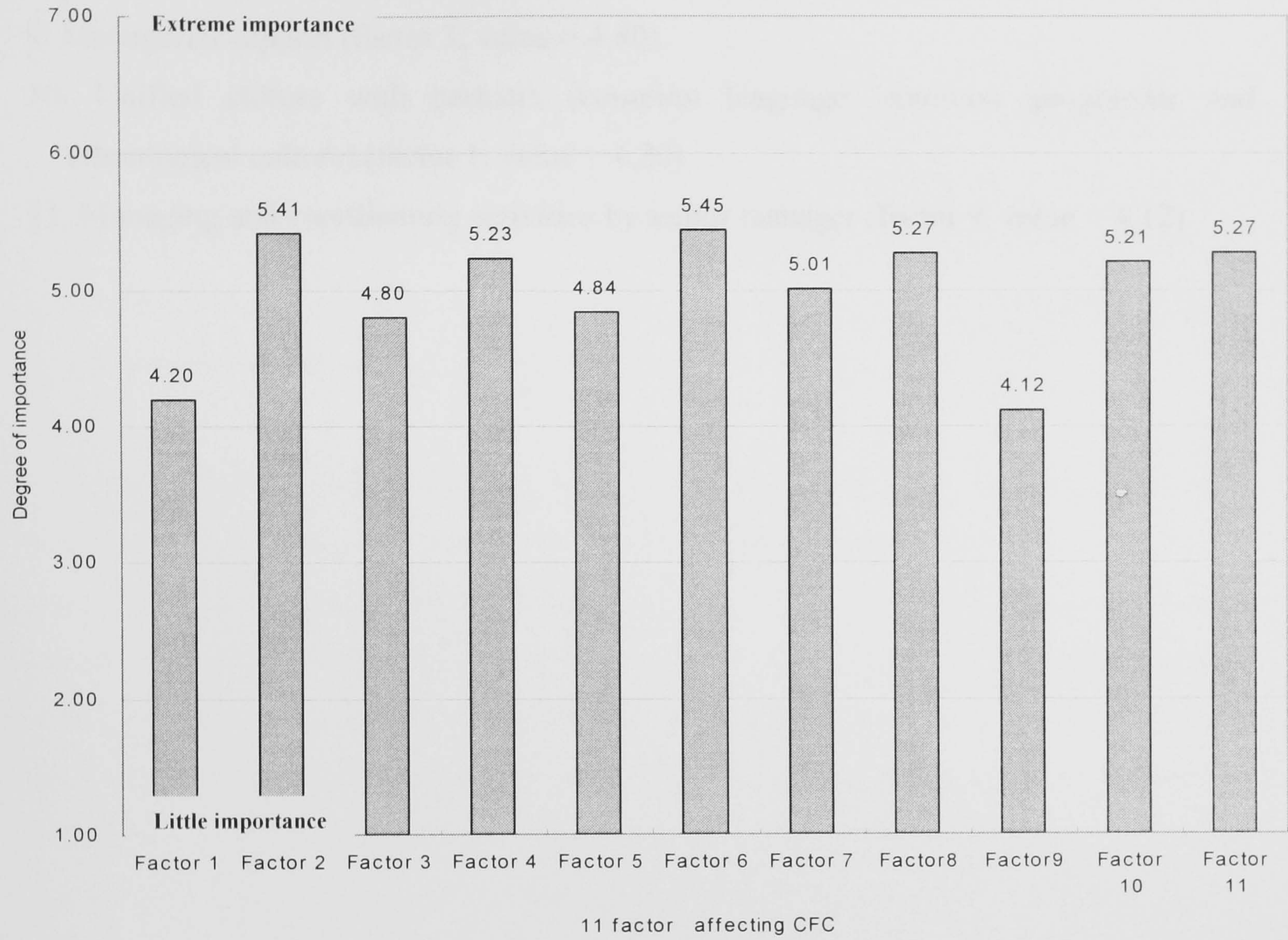
Table 25 shows each of the eleven factors and their elements from the twenty-four factors. This was the result of focus group work in the previous stage of this research. The value of each of the eleven factors was calculated by finding the mean value from each group. For example, if the factor, 'Choosing partners who have professional skills and knowledge within his/her area', is 5, and the factor, 'Choosing partners with whom there is a good interpersonal relationship and good experience of CFC', is 6, then the value of the factor, 'Choosing suitable partners', which was titled as a representative factor for the above two factors (statements) in the 11-factor group, was 5.5 after calculating as follows; (5+6) / 2 = 5.5.

Table 25 Eleven factors condensed based on the homogeneity and similarity among 24 factors identified by the focus group.

	11-factors	24-factors
1	*Building trust and cohesion* (factor 6, value = 5.45)	Taking collective responsibility for a project Building trust between functional group partners Having a sense of belonging and cohesion
2	*Having a proper organisation and a flexible organisational culture for cross-functional collaboration* (factor 2, value = 5.41)	Having a proper organisation and a flexible organisational culture for cross-functional collaboration
3	*Encouraging interaction between partners* (factor 11, value = 5.27)	Having good quality communication (information sharing) between other functional group partners Close location between functional partners Having frequent (quantitative) communication (information sharing) between other functional group partners
3	*Having a close physical location between functional partners* (factor 8, value = 5.27)	Having a close location between functional partners

5	*Sharing a unified vision and goals at both corporate level and project level* (factor 4, value = 5.23)	Sharing a unified goals & objectives (project level) Sharing a common vision and goals (corporate level) Having a unified strategy and policy company upstream and down stream
6	*Working rationally & logically* (factor 10, value = 5.21)	Working rationally & logically
7	*Choosing suitable partners* (factor 7, value = 5.01)	Choosing partners who have professional skills and knowledge within his/her area Choosing partners with whom there is a good interpersonal relationship and good experience of cross-functional collaboration
8	*Having an informal social relationship (or system) with other functional group partners* (factor 5, value = 4.84)	Having an informal social relationship (or system) with other functional group members
9	*Managerial support* (factor 3, value = 4.80)	Having a mutual understanding of role and knowledge of partners' departments and/or partner Equality of contribution Allocating sufficient resources Having a well-defined and organised design process Having a well-developed management process and systems Having a well-planned schedule for product development Having a joint rewards system rather than individual rewards system Monitoring progresses frequently and rapidly
10	*Unified culture with partners (common language, common geographic and ethnological culture)* (factor 1, value = 4.20)	Unified Culture (common language, common geographic and ethnological culture)
11	*Managing and coordinating activities by senior manager* (factor 9, value = 4.12)	Managing and coordinating activities by senior manager

Figure 41 Degree of importance of each factor affecting CFC (11-factors)



As a result, the importance of the eleven contributory factors affecting CFC is prioritised below.

1. Building trust and cohesion (factor 6, value = 5.45)
2. Having a proper organisation and a flexible organisational culture for the cross-functional collaboration (factor 2, value = 5.41)
3. Encouraging interaction between partners (factor 11, value = 5.27)
3. Having a close physical location between functional partners (factor 8, value = 5.27)
5. Sharing a unified vision and goals at both corporate and project level (factor 4, value = 5.23)
6. Working rationally and logically (factor 10, value = 5.21)
7. Choosing suitable partners (factor 7, value = 5.01)

8. Having an informal social relationship (or system) with other functional group partners (factor 5, value = 4.84)
9. Managerial support (factor 3, value = 4.80)
10. Unified culture with partners (common language, common geographic and ethnological culture) (factor 1, value = 4.20)
11. Managing and coordinating activities by senior manager (factor 9, value = 4.12)

6.4.1 Comparing a design group and a non-design group

In addition, the difference in opinion about the degree of importance of each contributory factor affecting CFC for product design development between a design group and a non-design group was also analysed using the Independent T-test which is used when there are two experimental conditions and different subjects assigned to each condition (Kim K. M.1998). The *t*-statistic is calculated by dividing the mean difference by the standard error of the sampling distribution of differences.

Two appendices (**Error! Reference source not found.** and Appendix 13) were produced to represent the output of the Independent *t*-test. Missing values in the questionnaires were excluded in this analysis. **Error! Reference source not found.** presents the mean values of each factor, number of samples of each factor (for example, designers 110, non-designers 131 in the case of the first factor), Standard deviations and Standard error mean of each factor. The total average for the degrees of importance were also calculated by using the mean value of all factors in each group. As a result, the designer's group indicated a value of 5.05, and the non-designer's group is a value of 4.96.

Appendix 13 contains the main *t*-test statistics. This table also shows the *Levene's test*. The Levene's test is similar to a *t*-test in that it tests the hypothesis that the variances in two groups are equal (i.e. the difference between the variance is zero). The 95% confidence interval indicates that 95% of the time the interval specified will reveal the true difference between the population means. By using the Levene's value and the t-value, and two-tail significance as a main result of the t-test, determination can be made as to whether there is a significant difference between the two groups. The correct way to determine significance is to consult the critical t-tables. In the results of the *t*-test, the exact significance value of *t* was produced. As results of the *t*-test, two-tailed *p* values less than 0.05 are shown in Appendix 13.

From the results of the t-test, eight factors were discovered as showing a significant difference in the two groups' opinions about the degree of importance of contributory factors affecting CFC for product design development (*t*-test is significant at $p < 0.05$).

These factors are

a. Having well-developed management process and systems (the average for designers is 4.85 vs. 4.53 for non-designers)
b. Having a well-planned schedule for product development (the average for designers is 4.93 vs. 4.46 for non-designers)
c. Having a well-defined and organised design process (the average for designers is 5.13 vs. 4.62 for non-designers)
d. Choosing partners who have professional skills and knowledge within his/her area (the average for designers is 5.33 vs. 4.94 for non-designers)
e. Managing and coordinating of activities by senior manager (the average for designers is 4.51 vs. 3.80 for non-designers)
f. Taking collective responsibility for a project (the average for designers is 5.58 vs. 5.94 for non-designers)
g. Having a joint rewards system rather than individual rewards system (the average for designers is 4.27 vs. 4.80 for non-designers)
h. Having a sense of belonging and cohesion (the average for designers is 4.82 vs. 5.23 for non-designers)

In summary, these eight factors can be identified as factors, which show that there is significant difference in opinions about the degree of importance of factors affecting CFC between a design group and a non-designer group. Five factors (the above a, b, c, d, e) were discovered as factors thought to be more significant by designers rather than non-designers (such as marketers, engineers, manufactures etc.). Otherwise, three factors (the above f, g, h) were thought to be more significant by non-designers than designers, as much as the paired gap values between the two groups.

6.4.2 Comparing a less experienced specialists group and a more experienced specialists group

The difference in opinion about the degree of importance of factors affecting CFC for product design development between a less experienced specialists (career under 5 years) group and a more experienced specialist (career over 6 years) group was also identified using the same method, that is the Independent *t*-test.

The results of this *t*-test analysis are presented in appendices 12 and 13. Appendix 14 presents the number of samples, mean values, standard deviations and standard error mean of each factor. The total mean values of each group are almost equal (approximately 5.0).

Appendix 15 shows the main results of the Independent *t*-test analysis, comparing differences in opinion about the degree of importance of factors between two groups. As a result, the significant values of twenty-two factors were greater than 0.05 ($p > 0.05$). Only two other factors indicate significant values below 0.05 ($p < 0.05$), that means only two factors were discovered as being significantly discriminating factors, which show an opinion gap between a less experienced group (under 5 years) and a more experienced group (over 6 years). These two factors are listed below.

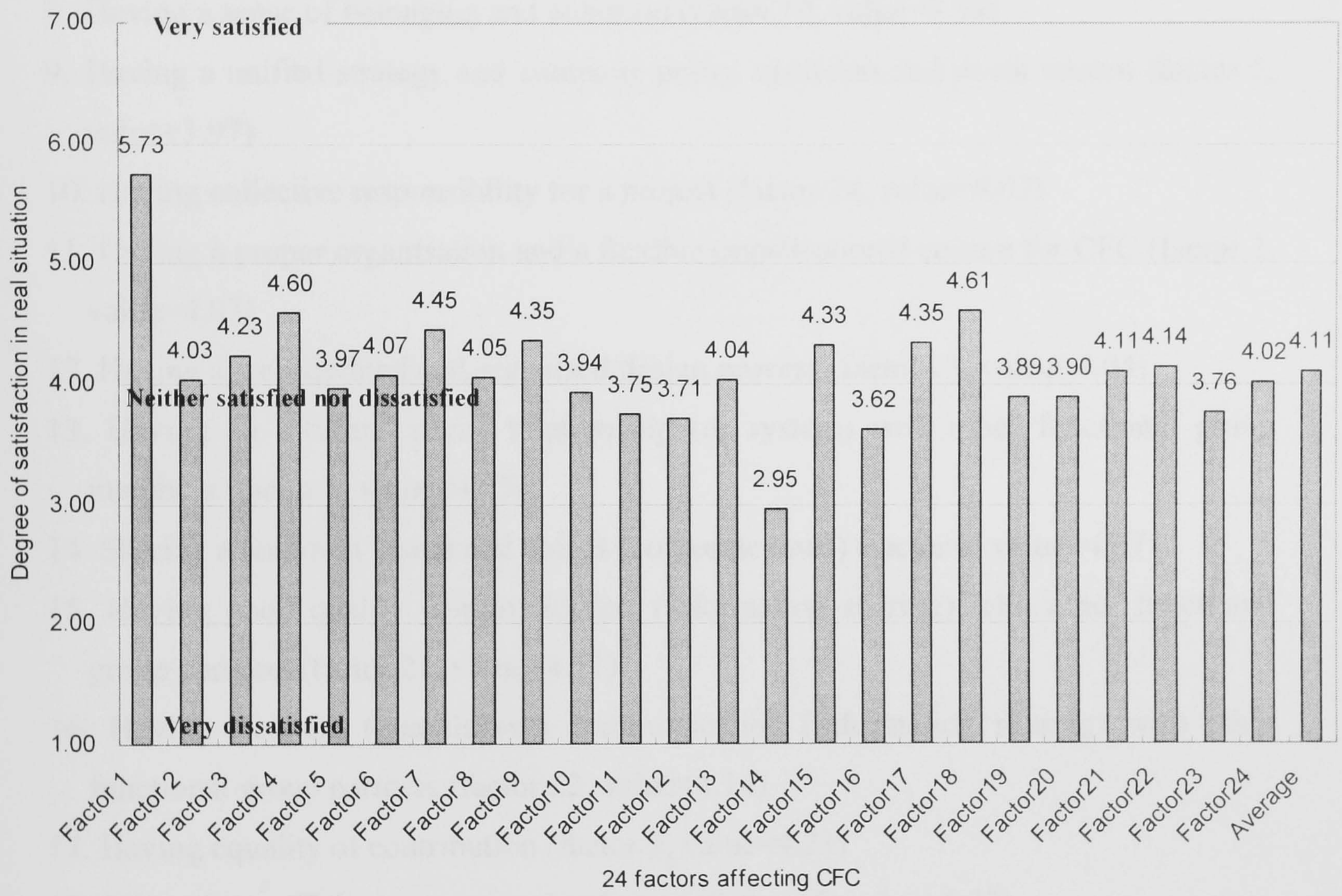
- Allocating sufficient resources (the average of less experienced specialists is 5.19 vs. 4.86 for the more experienced specialists)
- Working rationally and logically (the average of less experienced specialists is 5.39 vs. 5.03 for the more experienced specialists)

As results, the above two factors are thought to be more important by the less an experienced specialist group rather than the more experienced specialist group.

6.4.3 The degree of satisfaction in related to each factor affecting CFC.

The degree of satisfaction with each factor affecting CFC was measured based on the latest completed design development project. Figure 42 shows the results from section C (see footnote[28]) in the questionnaire.

Figure 42 The degree of satisfaction in actual situations related to each factor



The degree satisfaction in related to twenty-four contributory factors affecting CFC is prioritised below. These are ordered from low to high in related to real design development situations.

1. Having a joint rewards system rather than individual rewards system (factor 14, value=2.95)

[28] Section C: Purpose: In order to measure the level of CFC (cross-functional collaboration) in your design development project. Question: Please, evaluate, according to the grading in each factor, the new design development situation related to your the latest completed design project.

2. Having a close location between functional partners (factor 16, value=3.62)
3. Having a well-planned schedule for product development (factor 12, value=3.71)
4. Having well-developed management processes and systems (factor 11, value=3.75)
5. Working rationally and logically (factor 23, value=3.76)
6. Managing and coordinating activities by senior manager (factor 19, value=3.89)
7. Monitoring progress frequently and rapidly (factor 20, value=3.90)
8. Having a sense of belonging and cohesion (factor 10, value=3.94)
9. Having a unified strategy and company policy upstream and down stream (factor 5, value=3.97)
10. Having collective responsibility for a project (factor 24, value=4.02)
11. Having a proper organisation and a flexible organisational culture for CFC (factor 2, value=4.03)
12. Having a well-defined and organised design process (factor 13, value=4.04)
13. Having an informal social relationship (or system) with other functional group members (factor 8, value=4.05)
14. Sharing a common vision and values (corporate level) (factor 6, value=4.07)
15. Having good quality communication (information sharing) with other functional group partners (factor 21, value=4.11)
16. Having frequent (quantitative) communication (information sharing) with other functional group partners (factor 22, value=4.14)
17. Having equality of contribution (factor 3, value=4.23)
18. Allocating sufficient resources (hardware) (factor 15, value=4.33)
19. Building trust with functional group partners (factor 9, value=4.35)
19. Choosing partners with whom there is a good interpersonal relationship with you and good experience of cross-functional collaboration (factor 17, value=4.35)
21. Sharing unified goals & objectives (project level) (factor 7, value=4.45)
22. Having a mutual understanding of roles and knowledge of partners' departments and/or partner (factor 4, value=4.60)

23. Choosing partners who have professional skills and knowledge within his/her area (factor 18, value=4.61)
24. Having a common culture (common language, common geographic and ethnological culture) (factor 1, value=5.73)

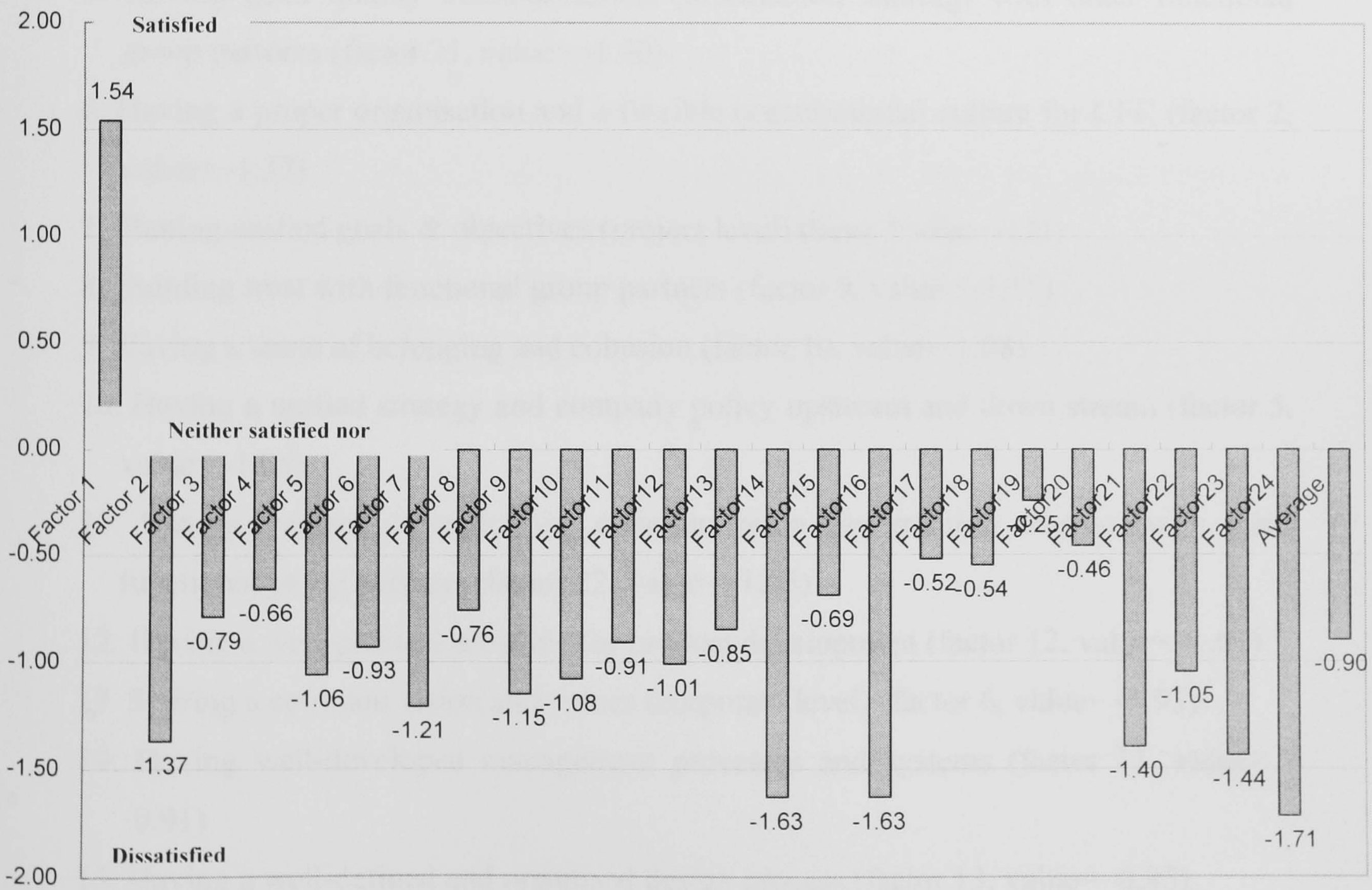
6.4.4 Priority of factors that are needed for more consideration of CFC in the actual field of consumer electronics firms.

In order to define the priority of factors that are needed for more consideration of CFC in the actual field of consumer electronics firms, the gaps between the degree of actual satisfaction of each factor and the ideal degree of importance of each factor were diagnosed. These gaps were calculated as follows;

[the value of the degree of actual satisfaction of each factor in practice *minus* the value of the ideal degree of importance of each factor]

The results of these calculations are presented in Figure 43.

Figure 43 The actual level of satisfaction in related to each factor affecting CFC against the ideal model of factors affecting CFC



As a result, the factor 'Having collective responsibility for a project (factor 24)' can be seen as the most considerable factor of all factors.

'Having a joint rewards system rather than individual rewards system (factor 14)' and 'Having a close location with other functional partners (factor 16)' are the second most important factors which need to be considered to improve CFC in the actual design development of consumer electronic products. The gap between the actual degree of satisfaction attached to each factor and the ideal degree of importance are listed below. These are ordered from low to high.

1. Having collective responsibility for a project (factor 24, value= -1.71)
2. Having a joint rewards system rather than individual rewards system (factor 14, value= -1.63)
2. Having a close location with other functional partners (factor 16, value= -1.63)
4. Working rationally and logically (factor 23, value= -1.44)
5. Having good quality communication (information sharing) with other functional group partners (factor 21, value= -1.40)
6. Having a proper organisation and a flexible organisational culture for CFC (factor 2, value= -1.37)
7. Sharing unified goals & objectives (project level) (factor 7, value= -1.21)
8. Building trust with functional group partners (factor 9, value= -1.15)
9. Having a sense of belonging and cohesion (factor 10, value=-1.08)
10. Having a unified strategy and company policy upstream and down stream (factor 5, value= -1.06)
11. Having frequent (quantitative) communication (information sharing) with other functional group partners (factor 22, value= -1.05)
12. Having a well-planned schedule for product development (factor 12, value= -1.01)
13. Sharing a common vision and values (corporate level) (factor 6, value= -0.93)
14. Having well-developed management processes and systems (factor 11, value= -0.91)
15. Having a well-defined and organised design process (factor 13, value= -0.85)
16. Having equality of contribution (factor 3, value=-0.79)

17. Having an informal social relationship with other functional group members (factor 8, value= -0.76)
18. Allocating sufficient resources (hardware) (factor 15, value= -0.69)
19. Having a mutual understanding of roles and knowledge of partners' departments and/or partner (factor 4, value= -0.66)
20. Choosing partners who have professional skills and knowledge within their area (factor 18, value= - 0.54)
21. Choosing partners with whom there is a good interpersonal relationship and good experience of cross-functional collaboration (factor 17, value= -0.52)
22. Monitoring progress frequently and rapidly (factor 20, value= -0. 46)
23. Managing and coordinating activities by senior manager (factor 19, value= -0.25)
24. Having a common culture (common language, common geographic and ethnological culture) (factor 1, value=1.54)

The results indicate that for one factor 'Unified culture' there is a small gap between the actual degree of satisfaction and the ideal degree of importance with it. On the other hand, the other twenty-three factors show a large gap between the actual degree of satisfaction and the ideal degree of importance with them.

In other words, it can be said that factors which show a greater gap need more consideration. Figure 43 shows these priorities in visual.

6.5 The correlation between the level of CFC and the performance of product design development, to define substantial factors affecting design development performance.

6.5.1 Introduction of aims and datasets.

The main aims of this section are largely divided into two parts. Firstly, the aim is to define the correlation between the level of CFC and the performance of product design development. The second aim is to define substantial factors affecting total design development performance (and each item of design development performance). Namely, to find which factors affect CFC substantially in relation to the performance of product design development. This second aim was divided into four sub aims and, each of the four aims were divided into a further two aims again. Table 26 shows these aims in detail.

Table 26 Aims: to discover a definition of the correlation between the level of CFC and the performance of product design development, and to define substantial factors affecting design development performance.

Aim 1	**Aim 1-1**	To define the correlation between the total level of CFC and the total weighted performance of product design development
	Aim 1-2	To define substantial factors affecting the total design development performance
Aim 2		To define the correlation between CFC and the performance of each item in product design development.
		To define substantial factors affecting the performance of each item in product design development
Aim 2-1	**Aim 2-1-1**	To define the correlation between the CFC and *the time performance* of product design development
	Aim 2-1-2	To define substantial factors affecting *the time performance* of a product design development item
Aim 2-2	**Aim 2-2-1**	To define the correlation between CFC and *the cost performance* of a product design development
	Aim 2-2-2	To define substantial factors affecting the *cost performance* of a product design development item
Aim 2-3	**Aim 2-3-1**	To define the correlation between CFC and *the quality performance* of product design output

	Aim 2-3-2	To define substantial factors affecting *the quality performance* of product design output
Aim 2-4	**Aim 2-4-1**	To define the correlation between CFC and *the effectiveness and efficiency of design management*
	Aim 2-4-2	To define substantial factors affecting *the effectiveness and efficiency of design management*

In order to achieve the aims in this section, the simple linear regression analysis and the multiple linear regression analysis were used. Regression is a statistic technique for predicting one dependent variable from one (Simple linear regression) or more (Multiple linear regression) independent variables. Namely, Simple regression seeks to predict an outcome from a single predictor, whereas multiple-regression seeks to predict an outcome from several predictors. It makes assumptions about the data (e.g. normality and linearity), and the results may be nonsensical if there is no clear reason why a causal relationship should exist. This is dealt with in subsequent sections in this chapter.

The 11-factors dataset was adopted rather than the 24-factor dataset for this analysis because of the following three reasons, as mentioned in the previous section; 6.3 The data set of factors affecting CFC.

6.5.2 The correlation between the level of CFC and the total performance of product design development, to define substantial factors affecting total design development performance. (Aim 1)

6.5.2.1 The correlation between the level of CFC and the total performance of product design development (Aim 1-1)

In order to explain the first aim of this section, which is to define the correlation between the total level of CFC and the total performance of product design development, the Simple regression analysis was used. The results are presented in tables 27, 28, 29, 30, 31 and Figure 44.

Table 27 Descriptive Statistics: between the level of CFC and the total performance of product design development

	Mean	Std. Deviation	N
Total weighted performance of design development	413.8476	98.0778	105
Level of CFC	4.105	.763	105

Table 28 Correlations between the total level of CFC and the total performance of product design development

		Total weighted performance of design development	Level of CFC
Pearson Correlation	Total weighted performance of design development	1.000	.791
	Level of CFC	.791	1.000
Sig. (1-tailed)	Total weighted performance of design development	.	.000
	Level of CFC	.000	.
N	Total weighted performance of design development	105	105
	Level of CFC	105	105

Both the above tables are not necessary for interpreting the regression model, but they provide a useful summary of the data. Table 27 shows each mean value, the standard deviation of each variable in the dataset, and the number of cases. The mean value of

the total performance of product design development was approximately 413, and the mean value of CFC was approximately 4.1. This 4.1 mean value suggests that respondents were neither satisfied nor dissatisfied with the total CFC level in their latest design development project, because value 4 is a middle value between very dissatisfied and very satisfied (Very dissatisfied was value 1, very satisfied was value 7 in the questionnaire).

Table 28 shows three facts as results of this part of the analysis. Firstly, this table shows the values of the Pearson correlation coefficient between a pair of variables. This coefficient of Pearson correlation is 0.791 (see Table 28), which means that there is a high positive correlation between the satisfaction level of CFC and the performance of design development. In the other words, as the satisfaction level of cross-functional collaboration increases, so does the performance of design development. If the Pearson correlation value were minus (for example –0.791), this would mean that there is a negative correlation between the two compared groups. For example, as an independent variables (group) increases, so another dependent variable decreases. Secondly, the 1-tailed significance of correlation is displayed as (p=0.05 means 5%, or a 1 in 20 chance, and =0.01 means a 1%, or 1 in 100 chance.). Thus, a low p value shows significance. In this analysis, p value (*Sig.* value) is well below 0.001 ($p < 0.001$), which means this correlation result is very reliable (see Table 28). Finally, the number of cases contributing to each correlation is shown. In the case of this analysis, the total 105 cases (questionnaires) were taken as valid questionnaires (N=105). Five invalid questionnaires were excluded in this analysis.

Table 29 Summary of simple regression analysis: between the total level of CFC and the total performance of product design development

	R	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**				
Model					F Change	df1	df2	Sig. F Change
1	.791 a)	.626	.622	60.2825	172.291	1	103	.000

a): Predictors: (Constant), Total collaboration satisfaction level

The above summary of simple regression analysis (see Table 29) provides the value of *'R'*, *'R Square'*, *'Adjusted R Square'*, *Std. Error of the Estimate'*, *'F change'*, *'df'*, *and 'Significant F Change'*. The value of the correlation between two groups is in the column labelled *'R'*. In this survey, The *R-value* is 0.791, which means that there is a high positive correlation between the cross-functional collaboration and the total performance of product design development. The next column *'R Square'* shows how much variability in the outcome, that is the total performance of product design development, is accounted for by cross-functional collaboration. Namely, *'R Square' value in* Table 29 is *0.626*, which means that the level of cross-functional collaboration can account for approximately 62.6% of the variation in the total performance of product design development. In other words, it can be explained why the performance of some product design development projects are better than others, it can be said the other variations in the performance of product design development. There might be many factors that can explain these variations, but the research output in this section, which includes only a level of cross-functional collaboration, can explain 62.6% of the total performance of product design development. This means that 37.4% of the variation in the total performance of product design development cannot be explained by the level of cross-functional collaboration. Therefore, 37.4% of the variation can be found from other variables that have an influence on the total performance of product design development.

Table 30 ANOVA (Analysis of Variance): between the level of CFC and the total performance of product design development

Dependent Variable: Total weighted performance of design development

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	626101.788	1	626101.788	172.291	.000 a)
	Residual	374299.774	103	3633.978		
	Total	1000401.562	104			

a): Predictors: (Constant), total CFC satisfaction level

The most important aspects of the output from this regression analysis are '*F value*', which is assessed by using the critical value for the corresponding degree of freedom, and the associated '*Significant value*' of that *F-ratio*. Table 30 shows the *F-ratio*, and *Significance value*. From the results of this SPSS analysis, *F value* is very high (*F* is 172.291) and the associated significance value of that F-ratio is below 0.01 ($p < 0.01$). Therefore, as a conclusion, this regression model produces a significantly better prediction of the performance of design development when compared to using the mean value of it. In short, this regression model predicts the performance of design development very well.

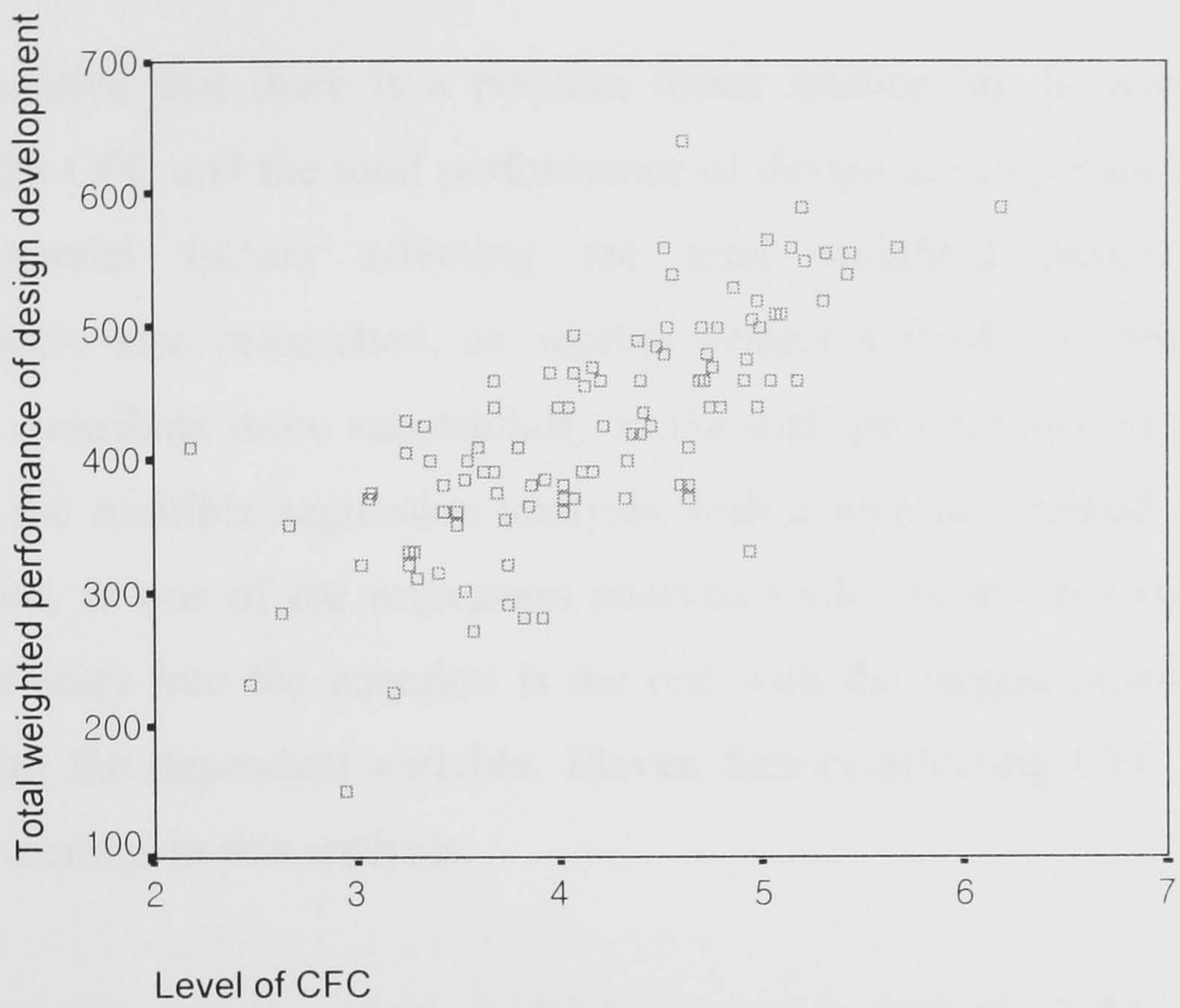
Table 31 Coefficients: between the level of CFC and the total weighted performance of product design development

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-3.355	32.324		-.104	.918
	Level of CFC	101.639	7.743	.791	13.126	.000

Dependent Variable: Total weighted performance of Design development

The ANOVA model (Table 30) shows results with a significantly good degree of prediction of the outcome variable. But, ANOVA does not give information about the individual contribution of variables in the model. Table 31 in SPSS output provides details of the model parameters (the beta values) and the significance of these values. From Table 31, B_0 is –3.355, and this value means that design development performance would be as much as the value (-3.355), if there was no cross-functional collaboration satisfaction. But it means nothing in this analysis, because the significance value is 0.918 (*Sig.* is much bigger than 0.05), therefore it can be said that is not a significant value. Also, B_1 value in Table 31 is 101.639, and this value can be interpreted as meaning that if the total level of cross-functional collaboration is increased by 1 degree (satisfactory degree) then 101 degree of the performance of product design development will be increased.

Figure 44 the scatter-plot of correlation between the total weighted performance of design development and the CFC Level



As further evidence from the results of this SPSS, the scatter-plot in figure 44 also indicates that there is a clear and high positive linear relationship between the satisfaction level of CFC and the total performance of design development. Linear means that the relationship is modelled as a straight line.

Therefore, as a conclusion, if there is a higher level of CFC during a product design development process, improved design development performance will be achieved.

6.5.2.2 To define substantial factors affecting total design development performance (Aim 1-2)

It has been verified that there is a positive linear relationship between the level of satisfaction with CFC and the total performance of design development in the previous section. Substantial factors affecting the total weighted design development performance were also researched, as another central aim of this research. To find which factors contribute more substantially to the total performance of product design development; the multiple regression analysis with a forward method was used. The forward method, as one of the regression analysis tools, means that the first variable considered for entry into the equation is the one with the largest positive or negative correlation with the dependent variable. Eleven factors affecting CFC were taken as independent variables in this analysis.

From the descriptive statistics of this multiple regression analysis, Table 32 (descriptive statistics) views the mean values of each factor affecting CFC, the standard deviation of each factor and the number of cases which were taken. The mean value of total weighted performance of design development is approximately 411, the mean value of 'Unified culture with partners (common language, common geographic & ethnological culture)' is 5.7, which is highly marked in comparison to other factors. The second highly marked factor is 'Having a proper organisation and a flexible organisational culture for CFC' with a 4.0 value for satisfaction level. The mean values of other factors are shown in Table 32.

Seven cases were excluded in this analysis, because of missing values in the questionnaires. Therefore, 103 cases were used in this analysis as Table 32 shows (N=103).

Table 32 Descriptive Statistics of multiple regression analysis: for the total performance of design development and each factor affecting CFC

	Mean	Std. Deviation	N
Total weighted performance of design development	411.2524	96.5264	103

1.Unified culture with partners (common language. common geographic & ethnological culture)	5.7670	1.3519	103
2. Having a proper organisation and a flexible organisational culture for the CFC	4.0194	1.2444	103
3.Managerial support	3.9102	.8194	103
4. Sharing unified vision and goals at both corporate level and project level	4.1259	1.0130	103
5. Having an informal social relationship (or system) with other functional group partners	4.0388	1.4479	103
6. Building trust and cohesion	4.0777	1.0135	103
7.Choosing suitable partners	4.4417	1.0056	103
8. Having a close physical location between functional partners	3.6117	1.5795	103
9. Managing and coordinating activities by senior manager	3.8835	1.2151	103
10.Working rationally and logically	3.7379	1.1712	103
11. Encouraging interaction between partners	4.0097	1.0525	103

Another result of this multi regression analysis, presents three facts as shown in appendix 14 shows. First, the table shows the value of the Pearson correlation coefficient between every pair of factors (variables), for example, 'Unified culture with partners' had a positive correlation with the total performance of design development because the *R value is 0.3*. Second, the '*1-tailed significance*' of each correlation is displayed, for example, the above correlation between 'Unified culture with partners' and 'total performance of design development' is significant, because the significance value is below 0.001 ($p < 0.001$). Finally, the number of cases, which was used as correlation data in this analysis, is also shown. The number of all cases in the analysis is 103 ($N = 103$).

From the output of these correlation values (see Appendix 16), we can conclude that there is a positive correlation between 'each factor affecting CFC' and 'the total performance of design development' *(all correlation values are positive and Sig. <= .001)*. Also, the correlation between each paired factor affecting CFC can be found from correlation values in Appendix 16.

As a body result of this analysis, four factors (variables) of all the eleven factors were discovered as factors substantially contributing to the total performance of product

design development. These four factors were found by means of giving a criterion of 95% probability of multiple regression analysis within a hierarchical method (Method = Forward, Criterion: Probability-of-F-to-enter <= .050, see Table 33). These four factors are 'Building trust and cohesion', 'Sharing unified vision and goals at both corporate level and project level', 'Encouraging interaction between partners', and 'Having a proper organisation and a flexible organisational culture for CFC', as Table 33 shows.

Table 33 Variables Entered/Removed of multiple regression analysis: for the total performance of design development a)

Model	Variables Entered	Method
1	6. Building trust and cohesion	Forward (Criterion: Probability-of-F-to-enter <= .050)
2	4.Sharing unified vision and goals at both corporate level and project level	Forward (Criterion: Probability-of-F-to-enter <= .050)
3	11. Encouraging interaction between partners	Forward (Criterion: Probability-of-F-to-enter <= .050)
4	2. Having a proper organisation and a flexible organisational culture for the CFC	Forward (Criterion: Probability-of-F-to-enter <= .050)

On other hand, the model summary table (Table 34) presents important information about this SPSS output. In the column labelled '*R*' are indicated the values of the correlation coefficient between predictors and the outcome, for example, when only 'Building trust and cohesion' is used as a predictor, this is the simple correlation between 'Building trust and cohesion' and 'Total performance of design development', the correlation coefficient value is 0.686 (R=0.686, see first model in Table 34). The next column shows the value of '*R Square*', which means how much of the variability in the outcome is accounted for by the predictors. For the first model its value is 0.470, which means that the 'Building trust and cohesion' predictor accounted for 47% of the variation in the total performance of design development. In the fourth regression model, the other three predictors, 'Sharing unified vision and goals at both corporate level and project level'; 'Encouraging interaction between partners', and 'Having a proper organisation and a flexible organisational culture for the CFC' are included as well. This value increases to 63.2% (*R Square* = 0.632) of the variance in the total performance of design development. All '*significant F change*' values are below 0.05 in

this output of regression analysis. 'Adjusted R square', 'Std. Error of the estimate', 'F change', 'df', and 'sig. F change' are also shown in Table 34.

Table 34 Model Summary of multiple regression analysis: for the definition of contributory factors affecting total design development.

	R	R Square	Adjusted R Square	Std. Error of the Estimate				
Model					F Change	df1	df2	Sig. F Change
1	.686 a)	.470	.465	70.5983	89.679	1	101	.000
2	.749 b)	.561	.552	64.5797	20.703	1	100	.000
3	.782 c)	.611	.599	61.1259	12.620	1	99	.001
4	.795 d)	.632	.617	59.7164	5.729	1	98	.019

a): Predictors: (Constant), 6. Building trust and cohesion, b): Predictors: (Constant), 6. Building trust and cohesion, 4. Sharing unified vision and goals at both corporate level and project level, c): Predictors: (Constant), 6. Building trust and cohesion, 4. Sharing unified vision and goals at both corporate level and project level, 11. Encouraging interaction between partners, d): Predictors: (Constant), 6. Building trust and cohesion, 4. Sharing unified vision and goals at both corporate level and project level, 11. Encouraging interaction between partners, 2. Having a proper organisation and a flexible organisational culture for cross-functional collaboration

Table 35 presents the output of an ANOVA (Analysis of Variance) that tests whether the model is significantly better at predicting the outcome when compared to using the mean as an estimate of the outcome in this research analysis. Table 35 is again divided into four sections: one for each regression model. As an important output of the ANOVA, the *F-ratio*, which represents the ratio of the improvement in prediction as a result of fitting the model relative to the inaccuracy that still exists in the model, was presented in the table. The *F-ratio* is calculated by dividing the average improvement in prediction by the model (MS_M) by the average difference between the model and the observed data (MS_R). If the improvement due to fitting the regression model is much greater than the inaccuracy within the model, then the value of F will be greater than 1 and SPSS calculates the exact probability of obtaining the value of F by change. From these models in Table 35, the *F-ratios* are 89.6, 63.9, 51.7, and 42.1, which are very unlikely to have occurred by chance and these are highly significant (*all* $p < .001$).

Table 35 ANOVA of multiple regression analysis for the total performance of design development e)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	446973.029	1	446973.029	89.679	.000 a)

	Residual	503396.408	101	4984.123		
	Total	950369.437	102			
2	Regression	533315.092	2	266657.546	63.938	.000 b)
	Residual	417054.345	100	4170.543		
	Total	950369.437	102			
3	Regression	580467.728	3	193489.243	51.785	.000 c)
	Residual	369901.709	99	3736.381		
	Total	950369.437	102			
4	Regression	600896.559	4	150224.140	42.126	.000 d)
	Residual	349472.878	98	3566.050		
	Total	950369.437	102			

a): Predictors: (Constant), 6. Building trust and cohesion, b): Predictors: (Constant), 6. Building trust and cohesion, 4. Sharing unified vision and goals at both corporate level and project level, c): Predictors: (Constant), 6. Building trust and cohesion, 4. Sharing unified vision and goals at both corporate level and project level, 11. Encouraging interaction between partners, d): Predictors: (Constant), 6. Building trust and cohesion, 4. Sharing unified vision and goals at both corporate level and project level, 11. Encouraging interaction between partners, 2. Having a proper organisation and a flexible organisational culture for cross-functional collaboration

Table 36 Coefficients of multiple regression analysis: for total design development performance. a)

		Unstandardized Coefficients		**Standardized Coefficients**	**t**	**Sig.**	**Collinearity Statistics**	
Model		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	144.925	28.971		5.002	.000		
	6.Trust and cohesion	65.314	6.897	.686	9.470	.000	1.000	1.000
2	(Constant)	78.068	30.302		2.576	.011		
	6.Trust and cohesion	47.516	7.423	.499	6.401	.000	.722	1.384
	4.Sharing a unified vision and goals	33.794	7.427	.355	4.550	.000	.722	1.384
3	(Constant)	51.282	29.656		1.729	.087		
	6.Trust and cohesion	28.950	8.757	.304	3.306	.001	.465	2.150
	4.Sharing a unified vision and goals	31.390	7.062	.329	4.445	.000	.716	1.397
	11.Interaction between partners	28.034	7.891	.306	3.552	.001	.531	1.883
4	(Constant)	38.287	29.477		1.299	.197		
	6.Trust and cohesion	26.560	8.613	.279	3.084	.003	.459	2.180
	4.Sharing a unified vision and goals	25.902	7.271	.272	3.563	.001	.645	1.552
	11.Interaction between partners	26.068	7.753	.284	3.362	.001	.525	1.905

	2.Proper organisation & a flexible organisational culture for the CFC	13.253	5.537	.171	2.393	.019	.736	1.358

As final output of this multi regression analysis. Table 36 provides the model parameters for four steps in the hierarchy. Interpreting the values in this SPSS output was focused on the final model in which all predictors were included. because this model accounts for the largest variance in the total performance of design development. This model, in which all four factors are included, accounts for the total performance of design development, 63.2% (R Square = 0.632).

- *Sharing unified vision and goals at both corporate level and project level with other functional partners (B =25.902):* The value indicates that as the factor, 'Sharing a unified vision and goals with other functional partners', increases by one degree on the seven-value satisfaction scale (very dissatisfied=1, very satisfied=7), the performance of design development can increase by approximately 25.9 points (the minimum performance point is 100 and the maximum performance point is 700)
- *Encouraging interaction between partners (B =26.068): The* value indicates that as the factor, 'choose suitable partners', increases by one degree on the seven-value satisfaction degree scale (very dissatisfied=1, very satisfied=7), the performance of design development increases by approximately 26 points (the minimum performance point is 100 and the maximum performance point is 700)
- *Having a proper organisation and a flexible organisational culture for CFC (B = 13.253):* The value indicates that as the level of satisfaction in relation to the factor, '*Proper organisation and a flexible organisational culture for CFC*', increases by one degree on the seven-value satisfaction scale (very dissatisfied=1, very satisfied=7), the performance of design development increases by approximately 13.2 points (the minimum performance point is 100 and the maximum performance point is 700)

The above interpretations are true only if the effects of the other predictors (factors) are held constant.

Each of these *Beta* values in Table 36 has an associated *Standard error* indicating to what extent these values would vary across different samples, and these Standard errors are used to determine whether or not the *B* value differs significantly from zero.

In a multiple-regression, it is easier to conceptualise the *t-tests* as measures of whether the predictor is making a significant contribution to the model. Therefore, if the *t-test* associated with a *B value* is significant (if the value in the column labelled *Sig.* is less than 0.05) then the predictor is making a significant contribution to the model. The smaller the value of *Sig.* (and the larger the *t-value*) is the greater the contribution of that predictor. From the magnitude of the *t*-statistics of this SPSS result, we can

conclude that 'Trust and cohesion' (t=3.563, p=0.003), 'Sharing unified vision and goals' (t=3.662, p=0.001), 'Interaction between partners' (t=2.393, p=0.001), and 'A proper organisation & a flexible organisational culture for CFC' (t=2.393, p=0.019) are all significant predictors, which affect the total performance of product design development.

The '*Standardized beta*' values were also provided in Table 36 by the SPSS output, and they indicated the number of standard deviations that the outcome will change as a result of one Standard deviation change in the predictor. All of the Standardized beta values were measured in Standard deviation units and so were directly comparable: therefore, the Standardized beta values give a better insight into the 'importance' of a predictor in the output of SPSS. To interpret these values literally, the Standard deviations of all the variables and these values can also be found in the SPSS output. These are shown in the previous Table 32, the descriptive statistics.

The Standardized beta value for 'Trust and cohesion' is 0.279 from the survey data. This value indicates that as the level of satisfaction in relation to degree of 'trust and cohesion' increases by one standard deviation (1.0135; see Table 32), the total performance of design development increases by 0.279 Standard deviations. The Standard deviation for the total performance of design development is 96.5264, so this constitutes a change of approximately 26.9 points (0.279 × 96.5264). In other words, if 1.0135 of the degree of satisfaction of 'Trust and cohesion' increases, the total performance of design development will increase by 26.9 points. Therefore, if it is calculated by one degree of satisfaction again, when one degree of satisfaction of 'Trust and cohesion' increases, the total performance of design development will increase by 26.5 points. The degree of satisfaction was measured between 1 (very dissatisfied) and 7 (very satisfied), and the total performance of design development was measured between 100 (the minimum performance point) and 700 (the maximum performance point) in this research. If the other Standardized beta values of each predictor are calculated in the same way: when one degree of satisfaction of 'Interaction between

partners' increases, the total performance of design development will be expected to increase by 26; when one of satisfaction degree of 'Sharing unified vision and goals' increases, the total performance of design development will increase by 25.9; and when one degree of satisfaction of 'Proper organisation & flexible organisation culture for CFC' increases, the total performance of design development will increase by 13.2, according to the Standardized beta values of these regression analysis results. These interpretations could be true only if the effects of the other predictors (contributory factors affecting CFC) are held constant.

SPSS output, Table 36, also provides some measures of whether there is multi-collinearly among the predictors (factors). Multicollinearity usually exists when there is a strong correlation between two or more predictors in a multi-regression analysis model. If the predictors are highly correlated, and each accounts for similar variance in the outcome, then it can be interpreted that there is high collinearity between the predictors. Multicollinearity between predictors makes it difficult to assess the individual importance of a predictor.

However, as Andy Field (2000) pointed out,
"it is virtually unavoidable to have some degree of collinearity in real-life data".

One way of identifying multicollinearty is to scan a correlation matrix of all of the predictor variables and see if any correlate very highly (very high means correlations of above 0.80 or 0.90, Andy Field (2000)). But SPSS produces more suitable forms of various collinearity diagnostics, one of which is *the Variance Inflation Factor (VIF)*. The VIF indicates whether a predictor has a strong linear relationship with the other predictor(s). However, there are fixed rules about what value of the VIF should be a cause of concern, as Field (2000) pointed out. Myers (1990) suggests that a value of 10 is a good value at which to worry. Bowerman and O'Connell (1990) also suggest that if the average VIF is greater than 1, then multicollinearity may be biasing the regression model. Related to the VIF is the *tolerance* statistic, which is its reciprocal (1/VIF). As

such, values below 0.1 indicate serious problems, although Menard (1995) suggests that values below 0.2 are worthy of concern.

The output of this research survey data (Appendix 16 and Table 36) indicates that the correlation values are all below 0.8, the VIF values are all well below 10, and the tolerance statistics all well above 0.2; therefore, from the data in this survey it is anticipated that there was no problem of collinearity within the data.

To calculate the average VIF, VIF values for each predictor are divided by the number of predictors:

(1.907+1.696+1.370+1.570) / 4 = 1.63

The average VIF is close to 1, and this suggests that collinearity is not a problem for the regression analysis model in this research. In other words, all eleven factors affecting CFC are worthy as independent factors to measure the total performance of design development.

In summary, as a main result of multiple regression analysis in this section, four factors were identified as greatly contributing to total design development performance (the $p < 0.05$). Also, these four factors account for quite a large amount of the variation in the total performance of design development, 63.2% (R Square=0.632). These four factors are prioritised according to the degree of significance influencing the total performance of product design development. It was calculated by using a Standardized Beta value. Each value in parenthesis presents the expected increasing degree of total design development performance dependent on one degree of satisfaction of each factor increase:

- 'Building trust and cohesion' (26.5)
- 'Encouraging interaction between partners' (26)
- 'Sharing unified vision and goals at both corporate level and project level' (25.9)
- 'Having a proper organisation and a flexible organisational culture for the CFC' (13.2)

6.5.3. To define the correlation between the level of CFC and each individual performance item (time, cost, quality, management) of product design development, and to define substantial factors affecting the performance of each design development item. (Aim 2)

After defining of the correlation between the level of cross-functional collaboration and the total weighted performance of product design development, the correlation between the level of CFC and each individual performance item of product design development were also investigated. These individual performance items of product design development consisted of time, cost, quality of design output, and finally the effectiveness and efficiency of design management.

As another central aim, substantial factors affecting each individual performance item of design development were defined using the same method, which had been used to define contributory factors affecting total design development performance in the previous section. The methods for interpreting the output data from SPSS are also the same, as was noted in the previous section. Therefore, the results are dealt with directly without a detailed explanation of the interpretation process.

In order to achieve the aims of this section, a regression analysis also was used.

6.5.3.1 To define the correlation between the level of CFC and *the time performance* of product design development (Aim 2-1-1)

In order to define the correlation between the level of CFC and *the time performance in product design development*, the simple regression analysis was also used. The results of this regression analysis are presented in tables 37, 38, 39 and figure 45.

The mean value of time performance of design development from respondents is 4.3, which can be interpreted as indicating that there was very little satisfaction with time performance in design development in relation to product development of respondents' latest project. The degree of satisfaction in relation to each factor was measured between values 1 and 7. Value 1 means very dissatisfied, value 7 means very satisfied, and the value 4.3 is a little bit biased towards satisfied. Total of 109 cases (questionnaires) were used as this analysis. Table 37 describes all the information.

Table 37 Descriptive Statistics: between the total level of cross-functional collaboration and the time performance of product design development

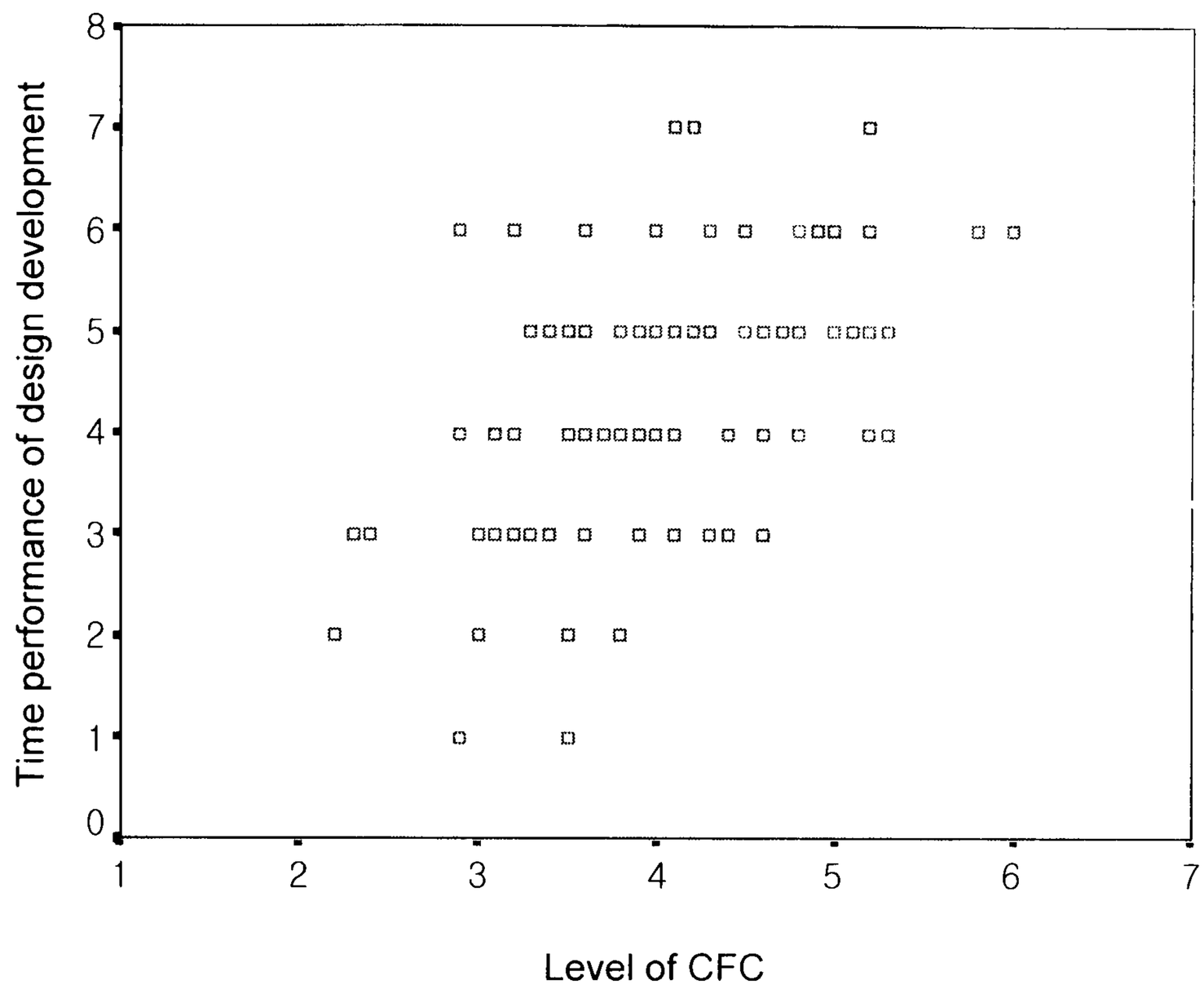
	Mean	Std. Deviation	N
Time performance of design development	4.3853	1.2831	109
Level of CFC	4.1018	.7634	109

In Table 38 below, the Pearson correlation value indicates 0.546, which means that there is a positive correlation between the CFC satisfaction level and the time performance of design development. The *p* value (*Sig.* value) is below 0.001 ($p < 0.01$), which means this correlation result is very significant. The Scatter-plot in figure 45 also shows that there is plus relationship between the CFC level and the time performance of design development.

Table 38 Correlations: between the total level of cross-functional collaboration and the time performance of product design development

		1.Time performance of design development	Level of CFC
Pearson Correlation	Time performance of design development	1.000	.546
	Level of CFC	.546	1.000
Sig. (1-tailed)	Time performance of design development	.	.000
	Level of CFC	.000	.
N	Time performance of design development	109	109
	Level of CFC	109	109

Figure 45 The scatter-plot of correlation between the time performance of design development and the CFC level



From the results of the Summary of the simple regression analysis model in Table 39, the satisfaction level of CFC accounts for 29.8% of the variability in the time performance of design development. *(R square: 0.298)*

Table 39 Summary of simple regression analysis: between the total level of cross-functional collaboration and *the time performance* of product design development

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.546	.298	.291	1.0803

(a) Predictors: (Constant), Whole collaboration satisfaction level on latest project

6.5.3.2 To define contributory factors affecting *the time performance* of design development (Aim 2-1-2)

In order to identify which factors affecting the time performance of design development substantially, the multiple regression analysis with a forward method was used. The results of this multiple linear regression analysis are presented in tables 40, 41, 42,43 and Appendix 17.

In Table 40, three cases, which included missing values, were excluded. Therefore, a total of 107 cases (questionnaires) were used in this analysis. Also, Table 40 presents the other mean value, the standard deviation value of factors affecting CFC and the number of cases, which were used in this analysis.

Table 40 Descriptive statistics of multiple regression analysis: for the *time performance* of design development and each factor affecting CFC

	Mean	Std. Deviation	N
Time performance of design development	4.3551	1.2757	107
1.Unified culture with partners (common language, common geographic & ethnological culture)	5.7383	1.3828	107
2.Having a proper organisation and a flexible organisational culture for cross-functional collaboration	4.0187	1.2437	107
3.Managerial support	3.9171	.8171	107
4. Sharing unified vision and goals at both corporate level and project level	4.1243	1.0140	107
5. Having an informal social relationship (or system) with other functional group partners	4.0187	1.4405	107
6. Building trust and cohesion	4.0720	1.0127	107
7.Choosing suitable partners	4.4486	1.0092	107
8. Having a close physical location between functional partners	3.5888	1.5659	107
9. Managing and coordinating activities by senior manager	3.8879	1.2463	107
10.Working rationally and logically	3.7290	1.1701	107
11. Encouraging interaction between partners	3.9953	1.0382	107

Appendix 17 shows the value of the Pearson correlation coefficient between every pair of factors (variables), the 1-tailed significance of each correlation, and the number of cases ($N = 107$). From the output values of the Pearson correlation coefficient in Appendix 17, we can conclude that there is a positive correlation between the nine

factors affecting CFC and the time performance of design development. These nine factors exclude three factors of the eleven factors. These are 'Unified culture', 'Informal social relationship with other functional group partners', and 'Close physical location between functional partners'. This is because, the significance values of the above three factors' are over 0.05 which means these three correlation coefficient values of factors (predictors) are not significant (*p.* > 0.05).

As a result of using a multi regression analysis, two factors (variables) were discovered as being substantial factors affecting to the time performance of product design development. These two factors were found by means of giving a criterion of 95% probability of multiple regression analysis within a hierarchical method (Method = Forward, Criterion: Probability-of-F-to-enter <= .050, see Table 41). These two factors are 'Interaction between partners', and 'Sharing unified vision and goals at both corporate level and project level'.

Table 41 Variables Entered/Removed of multiple regression analysis for the *time performance* of design development a)

Model	Variables Entered	Method
1	11.Interaction between partners	Forward (Criterion: Probability-of-F-to-enter <=.050)
2	4.Sharing unified vision and goals	Forward (Criterion: Probability-of-F-to-enter <=.050)

a) Dependent Variable: 1.Time performance of design development

The output of R value, R Square, Adjusted R Square, Std. Error of the Estimate, F change, and Sig. F change are presented in Table 42, which is a model summary table. The values of the results in the second model in Table 42 indicate that there is a simple correlation between two predictors, which are 'Interaction between partners', and 'Sharing unified vision and goals at both corporate level and project level' and the time performance of design development' (R = 0.508). Also this second model accounts for quite a large amount of the variation in time performance of design development (*R Square* = 0.339). In other words, the 'R Square value' indicates that these two factors account for 33.9% of the variance in the time performance of design development

(33.9%). All 'F change' are high and 'Significant F change' show less than 0.01 in the output of this multiple regression model (see Table 42).

Table 42 Model Summary of multiple regression analysis: for the *time performance* of design development

	R	R Square	Adjusted R Square	Std. Error of the Estimate		
Model					F Change	Sig. F Change
1	.507 a)	.257	.250	1.1048	36.331	.000
2	.582 b)	.339	.326	1.0472	12.871	.001

a) Predictors: (Constant), 11.Interaction between partners, b) Predictors: (Constant), 11.Interaction between partners, 4. Sharing unified vision and goals

The results of the correlation and collinearity statistics are presented in Table 43. The correlation values in this research are all below 0.8, the VIF values are all well below 10, and the tolerance statistics all well above 0.2. These values, therefore, suggest that there is no collinearity among the factors (predictors). Moreover, the average VIF (1.195) is very close to 1, and this indicates that collinearity is not a problem for this multiple-linear-regression analysis model.

Table 43 Coefficients of multiple regression analysis: for *time performance* of design development. a)

		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
Model		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	1.866	.427		4.375	.000		
	11.Interaction between partners	.623	.103	.507	6.028	.000	1.000	1.000
2	(Constant)	.863	.491		1.757	.082		
	11.Interaction between partners	.468	.107	.381	4.370	.000	.837	1.195
	4.Share unified goals and vision	.393	.110	.313	3.588	.001	.837	1.195

Dependent Variable: 1.Time performance of design development

Another result is that the standardized beta value for 'Interaction between partners' is 0.381 in Table 43. This value indicates that as the level of satisfaction with 'interaction between partners' increases by one standard deviation (1.0382: see table 39), the time performance of design development increases by 0.381 standard deviations. The

standard deviation for time performance of design development is 1.2757 and so this constitutes a change of approximately 0.4860 points (0.381 × 1.2757). Therefore, if 1.0382-satisfaction degree of 'interaction between partners' increases, the time performance of design development will increase by 0.4860 points. Namely, if it is calculated by one of satisfaction degree again, when the one-satisfaction degree of 'interaction between partners' improves, the time performance of design development increases by 0.4681 of degree. If the other standardized beta value of 'Sharing unified vision and goals at both corporate level and project level' is calculated in the same way: when one of satisfaction degree of 'Sharing unified vision and goals at both corporate level and project level' increases, the time performance of design development will be expected to increase by 0.3932 of degree according to the interpretation of the Standardized beta value of this regression analysis results. These interpretations could be with in the hypothesis if the effects of the other predictors (contributory factors affecting CFC) are held constant.

In summary, as a result of the multiple linear regression analysis in this section, two factors were defined as being important contributory factors to *the time performance* of design development ($p. < 0.01$). These two factors are prioritised according to the degree of significance influencing the time performance of product design development. Each value in the following parenthesis presents the expected increasing degree of time design development performance dependent on one degree of satisfaction of each factor increase:

- 'Interaction between partners' (0.4681 degree)
- 'Sharing unified vision and goals at both corporate level and project level' (0.3932 degree).

6.5.3.3 To define the correlation between the level of CFC and *the cost performance* of product design development (Aim 2-2-1)

In order to define the correlation between the level of CFC and *the cost performance* of product design development, the simple regression analysis was also used. All the results of this regression analysis are presented in tables 44, 45, 46, and figure 46.

Table 44 shows the Mean value, Std. deviation, and number of used cases in this analysis. The mean value of cost performance of design development is 4.7, which can be interpreted as indicating a low degree of satisfaction in relation to cost performance. This cost performance value (4.7) of product design development is a little bit higher than the time performance value (4.3) of product design development. The Mean value of CFC level is 4.1, and the Standard deviation values were also presented in Table 44. A total of 109 cases were used in this analysis.

Table 44 Descriptive Statistics: between the total level of cross-functional collaboration and the cost performance of product design development

	Mean	Std. Deviation	N
Cost performance of design development	4.78899	1.31989	109
Level of CFC	4.1018	.7634	109

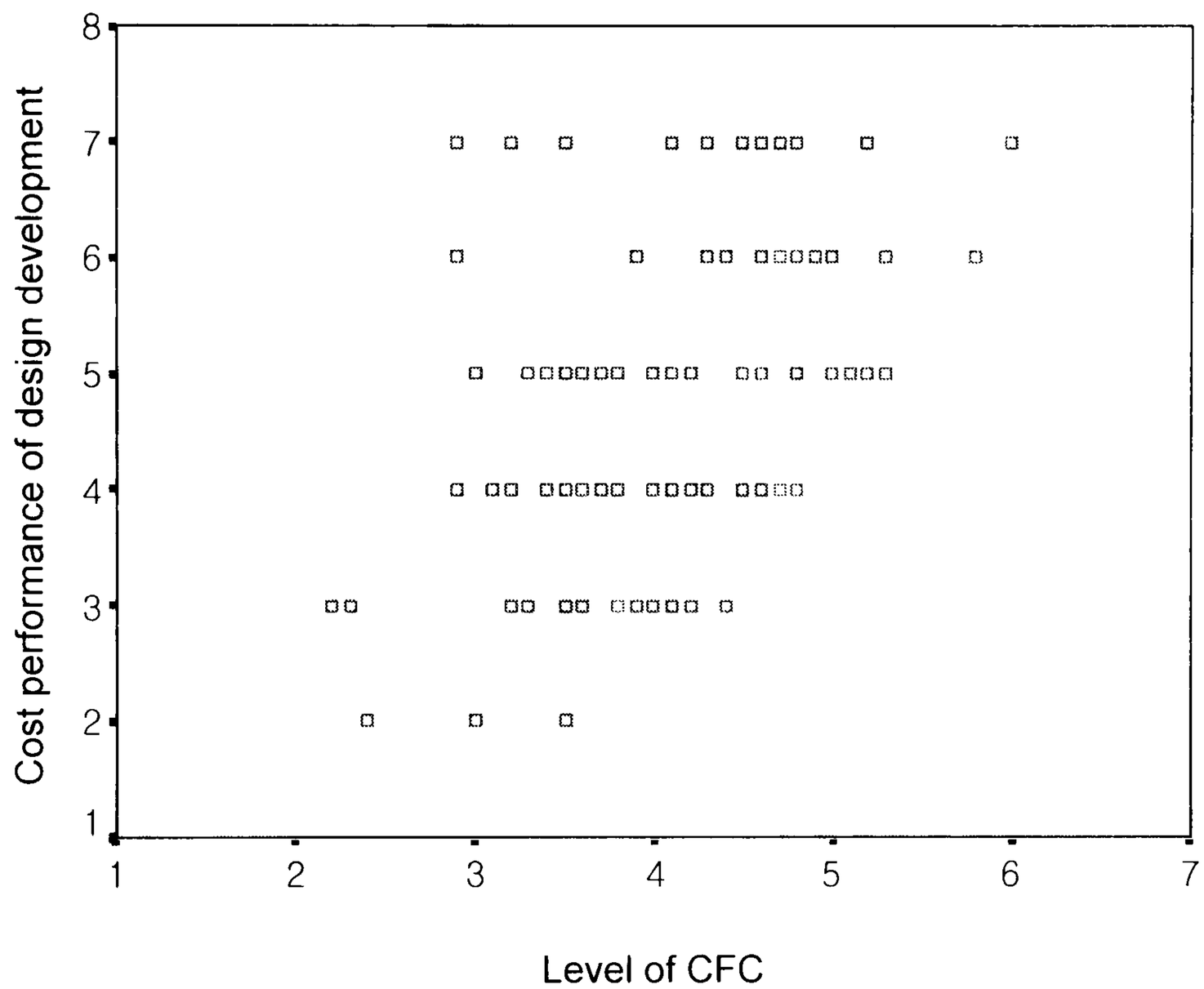
This Pearson correlation value (0.456 in Table 45) and the Scatter-plot in Figure 46 indicates that there is also a positive correlation between the satisfaction levels of CFC (cross-functional collaboration) and the cost performance of design development. In this analysis, *Sig.* value is below 0.01 ($p. < 0.01$), which means this correlation result is very significant (see Table 45)

Table 45 Correlations between the total level of cross-functional collaboration and the cost performance of product design development.

		2.Cost performance of design development	Level of CFC
Pearson Correlation	2.Cost performance of design development	1.000	.456
	Level of CFC	.456	1.000
Sig. (1-tailed)	2.Cost performance of design development	.	.000

	Level of CFC	.000	.
N	2.Cost performance of design development	109	109
	Level of CFC	109	109

Figure 46 The scatter-plot of correlation between the cost performance of design development and the CFC level



The result of the summary of simple regression analysis model in Table 46 indicates that the CFC issue accounts for 20.8% of the variability in the cost performance of design development. *(R square: 0.208)*

Table 46 Model Summary of simple regression analysis: between the total level of cross-functional collaboration and the cost performance of product design development

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.456 a)	.208	.201	1.18002

a) Predictors: (Constant), Level of CFC

6.5.3.4 To define substantial factors affecting *the cost performance* of design development item (Aim 2-2-2)

Also, the multiple regression analysis with a forward method was used to find substantial factors affecting cost performance of design development.

Tables 47, 48, 49 and Appendix 18 present the results of this multiple linear regression analysis. A total of 109 cases were used in this analysis; the cases with missing values were excluded. Table 47 shows the Means, Standard deviations of each factor affecting CFC and the number of cases (N= 107) that were taken in this analysis.

Table 47 Descriptive statistics of multiple regression analysis: for the cost performance of design development.

	Mean	Std. Deviation	N
2.Cost performance of design development	4.74766	1.29654	107
1.Unified culture with partners (common language, common geographic & ethnological culture)	5.7383	1.3828	107
2. Having a proper organisation and a flexible organisational culture for cross-functional collaboration	4.0187	1.2437	107
3.Managerial support	3.9171	.8171	107
4. Sharing unified vision and goals at both corporate level and project level	4.1243	1.0140	107
5.Having an informal social relationship (or system) with other functional group partners	4.0187	1.4405	107
6. Building trust and cohesion	4.0720	1.0127	107
7. Choosing suitable partners	4.4486	1.0092	107
8. Having a close physical location between functional partners	3.5888	1.5659	107
9. Managing and coordinating activities by senior manager	3.8879	1.2463	107
10.Working rationally and logically	3.7290	1.1701	107
11. Encouraging interaction between partners	3.9953	1.0382	107

The value of the Pearson correlation coefficient between every pair of factors (variables), the 1-tailed significance of each correlation, and the number of cases contributing to each correlation (*N=107*) is displayed in Table 48.

All coefficient of the correlation was found to be significant at the 0.05 level, except two of these eleven factors, these are 'Having an informal social relationship (or system) with other functional group partners', and 'Having a close physical location between functional partners'. The significance values of these two factors are over 0.05.

which means the probability of this correlation being a 'fluke' is very high ($p. > 0.05$). As a result, the coefficient of the Pearson correlation indicates that there is positive correlation between each factor affecting CFC and cost performance of design development, but only nine of the eleven factors are found to be significant.

As a result of this analysis, only one factor (variable) was discovered as being a factor, which substantially contributes to the cost performance of product design development. This factor was found by means of giving a criterion of 95% probability of multiple regression analysis within a hierarchical method (Method = Forward, Criterion: Probability-of-F-to-enter <= .050, see Table 48). This factor is 'Interaction between partners'.

Table 48 Variables Entered/Removed in multiple regression analysis for the cost performance of design development a)

Model	**Variables Entered**	**Method**
1	11.Interaction between partners	Forward (Criterion: Probability-of-F-to-enter <= .050)

a): Dependent Variable: 2.Cost performance of design development

The values of output in Table 49 indicate that there is a positive correlation between the predictor, 'interaction between partners' and 'the cost performance of design development' (R = 0.476), and this factor, 'interaction between partners', accounts for 22.6 % of the variance in the cost performance of design development (*R Square* = 0.226). The 'F change' is lower than 1 and 'significant F change' is less than 0.01 in the output of this linear regression model. These output values lead us to believe that this is unlikely to have happened by chance and this is highly significant (*Sig. F Change* < *.000*).

Table 49 Model Summary of multiple regression analysis: for the cost performance of design development and independent variables a)

	R	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**		
Model					F Change	Sig. F Change
1	.476	.226	.219	1.14586	30.711	.000 a)

a): Predictors: (Constant), 11.Interaction between partners

Table 50 Coefficients of multiple regression analysis: for cost design development performance. a)

		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
Model		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.374	.442		5.366	.000		
	11.Interaction between partners	.594	.107	.476	5.542	.000	1.000	1.000

Dependent Variable: 2.Cost performance of design development Coefficients

The 'Beta value', 't value', 'sig. Value' and 'collinearity' in this regression analysis are presented in Table 50. As a result, only one predictor is produced in this regression model, therefore, collinearity is a perfect value, namely 1.

The Standardized beta value for 'interaction between partners' is 0.476. This value indicates that as the level of satisfaction with interaction between partners increases by one standard deviation (1.0140; see Table 47), the cost performance of design development increases by 0.476. The standard deviation for *cost performance* of design development is 1.2965 and so this constitutes a change of approximately 0.6171 points (0.476 × 1.2965). Therefore, if 1.0140 of satisfaction degree of 'Interaction between partners' increases, the cost performance of design development will increase by 0.6171 of degree. Namely, if it is calculated by one of satisfaction degree again, when one of satisfaction degree of 'Interaction between partners'' factor increases, the total performance of design development will increase by 0.6257 of degree according to the standardized beta value in this regression analysis.

In summary, as a result of the multiple linear regression analysis in this section, one factor was defined as being a major contributory factor to *the cost performance* of design development (the $p < 0.001$). This factor is

- 'Interaction between partners' (0.6257 degree).

The value in parenthesis presents the expected increasing degree in cost design development performance dependent on one degree of satisfaction of the factor. Interaction between partners'. increases.

6.5.3.5 To define the correlation between the level of CFC and *the quality performance* of product design output (Aim 2-3-1)

The simple regression analysis was also used in order to define the correlation between the level of CFC and the *quality performance* in product design output.
Tables 51, 52, 53, and Figure 47 present the results of this analysis.

Table 51 shows descriptive statistics. The mean value of the *quality performance* in product design output is 4.1, which is almost a middle value between very dissatisfied and very satisfied. Therefore, this value can be interpreted as being 'neither satisfied nor dissatisfied about the *quality performance* in product design output'. A total of 109 cases were used in this analysis.

Table 51 Descriptive Statistics: between the level of cross-functional collaboration and quality performance in product design output

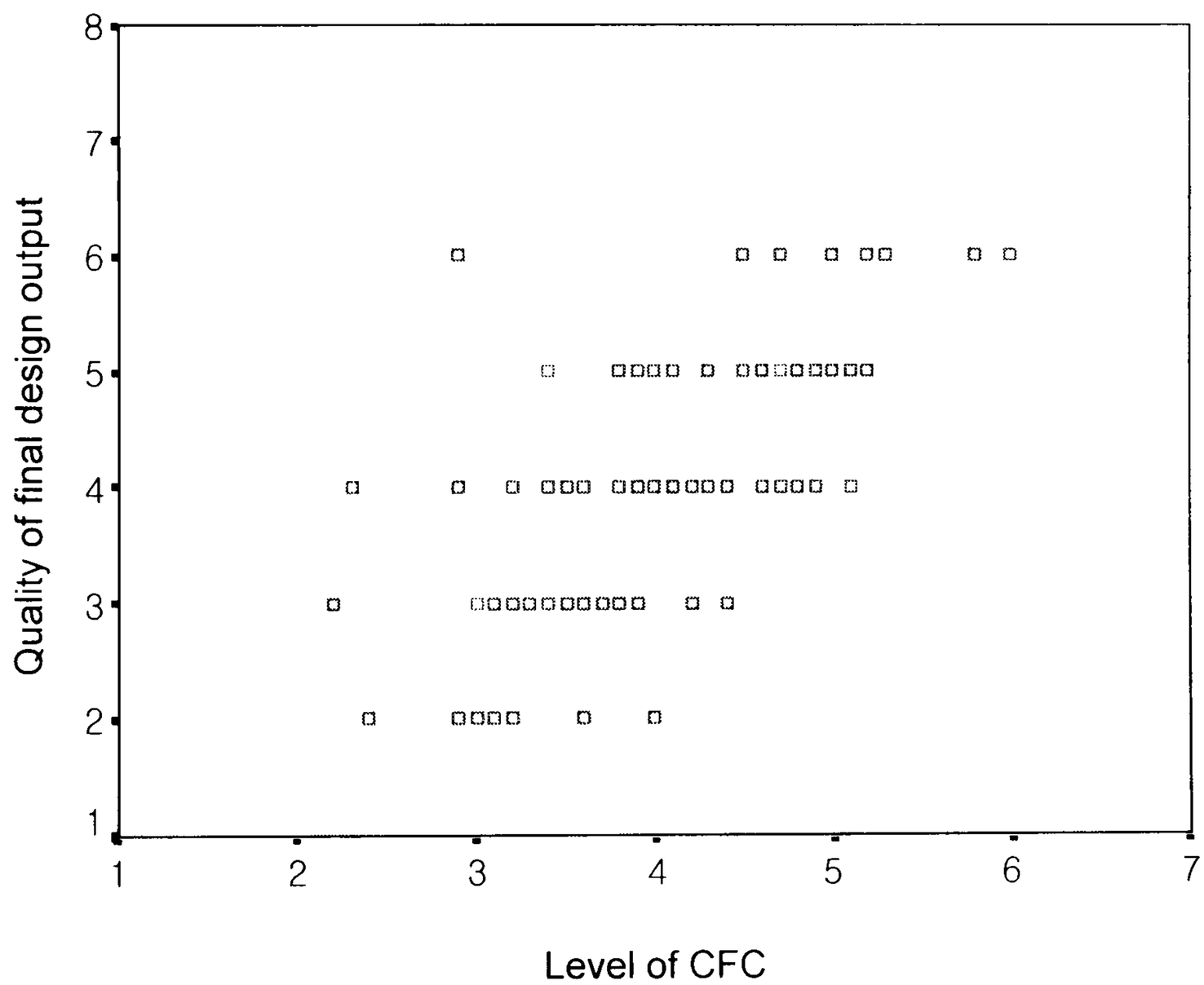
	Mean	Std. Deviation	N
3.quality of final design output	4.1193	1.1605	109
Level of CFC	4.1018	.7634	109

From the output in Table 52, the Pearson correlation value is 0.75, which means that there is a high positive correlation between the satisfaction level with CFC and the quality performance in product design output. The coefficient of correlation was found to be significant at 0.01 level ($p < 0.01$). The Scatter-plot in Figure 47 also shows that there is a plus relationship between the level with CFC and the quality performance in product design output.

Table 52 Correlations: between the level of cross-functional collaboration and the quality performance in product design output

		3.quality of final design output	Level of CFC
Pearson Correlation	3.quality of final design output	1.000	.725
	Level of CFC	.725	1.000
Sig. (1-tailed)	3.quality of final design output	.	.000
	Level of CFC	.000	.
N	3.quality of final design output	109	109
	Level of CFC	109	109

Figure 47 The scatter-plot of correlation between the quality of design output and the CFC level



The R Square value of this simple regression analysis model in Table 53 also indicates that the satisfaction level with CFC accounts for 52.6% of the variability in the quality performance in product design output. *(R square: 0.526)*

Table 53 Summary of simple regression analysis: between the level of cross-functional collaboration and the *quality performance* of product design output.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
	.725	.526	.521	.8029

a) Predictors: (Constant), Whole collaboration satisfaction level on latest project

6.5.3.6 To define substantial factors affecting *the quality performance* of product design output (Aim 4-2)

In order to define factors contributing to the *quality performance* of product design output, the multiple regression analysis of SPSS was used. The results of this multiple linear regression analysis are presented in tables 54, 55, 56, 57, and appendix 17. Cases (questionnaires) with missing values were also excluded from the analysis. Therefore, a total of 107 cases were used in this analysis. Table 54 presents the mean values, Std. Deviations, and Number of cases.

Table 54 Descriptive Statistics

	Mean	Std. Deviation	N
Quality performance of design output	4.0935	1.1536	107
1.Unified culture with partners (common language, common geographic & ethnological culture)	5.7383	1.3828	107
2. Having a proper organisation and a flexible organisational culture for cross-functional collaboration	4.0187	1.2437	107
3.Managerial support	3.9171	.8171	107
4. Sharing unified vision and goals at both corporate level and project level	4.1243	1.0140	107
5. Having an informal social relationship (or system) with other functional group partners	4.0187	1.4405	107
6. Building trust and cohesion	4.0720	1.0127	107
7. Choosing suitable partners	4.4486	1.0092	107
8. Having a close physical location between functional partners	3.5888	1.5659	107
9. Managing and coordinating of activities by senior manager	3.8879	1.2463	107
10.Working rationally and logically	3.7290	1.1701	107
11. Encouraging interaction between partners	3.9953	1.0382	107

Table 55 shows the value of the Pearson correlation coefficient for every pair of factors (variables), the 1-tailed significance of each correlation, and the number of cases contributing to each correlation (*N=107*). The output of these values of the Pearson correlation coefficient indicates that there is a clear positive correlation between each factor affecting CFC and the quality performance of design output (all coefficient correlation values are positive, and all significant values are below 0.01, *p.* <= 0.01)

As a major result of this analysis, three factors were identified as substantial factors contribute to the quality performance of design output. This factor was found by means of giving a criterion of 95% probability of multiple regression analysis within a hierarchical method (Method = Forward, Criterion: Probability-of-F-to-enter <= .050, see Table 55) These three factors are 'Managerial support', 'Sharing unified vision and goals at both corporate level and project level', and 'Choosing suitable partners'.

Table 55 Variables Entered/Removed in multiple regression analysis: for the quality of design output a)

Model	Variables Entered	Method
1	3.Managerial support	Forward (Criterion: Probability-of-F-to-enter <=.050)
2	4.Sharing unified vision and goals	Forward (Criterion: Probability-of-F-to-enter <=.050)
3	7.Choosing suitable partners	Forward (Criterion: Probability-of-F-to-enter <=.050)

a) Dependent Variable: 3.quality of final design output

The R value, R Square, Adjusted R Square, Std. Error of the Estimate, F change, and Sig. F change in this analysis output are presented in Table 56, which is a model summary table. As a result, these values in the third model in Table 56 indicate that there is also a positive correlation between three factors (predictors) and the quality performance of design output *(R = 0.723)*. Also, the third model accounts for quite a large amount of the variation in the quality performance of design output. Namely, the three factors account for 52.2% of the variance in the quality performance of design output (*R Square* = 0.522). All ' F Change' is over 1 and 'significant F change' show less than 0.01 in the output in this multiple linear regression model. These output values indicate that

this is unlikely to have happened by chance and this is highly significant *(Sig. F Change <= .001)*.

Table 56 Model Summary of multiple regression analysis: for the quality of l design output and independent variables

	R	R Square	Adjusted R Square	Std. Error of the Estimate		
Model					F Change	Sig. F Change
1	.630 a)	.397	.391	.9000	69.170	.000
2	.676 b)	.457	.447	.8582	11.480	.001
3	.723 c)	.522	.509	.8087	14.104	.000

a) Predictors: (Constant), 3.Managerial supports, b) Predictors: (Constant), 3.Managerial support, 4. Sharing unified vision and goals at both corporate level and project level, c) Predictors: (Constant), 3.Managerial support, 4. Sharing unified vision and goals at both corporate level and project level, 7.Choosing suitable partners

Table 57 presents other important results, firstly, the VIF values are all well below 10, and the tolerance statistics all well above 0.2, and the correlation values are all below 0.8 (see Appendix 19). These values in Table 57 suggest that there is no problem of collinearity within these data. Therefore, all factors can be seen as independent variables in this analysis.

Table 57 Coefficients of multiple regression analysis: for the quality of design output. a)

		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
Model		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	.608	.428		1.422	.158		
	3.Managerial supports	.890	.107	.630	8.317	.000	1.000	1.000
2	(Constant)	.148	.430		.344	.731		
	3.Managerial supports	.651	.124	.461	5.248	.000	.677	1.478
	4.Share unified goals and vision	.339	.100	.298	3.388	.001	.677	1.478
3	(Constant)	-.578	.449		-1.288	.201		
	3.Managerial support	.423	.132	.299	3.211	.002	.533	1.877
	4.Share unified goals and vision	.366	.094	.322	3.878	.000	.672	1.487
	7.Choose suitable partners	.338	.090	.296	3.756	.000	.747	1.339

a): Dependent Variable: 3.quality of design output

Further output, standardized beta values are presented in Table 57. The standardized beta value for 'Managerial support' is 0.299. This value indicates that as the level of satisfaction in relation to the degree of managerial support increases by one standard deviation (0.8171; see Table 54), the quality performance of design output increases by 0.299 standard deviations. Therefore, through the same calculation process which was used in the previous section, this value of output suggests that when one-satisfaction degree of 'Managerial support' factor increases, the quality performance of design output will increase by 0.421 of degree, when one-satisfaction degree of 'Sharing unified vision and goals at both corporate level and project level' is enhanced, the quality performance of design output will be expected to increase by 0.3663, and when one-satisfaction degree of 'Choosing suitable partners' is encouraged, the quality performance of design output will increase by 0.3383 according to the standardised beta values of these regression analysis results. These interpretations could be true if the effects of the other predictors (contributory factors affecting CFC) are held constant.

In summary, a major finding from the multiple linear regression analysis in this section is that three factors greatly contribute to *the quality of design output* ($p < 0.01$). These three factors are also prioritised according their degree of significance in influencing the quality performance of design output. Each value in parenthesis present the expected increasing degree of quality performance of design output dependent on one degree of satisfaction:

- 'Managerial support' (0.421 degree),
- 'Sharing unified vision and goals at both corporate level and project level' (0.3663 degree)
- 'Choosing suitable partners' (0.3383 degree)

6.5.3.7 To define the correlation between the level of CFC and *the effectiveness and efficiency* of *design management* (Aim 2-4-1)

In order to define the correlation between the level of CFC and *the effectiveness and efficiency of design management*, the simple regression analysis was used. All the results of this analysis are presented in tables 58, 59, 60 and figure 48.

Table 58 shows the Means, Std. deviation, and Number of cases. From the results, the satisfactory degree value of the effectiveness and efficiency of design management is the lowest in comparison to the other three items for measuring the performance of design development. This 3.8 value means that respondents were not satisfied with the effectiveness and efficiency of design management. A total of 109 cases were used in this analysis.

Table 58 Descriptive Statistics: between the total level of cross-functional collaboration and *the effectiveness and the efficiency performance* of *design management*

	Mean	Std. Deviation	N
4.Effectiveness and efficiency of design management	3.835	1.198	109
Level of CFC	4.1018	.7634	109

A Pearson correlation value is presented in Table 59; this value is 0.566, which means that there is a positive correlation between the level of satisfaction with CFC and the effectiveness and efficiency of design management. The coefficient of the correlation was found to be significant at the level of 0.01 ($p. < 0.01$).

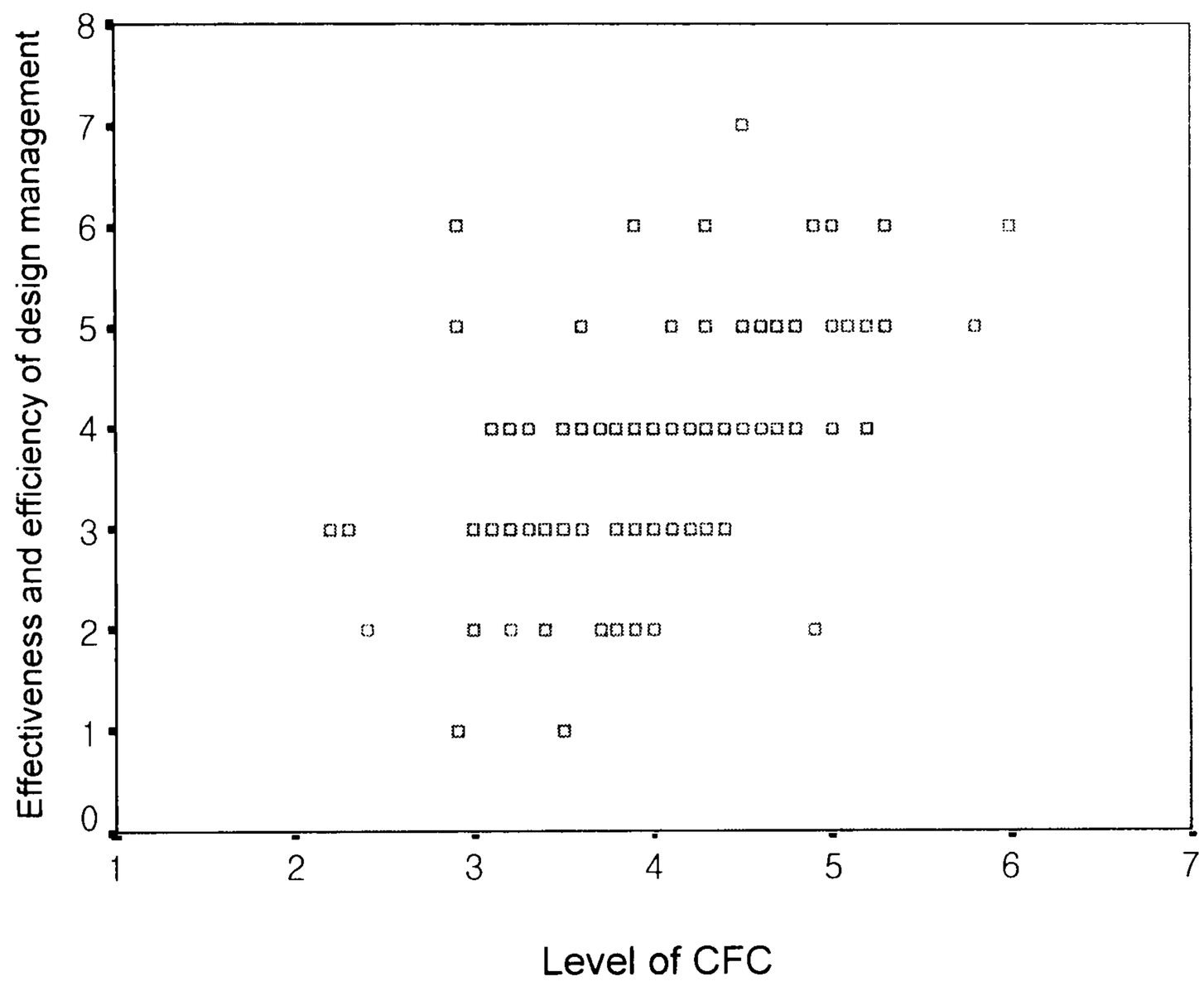
Table 59 Correlations between the level of CFC and *the effectiveness and the efficiency* of *design management*

		4.Effectiveness and efficiency of design management	Level of CFC
Pearson Correlation	4.Effectiveness and efficiency of design management	1.000	.566
	Level of CFC	.566	1.000
Sig. (1-tailed)	4.Effectiveness and efficiency of design management	.	.000
	Level of CFC	.000	.
N	4.Effectiveness and efficiency of design management	109	109

	Level of CFC	109	109

The scatter-plot in Figure 48 also indicates that there is a plus relationship between the level of CFC and the effectiveness and the efficiency of design management.

Figure 48 The scatter-plot of correlation between the effectiveness and the efficiency of design management and the CFC level.



From the results of the summary of the simple regression analysis model in Table 60, the satisfaction level with CFC accounts for 32.1% of the variability in the effectiveness and efficiency of design management *(R square: 0.321)*.

Table 60 Summary of simple regression analysis: between the level of CFC and the effectiveness and efficiency of design management.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.566 a)	.321	.314	.992

a) Predictors: (Constant), Level of CFC

6.5.3.8 To define substantial factors affecting *the effectiveness and efficiency of design management* (Aim 2-4-2)

Finally, in order to define substantial factors contribute to the *effectiveness and efficiency of design management*; multiple regression analysis was also used. Tables 61, 62, 63, 64, and Appendix 20 show the results of this multiple linear regression analysis. Cases with missing values were excluded from the analysis. Therefore, a total of 107 cases were used in this analysis.

Table 61 shows the means, the standard deviations of each factor affecting CFC and the number of cases which were used in this analysis.

Table 61 Descriptive statistics of multiple regression analysis: to show the effectiveness & efficiency of design management and independent variables

	Mean	Std. Deviation	N
Effectiveness and efficiency of design management	3.822	1.188	107
1.Unified culture with partners (common language, common geographic & ethnological culture)	5.7383	1.3828	107
2. Having a proper organisation and a flexible organisational culture for cross-functional collaboration	4.0187	1.2437	107
3.Managerial support	3.9171	.8171	107
4. Sharing unified vision and goals at both corporate level and project level	4.1243	1.0140	107
5. Having an informal social relationship (or system) with other functional group partners	4.0187	1.4405	107
6. Building trust and cohesion	4.0720	1.0127	107
7. Choosing suitable partners	4.4486	1.0092	107
8. Having a close physical location between functional partners	3.5888	1.5659	107
9. Managing and coordinating activities by senior manager	3.8879	1.2463	107
10.Working rationally and logically	3.7290	1.1701	107
11. Encouraging interaction between partners	3.9953	1.0382	107

The value of the Pearson correlation coefficient between every pair of factors (variables), the 1-tailed significance of each correlation, and the number of cases contributing to each correlation (N=107) is displayed in Appendix 20.

All coefficient correlations were found to be significant at the 0.05 level, except two of these eleven factors, these are 'Having an informal social relationship (or system) with other functional group partners', and 'Having a close physical location between functional partners'. The significant values of these two factors are over 0.05 ($p. > 0.05$). As a result, the coefficient of the Pearson correlation indicates that there is a positive correlation between each factor affecting CFC and the effectiveness and efficiency of design management, but only nine of the eleven factors were found to be significant.

As a result of this analysis, two factors (variables) were discovered as factors, which substantially contribute to the effectiveness and efficiency of design management. These factors were found by means of giving a criterion of 95% probability of multiple

unlikely to have happened by chance and this is highly significant *(Sig. F Change < .005)*.

Table 63 Model summary of multiple regression analysis: for the effectiveness & efficiency of design management and the independent variables

	R	R Square	Adjusted R Square	Std. Error of the Estimate		
Model					F Change	Sig. F Change
1	.490 a)	.240	.233	1.041	33.124	.000
2	.551 b)	.304	.291	1.001	9.592	.003

a): Predictors: (Constant), 3.Managerial support, b): Predictors: (Constant), 3.Managerial support, 10.Working rationally and logically

The VIF values are well below 10, and the tolerance statistics well above 0.2 in Table 64. From these results it could be proposed that there is no collinearity within the data. Therefore, all factors can be seen as independent variables in this analysis.

Table 64 Coefficients of multiple regression analysis for the effectiveness & efficiency of design management. a)

		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
Model		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	1.033	.495		2.088	.039		
	3.Managerial support	.712	.124	.490	5.755	.000	1.000	1.000
2	(Constant)	.772	.483		1.596	.113		
	3.Managerial support	.494	.138	.340	3.579	.001	.741	1.349
	10.Work rationally and logically	.299	.096	.294	3.097	.003	.741	1.349

a): Dependent Variable: 4.Effectiveness and efficiency of design management

Through the same calculation process, the value of Standardized beta output suggests that when one of satisfaction degree of 'Managerial support' factor increases, the effectiveness and efficiency of design management will increase by 0.4943-degrees, and when one of satisfaction degree of 'Working rationally and logically' increases, the effectiveness and efficiency of design management will be expected to rise by 0.3035-

degrees (according to the interpretation of the Standardized Beta value in this regression analysis results). These interpretations could be true only if the effects of the other predictors (contributory factors affecting CFC) are held constant.

In summary, an important finding in this final section is that two factors were defined as a greatly contributing to the effectiveness and efficiency of design management ($p < 0.01$). These two factors are prioritised according to degree of significance influencing the effectiveness and efficiency of design management. Each value in the parenthesis present the expected increasing degree of effectiveness and efficiency of design management dependent on one degree of satisfaction of each factor increase:

- 'Managerial support' (0.4943 degree)
- 'Working logically and rationally' (0.3035-degree).

6.6 Development of new conceptual framework of CFC for design development of consumer electronics products.

This empirical research has four major aims, as has been noted. These are as follows:

1) To define the correlation between the level of CFC and the performance of design development of consumer electronics products.
2) To define the factors affecting CFC for design development of consumer electronics products.
3) To define the priority of importance of the factors affecting CFC.
4) To define factors affecting total design development performance and factors affecting each individual performance item of design development of consumer electronics products.

The above four aims were used to produce pragmatic information to create a conceptual model of CFC for design development of consumer electronics products. This is the central aim of this empirical research.

The first aim was undertaken to verify that CFC for the design development of consumer electronics products brings a range of benefits to the performance of design development. It is very important and had to be achieved before producing the information about CFC for product design development. But, no empirical research was found which proves whether CFC improves the performance of design development of consumer electronics products on a practical level, although it is widely acknowledged that CFC contributes to new product development (Beckwith D. & Harris D. (1993), Faust W. (1993), Olson E. M. (1993, 1994)... refer to Exhibit 2).

The first of the above four aims was undertaken to establish whether CFC improves the design development performance of consumer electronics products or not on a practical level

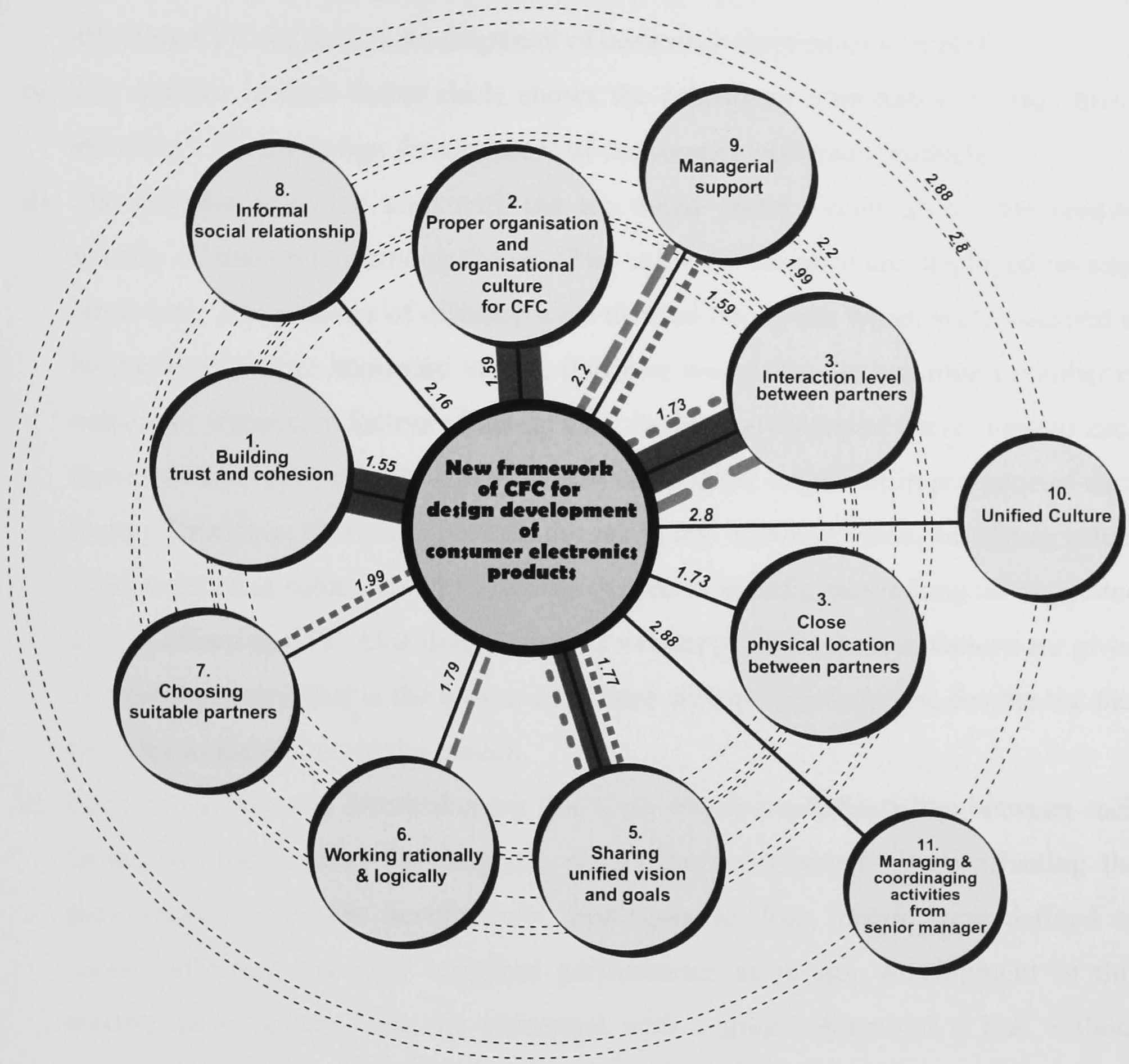
As a result, it was found that there is a clear positive correlation between the level of CFC and the total weighted performance of product design development. Namely, this research has indicated that if the level of CFC increases, the total performance of new design development will increase. Also, it has been verified that there is a positive correlation between the level of CFC and each individual performance item of product design development, which is an element of the total performance of design development in this research. These items include the time performance of product design development, the cost performance of product design development, the quality of design output and the effectiveness and efficiency of design management.

After achieving the aim of this research, the other major three research aims have produced the basic information for CFC.
All three aims were also successfully achieved after analysis of the questionnaires.

In order to present all the findings from this research work effectively, a conceptual framework of CFC (Cross-Functional Collaboration) has been developed in a visual way as a final central aim of this empirical research. In other words, this model has been created using all the condensed information which was resulted from the above-three aims of this empirical research.

This created model, which is a new framework model of CFC for design development of consumer electronics products, is presented in Figure 49.

Figure 49 New conceptual framework model of CFC (Cross-Functional Collaboration) for design development of consumer electronics products



▬▬▬▬	Total design development performance
●●●●●	Time performance of design development
●▬●▬	Cost performance of design development
▮▮▮▮▮▮▮▮▮▮	Quality of design output
▮▮▮▮▮▮	Effectiveness and efficiency of design management
▪ Distance from core means the degree of relative importance among factors	

A description of the developed visual model of CFC is as follows:

b) This created the framework model shows the finally condensed eleven factors affecting CFC for design development of consumer electronics products.

c) The number in each factor circle shows the priority of importance of each factor affecting CFC for design development of consumer electronics products.

d) The distance from the core with the ten doted raider circles shows the relative priority of importance among factors. The values of distance are displayed on each circle line. These values of distance were divided into seven which were assumed to be the ideal perfect important values, (because seven was the maximum number of values for significant factors affecting CFC in this questionnaire survey) *minus* each factor's mean value of importance, which marked the degree of importance of each factor. Therefore, these numbers do not mean any absolute value, but these values expose the ratio value, which shows the degree of significance among all suggested factors affecting CFC. One dotted circle is overlapped because two factors are given as a third priority, that is the reason why there are ten dotted circles, despite the fact that eleven factors are in the model.

e) Each colour line and discriminating line type, which is a linkage-line between each factor and the core of the diagram, shows the contributory factor affecting the performance of design development. For example, four factors were defined as factors affecting the total weighted performance of design development in this model; these linkage-lines are presented with a grey colour and a line without dashes. On the other hand, the blue rounded dashed line with the same line length is used to express factors affecting the time performance of design development, the purple rounded dashed line with a different length line is used to express factors affecting the cost performance of design development, the red square dashed line with the same line length is used to express factors affecting the quality of design output. Finally, the green square dashed line with a different line length is used to express factors affecting the effectiveness and efficiency of design management. Each of these linkage-lines is seen in Figure 49.

f) The thickness degree of line the above-explained line shows the relative priority of

important degree of factors affecting the each performance item of design development. For example, four factors were defined as a factor affecting the total weighted performance of design development, the strongest contributory factor affecting the total weighted performance of design development is 'Trust and cohesion'. This factor is linked via the thickest line to the core. The next factor affecting the total weighted performance of design development shows a less thicker line than the first factor, but it is thicker than the third factor affecting the total weighted performance of design development. The thickness of the line is calculated by the value of Standardised beta from the results of Regression analysis of SPSS.

To sum up briefly, the new framework model displays finally condensed factors affecting CFC for new design development of consumer electronics products. Also, this developed framework model not only shows the priority of importance of these eleven factors, but also exhibits discriminatory factors substantially contributing to the total the performance of product design development, including each sub-performance item (time, cost, quality, design management) of which consists the total design development performance here.

Chapter 7: Evaluation of the usability of the new conceptual framework for CFC for design development of consumer electronics products

Chapter7: Evaluation of the usability of the new condeptual framework of CFC for design development of consumer electronics products

7.1 Introduction

This chapter presents an evaluation of the usability of the new framework model of CFC for design development of consumer electronics products. This chapter starts with a brief explanation of the aim and method for the evaluation of the usability of the model. Section 7.2 presents general information about the interviews and interviewees. Section 7.3 summarises the findings of this evaluation survey as a main body to this chapter.

To remind readers, the main aim in this stage of the research is:
to evaluate the usability of the information within new framework model in practice.

Method
Structured interviews with current senior design managers in the consumer electronics industry sector were undertaken. The interview agenda consisted of main five questions.

7.2 General description about the interviews and interviewees

This section presents a general description of the interviews and interviewees.

The interviews were conducted for 3 weeks between the middle of April 2001 and the early part of May 2001.

The average number of years interviewees had worked was 18 years.

The average interview time was one hour and 21 minutes.

The average time for face-to-face interviews was one hour and 35 minutes

The average time of the phone interviews was one hour and 7 minutes

General background information about contacted interviewees and the time of each interview are shown in Table 65.

Table 65 General background information about contacted interviews and the time of each interview.

	Name of interviewee	**Department of interviewee**	**Job title**	**Working years**	**Amount time for Interview**
Samsung Electronics	Byeong Young Song	Design group	Senior Manager	14 years	1 hour 05 minutes
LG Electronics	Woo-Young Oh	Corporate Design Centre	Chief Designer	23 years	1 hour
Daewoo Electronics	Hyung-Lock Lee	Design Research Centre	Senior Design Manager	13 years	1 hour 10 minutes
Hitachi Home Electronics	Taisuke Kashima	Business Planning Division	Chief Design Manager	21 years (worked for over 14 years at design centre in Tokyo in Japan. and worked for 5 years in the design office in San Diego in USA. Now he works at the Hitachi Design Centre. Europe in UK	1 hour 30 minutes
Xerox Limited (Europe Xerox)	Leslie Wynn	Human interface & Design Development	Senior Manager	19 years	1 hour 40 minutes

7.3 Evaluation of the usability of the new framework model of CFC.

All summarised opinions of each interviewee to each question posed in the interview are presented in tables 66, 67, 68, 69, and 70.

Table 66 summarises the opinions of each interviewee to question one.

Question 1: To what extent does this theoretical model support and challenge existing thinking in your organisation?

Table 66 The opinions of each interviewee to Question one:

	Summary of opinions
Samsung Electronics Byeong-Young Song	"This model's information does not challenge my perception of CFC, but it gives more precise information and makes me have clear ideas to my existing thinking about CFC."
LG Electronics Woo-Young Oh	"This information does not challenge my thinking much, but it helps to understand the large picture, which can improve CFC circumstances in product design development."
Daewoo Electronics Hyung-Lock Lee	"This model supports my existing thinking. I have never seen this kind of information before."
Hitachi Home Electronics Taisuke Kashima	"It does not change my ideas, but several angles of information for CFC support my existing ideas effectively and make my ideas stronger."
Xerox Limited (Europe Xerox) Leslie Wynn	"It does not challenge my perception, but I strongly agree with the information from the model of CFC".

Four senior design managers responded that this model's information does not challenge their existing ideas very much, except one design manger in the Design Research Centre at Daewoo Electronics. The design manager at Daewoo positively answered that this model supports his existing thinking.

All interviewees agreed with the information in the framework model and they admitted that this model helps and supports their existing ideas. On the other hand, the fact that this model's information does not challenge the current design managers' ideas very much, leads us to infer that this model shows the large amount group knowledge in practice well.

Table 67 summarises the opinions of each interviewee to question two.

Question 2: Which areas in relation to CFC(Cross-Functional Collaboration) need to be changed in your company: Base your answers on the factors in the model?

Table 67 The opinions of each interviewee to Question two

	The summary of opinions
Samsung Electronics Byeong-Young Song	- 'Trust and cohesion level': Song stated that the trust and cohesion level among the partners for design development is decreasing these days. - 'Working rationally & logically rather than working by relying on his/her intuition': It is getting difficult to work rationally & logically because the time for design development is getting shorter and shorter. In this context, he emphasised that the role of trust and cohesion with partners, which is the prime factor in the model, is becoming more important. - 'Choosing suitable partners': it is also one of the weaknesses in the design organisation at Samsung. Song said "it sometimes happens that some designers require that his/her other functional partner is changed, when he/she is very dissatisfied with his/her partner." - 'Close physical location between partners': He also indicated that their partner departments, for example, the engineering department and marketing department, are not located in the same city. These departments are located in a factory in a local city and the design department is located in central Seoul, which is the capital of South Korea.
LG Electronics Woo-Young	- 'Close physical location between partners': the design department is located far away from other functional departments,

Oh	particularly, the engineering department and manufacturing department. These departments are located in a factory, which is located far from the Design Centre. - 'Proper organisation and flexible organisational culture for CFC': Lee also insisted that the Design Center (Organisation) at LG is not suitable for CFC. - 'Interaction level between partners': he pointed out that the level of interaction between partners needs to be enhanced in his organisation.
Daewoo Electronic Hyung-Lock Lee	- 'Choosing suitable partners': "it is a vital to have partners who work well together, but, it not satisfactory in our organisation" - 'Proper organisation and flexible organisation culture for CFC': "The Daewoo Electronics Design Institute is an independent organisation. I don't think it is a good organisation type for collaboration with other functional groups. I (design managers) cannot handle this problem in my organisation even if this issue is significant for CFC, because it is out of my authority to choose other functional partners. The partner who is in charge of the project in his/her special functional area is chosen by his/her boss (manager), namely it is not from the design manger." - 'Close physical location between partners': The Daewoo Electronics Design Institute is also isolated compared to other functional departments. Our building is placed in a central capital city (Seoul). Otherwise, other functional departments, such as the Marketing department, Engineering department and Manufacturing department, are spread out based on their division and factory.
Hitachi Home Electronics Taisuke Kashima	- 'Proper organisation and flexible organisational culture for CFC': I don't think that our organisation is suitable for the optimised CFC. - 'Close physical location between partners': they (designers) often work with partners that are situated far away. The Engineering and Manufacturing department are usually placed in a factory which is usually located locally, otherwise, the design centre is situated mainly in Tokyo

	- 'Unified Culture (e.g. having a common language, geographical culture, and ethnological culture)': "they sometimes have culture gaps among partners. Also this situation has developed, because more and more NPD projects are conducted on a global level with another country people." - 'Managing & coordinating activities by senior manager': "there is not much involved and coordinated by senior managers, even if there are troubles among partners."
Xerox Limited (Europe Xerox) Leslie Wynn	- 'Close physical location between partners': "First and most importantly, the factor, 'close physical location between partners', is the most significant factor, which should be considered in my current organisation." - 'Unified culture (e.g. having a common language, geographical culture, and ethnological culture)': - 'Informal social relationship': "In the second place, 'Informal social relationship' and 'Unified culture (e.g. having a common language, geographical culture, and ethnological culture)' is not really addressed in my organisation, even if these are important factors he believes." - 'Choosing suitable partners': the factor, 'Choosing suitable partners', is beginning to be recognised as an important issue to create a good level of CFC (further, enhance design development performance). But it has not been dealt with well. The reason he pointed out is that there is no tool (criterion) and process to judge in advance how good a partner is going to be.

The second question was posed to discover the weaknesses within each company in relation to CFC through the proposed information for the model. The CFC environment within the organisation in each company was diagnosed by interviewees based on the developed model, and then their opinions on it are presented in Table 67.

A total of eight factors (issues) in relation to the weaknesses in their organisations were indicated through interviews with five senior design managers. Furthermore, three of

the eight factors were emphasised by several interviewees. these three factors are. 'Proper organisation and flexible organisational culture for CFC'. 'Close physical location between partners'. and 'Choosing suitable partners'. In particular. 'Close physical location between partners' was underlined as a weakness in the organisation by all interviewees. This reason is a unique situation in relation to design development in the consumer electronics industry. Almost all design departments (usually named Design Laboratory Centres) in this industry sector are located in the headquarters of the company in central cities in the interviewees' countries. Usually the Engineering department and the Manufacturing department are located within the factory in a local place, which is far from the design department. Other factors, which were pointed out by interviewees were 'Proper organisation and flexible organisational culture for CFC' and 'Choosing suitable partners'. These factors were repeated by three of the five senior design managers. The one of the major reasons why these two factors were indicated as weaknesses in their organisations can be found in the structure of organisations.

The results of this research identified that many new CE products (approximately 76% of new products according to this research survey findings) have been developed in a functional organisational structure (for further details, see section 5.4 in chapter 5; the results of the interview survey – the organisation forms of new product design developments in the consumer electronic industry).

One of the main characteristics of a functional organisation is that the authority for arrangement of each project belongs to each functional manager. Hyung-Lock, who is the senior design manager at the Daewoo Laboratory Design Centre, pointed out that there is no authority to choose other functional partners in a functional organisational structure. This authority is given to the manager who is in charge of his/her functional department in the functional organisation. From this context, it can be understood that both factors, the organisation factor and the selecting suitable partners factor, could be stressed as weaknesses for CFC because of particular organisational characteristics (functional organisation type) in this industry sector.

Thirdly, 'Unified culture' was mentioned twice. It seems that the number of design projects, which are being developed with partners from different countries, are increasing. Many consumer electronics companies are using global strategies and they are already operating globally in the world market place (Euromoniter Report, 1997). Therefore, product design development is becoming more globally involved with multi-country people partners. For example, when a Korean designer develops a TV set for the European market place and it is going to be manufactured in a factory in Poland, designers should cooperate with marketers, who are located in Europe and take charge in the Europe market sector, and manufacturers in factory in Poland. From this context, the factor, unified culture, is being recognised as an important issue for CFC, but it seems it has not been dealt with well. The other factors, which were pointed out once as factors which need to change by the interviewees are as follows:

- 'Trust and cohesion level'
- 'Interaction level between partners'
- 'Working rationally and logically'
- 'Informal social relationship'
- 'Managing and coordinating activities by senior manager (in particular, there are problems among partners)'

The remarkable fact from the results of this second question is that the interviewees (each design manger) could diagnose what the weaknesses were in their organisation in relation to CFC through this proposed model's information. This could mean that the developed model shows one of the possible usability in practice.

Table 68 summarises the opinions of each interviewee to question three.

Question 3: Please, comment on the relative values attributed to other factors?

Table 68 The opinions of each interviewee to Question three:

	The summary of opinions
Samsung Electronics Byeong-Young Song	The interviewee totally agreed with the relative values from the survey results (the model). But, only one factor, factor 5 ('sharing unified vision and goals') should be dealt with more importantly than factor 3, 'Close physical location between partners' in the model.
LG Electronics Woo-Young Oh	The interviewee totally agreed with the relative values from the survey results and the priority of importance of factors, except one value 'choosing suitable partners'. He insisted that it should be prioritised to a greater degree than the factor value in the model shows.
Daewoo Electronic Hyung-Lock Lee	The interviewee agreed with the relative values from the survey results and the priority of importance of the factors. But, he insisted that the two issues; 'Choosing suitable partners' and 'Informal social relationship' should be given more importance than the model shows.
Hitachi Home Electronics Taisuke Kashima	The interviewee agreed with the relative values and the priority of importance of the factors. In addition, he mentioned, "I feel that only one factor, 'Unified Culture', needs to be more central than the model shows"
Xerox Limited (Europe Xerox) Leslie Wynn	The interviewee agreed with the relative values from the survey results, apart from one factor value, that is ' choosing suitable partners'. He commented that this factor should be positioned nearer the core of the model.

The produced relative values were calculated using mean data given by a total of 243 experts. In detail, 110 designers and 134 experts who are strongly involved in the design development process, these are Marketing department, Planning department, Engineering department, and Manufacturing department.

In this evaluation stage of the research findings using the developed model of CFC, the five senior design managers' opinions on the relative values were given to confirm the validity of the relative values in the model.

As a result, all interviewees totally agreed with the relative values, which means the priority of significance of each factor affecting CFC, in the model is reliable. There was little disagreement. They only commented that one or two factors should be dealt with more significantly than the proposed model indicated. The factor, 'choosing suitable partners' was repeated by three of five interviewees as a factor, which should deal more significantly. The reason can be found in the statement of Woo-Young Oh, who is chief design manager in Cooperate Design Center at LG. He illustrated that the factor, 'choosing suitable partners' should have more importance because this factor is connected to other factors affecting CFC. For example, if a designer chooses the right partners for his/her design development project, that means the other factors, for example, 'Trust and cohesion level, and 'informal social relationship', can be considered. For this reason, factor 7, 'choosing suitable partners', should be placed more nearer the core than the model shows.
'Sharing unified vision and goals', 'Informal social relationship' and ' Unified culture' were also mentioned as factors, which should be considered as being more important to than the model shows.

Question four was used as a main body question in this evaluation interview stage to assess the usability of the developed model. Table 69 summarises the opinions of each interviewee to question four.

Question 4: How can this theoretical model be used to improve practice in order to enhance CFC (Cross-Functional Collaboration) in design development?

Table 69 The opinions of each interviewee to Question four

	The summary of opinions
Samsung Electronics Byeong-Young Song	- This model can help design mangers who want to enhance CFC in their organisation with clear guide-information related to CFC. - This model can be used as good information (criterion) to help the decision-making related to improving the situation of CFC - This model (information) can be used as an education source to designers, particularly to design mangers, and other functional group people in order to create a high level of CFC
LG Electronics Woo-Young Oh	- This model can offer conceptual guidelines to help design managers who want to improve CFC in their organisation. For example, the priority of importance of issues (factors) can help decision-makers to improve the level of CFC in their organisation
Daewoo Electronic Hyung-Lock Lee	- This model's information is very helpful to give the larger picture of how to handle CFC in design development. - Design managers can recognise and concentrate on their weaknesses in CFC by using this model's information. (as in question two) - Design managers who are not satisfied with the total performance of design development or each performance of design development (time performance, cost performance, design output, design management), can be helped by the information in this model. - The model offers a unified vision of CFC for other functional groups.
Hitachi Home Electronics Taisuke Kashima	- This model can be used as a source of education in order to create a good level of CFC. For example, the Hitachi design centre has well-organised education programmes, it can be used in this programme as a source. - This model can be used as a source when a company is considering reengineering or restructuring their organisation.

Xerox Limited (Europe Xerox) Leslie Wynn	- This model of CFC is useful in formalising which areas (issues) could be concentrated on to improve an organisation as a process improvement tool. - "One of the most useful information sources that comes from this diagram (this model) is the linkage between factors and each performance item (the time performance of design development, the cost performance of design development, the quality of design output, the effectiveness and efficiency of design management). For example, if there is some organisation which usually fails to fix a design development time, first of all, it needs to improve particularly two factors, these are, ' Interaction level between partners', and ' Sharing unified vision and goals'. This proposed model of CFC gives this kind of valuable information." - This information in the model is also useful in helping to analyse past performances of CFC. For example, a design manager can identify which factors did not do well in a past project. Also this model can reveal some factors, which were neglected in their organisation.

The researcher asked for opinions about the usability of the proposed model in practice. The design managers (interviewees) gave ideas about the usability of the proposed model. In particular, several interviewees emphasised the necessity of education about CFC, because there was not much good source for education to improve CFC. In this kind of context, the model, which gives guidelines for CFC, is valuable as a useful source of education.

To summarise, seven usability factors for the developed model are identified through open-ended questions:

1) This model gives the larger picture and conceptual guidelines, which helps to achieve a high level of CFC in design development situations.

2) The priority of importance of factors affecting CFC in the model can be used to help decision-making related to improving the CFC situation.
3) Linkage information that offers factor(s) affecting the performance of design development in the model informs about where companies should concentrate to improve the several dimensional design development performance. These include the time performance of design development, the cost performance of design development, the quality of design output, the effectiveness and efficiency of design management and the total performance of design development. Therefore, this model's information helps organisations to concentrate upon weak areas in design performance.
4) The information in the model can be used as a tool to analyse the past performance of CFC in product design development (eleven factors can be used as items to assess the performance of CFC).
5) This model can be used as a source for education to achieve a high level of CFC.
6) This model can help to formalise which areas (issues) should be concentrated on to improve the organisation, as a process improvement tool.
7) The model can be used as a source for sharing a unified vision to collaborate with other functional groups.

A validity and usability of the new developed model was confirmed with the above question in practice.

For the final question in this evaluation interview, interviewees' final comments on the model were asked.

Question 5: Do you have any comments on the results which are shown in the new proposed model for CFC?

Summary of the opinions of each interviewee to this final question are presented in Table 70.

Table 70 The opinions of each interviewee to Question five

	The summary of opinions
Samsung Electronics Byeong-Young Song	- He strongly agreed with the results that there is a positive correlation between the level of CFC and design performance. On the other hand, he gave a negative viewpoint regarding having a close relationship with other functional group people. He pointed out that a designer's creative ideas might be interfered with or killed by other functional people. - He underlined the importance of cross-functional collaboration for effective design development. In this context, he suggested that it might be good to assess the collaboration level among partners as a system to evaluate an individual's performance in a company
LG Electronics Woo-Young Oh	- He pointed out that there is a relationship among some factors affecting CFC in the model. For example, when someone considers 'suitable partners', he/she (or his/her manager) usually considers the other factors in the model, such as, 'informal social relationship', 'trust level', 'partner location'. - He was eager for further information based on the model. For example, information on how to choose the right partners for CFC in new design development, and how to improve the interaction level between partners.
Daewoo Electronic Hyung-Lock Lee	- The priority of importance affecting CFC can be changed case-by-case in the design development situation, Such as the design development items or/and each division's organisation in practice. Therefore, more detailed models might be needed according to particular NPD situations.
Hitachi Home Electronics Taisuke Kashima	- The model's information is very understandable. - It might be a better model to understand, if this model was three-dimensional. - In order to achieve high level of CFC for effective design development, it is a vital to educate on the importance of the design role in new product development to other functional group

	people. Designers also need to know about other functional group roles.
Xerox Limited (Europe Xerox) Leslie Wynn	- "This model (information) is valuable enough to a design manager" - He agreed that all eleven factors, which are shown in the model, are significant factors affecting CFC in product design development. In addition, ten factors are seen as positive factors to enhance CFC, but one factor that is 'Managing & coordinating activities by the senior manager', is likely to be viewed as a negative factor. - He strongly agreed that the factor, 'Building trust and cohesion', is a primary factor affecting CFC. - "The most exciting fact in the model for CFC is the factor(s) affecting each design development performance (the time performance of design development, the cost performance of design development, the quality of design output, the effectiveness and efficiency of design management)". - He also pointed out that this model would be more valuable if the way, to choose suitable partners was given.

From these final additional responses, many interesting comments were also gathered. One of them was from Byeong-Young Song, who is a design manager at Samsung Electronics; he said that it is a necessary to assess the collaboration level of other functional partners after finishing each design project. Furthermore, he suggested that records of assessment could be used as a tool to assess personal performance. He said that he was thinking of proposing this idea in his organisation. On the other hand, he also indicated that a close cross-functional collaboration with other functional groups might interfere a designer's creative ideas as a negative viewpoint of CFC.

Two senior design managers at LG and Xerox expected further in-depth information based on this model. That is how to get each factor affecting CFC in an efficient way. For example, what is a criterion to choose the right partners for design development and

how should they be matched, what is the most effective organisation for CFC? and how could the interaction level between partners be improved?

Leslie Wynn, who is a senior design manager at Xerox Limited, again, expressed his interest in the model's information which identifies the factor(s) affecting each design performance (time, cost, quality of design output, and effectiveness and efficiency of design management).

Thus, these final comments from the senior design managers are very useful to ascertain the model's usability include advantages and disadvantages of the model.

Chapter 8: Discussion, Conclusion and Suggestions for future research

Chapter 8: Discussion, Conclusion and suggestions for future research

8.1 Introduction

The main purpose of this chapter is to review all the findings from this research, and to discuss the main findings. Section 8.2 summarises all the results into three categories. These are, firstly, a definition of factors affecting CFC and the priority of importance of factors in several dimensions, secondly, the correlations between the level of CFC and the performance of product design development after dividing the performance of product design development into five detailed performance elements. Finally, the substantial factors affecting the performance of product design development in the above same categories of performance were given. Section 8.3 reviews the major findings and discusses the contribution of the proposed new model of CFC as a conclusion to this research. Finally, Section 8.4 presents some suggestions for future research.

To reminder readers, the major aims of this research have been:

To define the correlation between the level of CFC and the performance of design development of consumer electronics products.

To produce fundamental information about CFC for new product design development in global consumer electronics firms through generating a conceptual model.

In addition, the two major aims of this research are further divided into sub-aims as follows. The first aim is divided into five categories:

1-1 To define the correlation between the level of CFC and the *total performance* of design development.

1-2 To define the correlation between the level of CFC and the *time performance* of design development.

1-3 To define the correlation between the level of CFC and the *cost performance* of design development.

1-4 To define the correlation between the level of CFC and the *design quality performance* of design output.

1-5 To define the correlation between the level of CFC and the effectiveness and efficiency of design management.

The second aim is divided into four sub-aims.

2-1 To define contributory factors (significant issues) affecting CFC for new design development of consumer electronics products.

2-2 To define the priority of importance of the above factors

2-3 To define substantial factors affecting total design development performance

2-4 To define substantial factors affecting each performance item (time, cost, design quality, effectiveness and efficiency of design management) of design development.

8.2 Overall findings

This section briefly summarises the overall findings in relation to the major aims of this research.

8.2.1 Findings 1: Definition of factors affecting CFC and the priority of importance among factors

In order to define factors (issues) affecting CFC for design development of consumer electronics products, this research conducted both an extensive literature survey and a field interview survey. As a result, a total of ninety-four factors were collected from both the field interview survey (52 factors) and the literature survey (42 factors). But, these factors (94 factors) were often the duplicated or factors were very similar. Therefore, these qualitative factors were grouped and renamed based on the similarity among the factors and then a representative title was given for each factor group. Thus, to develop the factors affecting CFC, the 'affinity diagram technique' with a brain group (focus group), which consisted of experts in the design management and/or product design field, was used as a research instrument.

As a result, the dataset groups of two factors affecting CFC were presented by this focus group work. One of them was a 24-factor group and the other was an 11-factor group, which were condensed from the above 24-factors.

This research also surveyed the priority of importance among the factors. As a result, ideally, the 24-four factors are prioritised in order below; (The values in parenthesis indicate the degree of importance of each factor from 1 (little importance) to 7 (extreme importance).

1. Taking responsibility for a project (value=5.78)
2. Sharing unified goals & objectives of a project (value=5.65)

3. Building trust between functional group partners (value=5.52)
4. Having good quality communication (information sharing) with other functional group partners (value=5.46)
5. Having a proper organisation and a flexible organisational culture for cross-functional collaboration (value=5.41)
6. Having a close physical location between functional partners (value=5.27)
7. Having a mutual understanding of roles and knowledge of partners' departments and/or partner (value=5.26)
8. Working rationally and logically (value=5.21)
9. Choosing partners who have professional skills and knowledge within his/her area (value=5.12)
10. Having frequent (quantitative) communication (information sharing) with other functional group partners (value=5.08)
11. Having a sense of belonging and cohesion (value=5.04)
12. Equality of contribution and benefits (value=5.02)
12. Having a unified strategy and company policy upstream and down stream (value=5.02)
12. Allocating sufficient resources (value=5.02)
12. Sharing a common vision and values (corporate level) (value=5.02)
16. Choosing partners with whom there is a good interpersonal relationship and good experience of cross-functional collaboration (value=4.90)
17. Having a well-defined and organised design process (value=4.85)
18. Having an informal social relationship (or system) with other functional group members (value=4.84)
19. Having well-developed management processes and systems (value=4.67)
19. Having a well-planned schedule for product development (value=4.67)
21. Having a joint rewards system rather than individual rewards system (value=4.56)
22. Monitoring progress frequently and rapidly (value=4.37)
23. Having a unified culture (common language, common geographic and ethnological culture) (factor 1, value=4.20)

24. Managing and coordinating activities by senior manager (value=4.12)

Figure 40 shows these priorities in visual.

On the other hand, the priority of importance among the 11-factors is prioritised after calculating the mean data of grouped factors from the 24-factor group in order below. These eleven factors can be seen as compressed factors from the 24 factors based on the homogeneity and similarity among factors.: (the mean values of each factor is also shown in parentheses)

Eleven factors affecting CFC are prioritised in order of importance as follows:

1. Building trust and cohesion (value = 5.45)
2. A proper organisation and a flexible organisational culture for the cross-functional collaboration (value = 5.41)
3. Encouraging interaction between partners (value = 5.27)
3. Having a close physical location between functional partners (value = 5.27)
5. Sharing a unified vision and goals at both corporate level and project level (value = 5.23)
6. Working rationally and logically (value = 5.21)
7. Choosing suitable partners (value = 5.01)
8. Having an informal social relationship (or system) with other functional group partners (value = 4.84)
9. Managerial support (value = 4.80)
10. Unified culture with partners (common language, common geographic and ethnological culture) (value = 4.20)
11. Managing and coordinating activities by senior manager (value = 4.12)

Figure 41 shows these priorities in visual.

8.2.1.1 Findings 1-2: the priority of factors that need more consideration for CFC in the consumer electronics industry

In order to define the priority of factors that need more consideration in the actual field of the consumer electronics industry, the gaps between the ideal degree of importance of each factor and the degree of actual satisfaction with each factor were diagnosed. These idea gaps were calculated as follows:

[the value of the degree of actual satisfaction with each factor in practice *minus* the value of the ideal degree of importance of each factor]

As a result, the gap between the ideal degrees of importance with each factor and the actual degrees of satisfaction are all listed below. These are ordered from greater dissatisfaction to less dissatisfaction.

1. Taking collective responsibility for a project (factor 24, value= -1.71).
2. Having a joint rewards system rather than individual rewards system (factor 14, value= -1.63).
2. Having a close location between other functional partners (factor 16, value= -1.63).
4. Working rationally and logically (factor 23, value= -1.44).
5. Having good quality communication (information sharing) with other functional group partners (factor 21, value= -1.40).
6. Having a proper organisation and a flexible organisational culture for cross-functional collaboration (factor 2, value= -1.37).
7. Sharing unified goals & objectives for project (factor 7, value= -1.21).
8. Building trust between functional group partners (factor 9, value= -1.15).
9. Having a sense of belonging and cohesion (factor 10, value=-1.08).
10. Having a unified strategy and company policy upstream and down stream (factor 5, value= -1.06).
11. Having frequent (quantitative) communication (information sharing) with other functional group partners (factor 22, value= -1.05).
12. Having a well-planned schedule for product development (factor 12, value= -1.01).

13. Sharing a common vision and values (corporate level) (factor 6, value= -0.93).
14. Having well-developed management processes and systems (factor 11, value= -0.91).
15. Having a well-defined and organised design process (factor 13, value= -0.85).
16. Equality of contribution (factor 3, value=-0.79).
17. Having an informal social relationship (or system) with other functional group members (factor 8, value= -0.76).
18. Allocating sufficient resources (hardware) (factor 15, value= -0.69).
19. Having a mutual understanding of roles and knowledge of partners' departments and/or partner (factor 4, value= -0.66).
20. Choosing partners who have professional skills and knowledge within their area (factor 18, value= - 0.54).
21. Choosing partners with whom there is a good interpersonal relationship and good experience of cross-functional collaboration (factor 17, value= -0.52).
22. Monitoring progress frequently and rapidly (factor 20, value= -0. 46).
23. Managing and coordinating activities by senior manager (factor 19, value= -0.25).
24. Having a common culture (common language, common geographic and ethnological culture) (factor 1, value=1.54).

One factor 'Unified culture' is shown there is not much of a gap between the ideal degree of importance and the actual degree of satisfaction with it, which means there is little dissatisfaction with this factor in reality. On the other hand, the other twenty-three factors show a clear gap between the ideal degree of importance and the actual degree of satisfaction. These findings suggest that these twenty-three factors are dissatisfaction factors in reality, therefore, it is inferred that these factors need more consideration to improve CFC in actual field. Figure 43 shows these priorities in visual form.

8.2.1.2 Findings 1-3: Comparing opinions about the degree of importance of each factor affecting CFC between a design group and a non-design group

In addition, in order to give a wide view regarding to CFC, the difference in ideas about the degree of importance of each factor affecting CFC for product design development between a design group and a non-design group was examined using the Independent T-test. From the results of this analysis, eight factors were discovered as factors, which revealed different opinions about the degree of importance of factors between the two groups. This result was produced to be significance value of the t-test below 0.05 ($p < 0.05$). These factors are listed below:

a. Having well-developed management processes and systems (average of designer is 4.85, average of non-designer is 4.53).
b. Having a well-planned schedule for product development (average of designer is 4.93, average of non-designer is 4.46).
c. Having a well-defined and organised design process (average satisfactory degree value from the designer is 5.13, average of the non-designer is 4.62).
d. Choosing partners who have professional skills and knowledge within his/her area (average satisfactory degree value from the designer is 5.33, average of the non-designer is 4.94).
e. Managing and coordinating of activities by senior manager (average satisfactory degree value from the designer is 4.51, average of the non-designer is 3.80).
f. Taking collective responsibility for a project (average satisfactory degree value from the designer is 5.58, average of the non-designer is 5.94).
g. Having a joint rewards system rather than individual rewards system (average satisfactory degree value from the designer is 4.27, average of the non-designer is 4.80).
h. Having a sense of belonging and cohesion (average satisfactory degree value from the designer is 4.82, average of the non-designer is 5.23).

The first five factors (a, b, c, d, e) of the eight factors (as above) are recognised as CFC factors, which the designers believe to be more significant factors than non-designers (a marketer, an engineers, a manufacture) for the design development of consumer

electronics products. Otherwise, the last three factors (f, g, h) from the above list were recognised as CFC factors, which non-designers believed more significant than designers as much as the gap between the above paired average values.

8.1.1.3 Findings 1-4: Comparing opinions about the degree of importance of each factor affecting CFC between a less experienced specialist group and a more experienced specialist group

The difference in opinion about the degree of importance of factors affecting CFC for product design development between a less experienced specialist (career under 5 years) group and a more experienced specialist (career over 6 years) group was also compared using the same method that is the Independent T-test.

As a result, only two factors were discovered as being significantly discriminating factors between a young specialist group (under 5 years) and a senior specialist group (over 6 years). These two factors are listed below.

a. Allocating sufficient resources (average satisfactory degree value from the less experienced group is 5.19, the more experienced group value is 4.89).
b. Working logically and rationally (average satisfactory degree value from the less experienced group is 5.39, the more experienced group value is 5.03).

Both factors (issues) were thought to be more significant amongst less experienced respondents, who have worked for less than 5 years as specialists, when compared to more experienced respondents, who have worked for over 6 years as specialists. It also let us believe that there is no much opinion gap between a less experienced specialist group and a more experienced specialist group within the other twenty-two factors.

8.2.2 Findings 2: Definition of the correlation between the level of CFC and the total weighted performance of product design development.

A major aim of this research was to define the correlation between the level of CFC and the design development performance of consumer electronics products. This was essential to judge the value of the model for CFC.

In order to produce a more detailed correlation between the level of CFC and the design development performance of consumer electronics products, the correlation between them was divided into five categorises after dividing the design development performance into five detailed performance element, these are below.

1) the total weighted performance of product design development
2) the time performance of product design development
3) the cost performance of product design development
4) the quality performance of product design output
5) the effectiveness and efficiency of design management

The total returned 110 questionnaires were analysed to achieve this section's aims.
The Simple regression analysis of SPSS was used as an analysis instrument.
The results are presented the following sub-sections.

8.2.2.1 Findings 2-1: Definition of the correlation between the level of CFC and the total weighted performance of product design development.

The result shows that there is a clear and highly positive correlation between the satisfaction level with CFC and the total weighted performance of design development (Pearson correlation value is 0.791, $p. < 0.01$). Namely, if a level of cross-functional collaboration increases, the performance of design development will be enhanced. The

results also indicate that CFC could account for approximately 62.6% of the variation in the total performance of product design development (*'R Square'* value is 0.626).

8.2.2.2 Findings 2-2: Definition of the correlation between the level of CFC and *the time performance* of product design development.

The result from the analysis shows that there is also a plus correlation between the level of CFC and the time performance of design development *(Pearson correlation coefficients value is 0.546, p. < 0.01)*. The results indicate that CFC accounts for 29.8% of the variability in the time performance of design development *(R square value is 0.298)*.

8.2.2.3 Findings 2-3: Definition of the correlation between the level of CFC and *the cost performance* of product design development.

There is a positive correlation between the level of CFC and the cost performance of design development *(correlation coefficients value is 0.456, p. < 0.01)*. The results indicate that CFC accounts for 20.8% of the variability in the cost performance of design development. *(R square value is 0.208)*.

8.2.2.4 Findings 2-4: Definition of the correlation between the level of CFC and *the quality performance* of product design output.

There is a positive correlation between the level of cross-functional collaboration and the quality performance of product design output *(correlation coefficients value indicates 0.725,*

p. < 0.01). The result indicates that CFC accounts for 52.6% of the variability in the quality performance of product design output (*R square value is 0.526*).

8.2.2.5 Findings 2-5: Definition of the correlation between the level of CFC and *the effectiveness and efficiency of design management.*

There is a positive correlation between the level of cross-functional collaboration and the effectiveness and efficiency of design development (correlation coefficients value is 0.566, p. < 0.01). The result indicates that CFC accounts for 32.1% of the variability in the effectiveness and efficiency of design management (*R square value is 0.321*).

8.2.3 Findings 3: Definition of substantial factors affecting the design development performance of consumer electronics products

After verifying that there are all positive correlations between CFC and the each performance of product design development, this research attempted to identify factors affecting the design development performance of consumer electronics products as an advanced aim based on the above-results of this research.

In order to produce more detailed pragmatic information, substantial factor affecting the each design development performance was identified into five categories after the design development performance was divided into five categories.
These divided five categories for design development performance are the same as those used for the definition of correlation between CFC and the performance of consumer electronics products.

The total 110 design development projects (according to the returned 110 questionnaires) were analysed to achieve the above aims, but the cases (questionnaires) included missing value(s) were excluded in the analysis. The Multiple regression analysis of SPSS was used as an analysis instrument.
The results are presented the following sub-sections.

8.2.3.1 Findings 3-1: Definition of substantial factors affecting the total weighted design development performance of consumer electronics products.

Four factors of the eleven factors were identified as factors, which substantially contribute to the total performance of product design development. These four factors could be found by means of giving a criterion of 95% probability of multiple regression analysis within a hierarchical method (Method = Forward, Criterion: Probability-of-F-

to-enter <= .050). These four factors are prioritised according to the degree of significance influencing the total performance of product design development. It was calculated by using a Standardized Beta value. Each value in parenthesis presents the expected increasing degree of total design development performance according to one of satisfaction degree of each factor increases. These interpretations could be true only if the effects of the other contributory factors are held constant.

- 'Building trust and cohesion'(26.5)
- 'Encouraging interaction between partners' (26)
- 'Sharing unified vision and goals at both corporate level and project level' (25.9)
- 'Having a proper organisation and a flexible organisational culture for CFC' (13.2)

These four factors account for 63.2 % of the variability in the total weighted performance of design development of consumer electronics products. *(R square value is* 0.632, *Sig. F Change < .000).*

8.2.3.2 Findings 3-2: Definition of substantial factors affecting the time performance of design development of consumer electronics products.

Two factors were identified as factors, which substantially contribute to the time performance of product design development. These two factors could be found by means of giving a criterion of 95% probability of multiple regression analysis (Method = Forward, Criterion: Probability-of-F-to-enter <= .050). These two factors are prioritised according to the degree of significance influencing the time performance of product design development. Each value in parenthesis presents the expected increasing degree of time performance of design development according to one of satisfaction degree of each factor increases. These interpretations could be true only if the effects of the other contributory factor are held constant.

- 'Interaction between partners' (0.4681 degree)

- 'Sharing unified vision and goals at both corporate level and project level' (0.3932 degree).

These two factors account for 33.9 % of the variability in the time performance of design development. *(R square value is 0.339, Sig. F Change <= .001).*

8.2.3.3 Findings 3-3: Definition of substantial factors affecting the cost design development performance of a consumer electronics product.

Only one factor was identified as a factor, which substantially contributes to the cost performance of product design development. This factor was found by means of giving a criterion of 95% probability of multiple regression analysis (Method = Forward, Criterion: Probability-of-F-to-enter <= .050). This factor is

- 'Interaction between partners' (0.6257 degree).

The value in parenthesis presents the expected increasing degree in cost design development performance dependent on one degree of satisfaction of the factor. Interaction between partners', increase.

This factor, 'Interaction between partners', accounts for 22.6% of the variability in the cost performance of design development. *(R square value is 0.226, Sig. F Change < .000)*

8.2.3.4 Findings 3-4: Definition of substantial factors affecting the *quality performance* of product design output

Three factors were identified as factors, which substantially contribute to the quality performance of design output. This factor was found by means of giving a criterion of 95% probability of multiple regression analysis (Method = Forward, Criterion: Probability-of-F-to-enter <= .050). These three factors are prioritised according to the degree of significance influencing the quality performance of design output. Each value parenthesis presents the expected increasing degree in quality performance of design output dependent on one degree of satisfaction of each factor increase. These interpretations could be true only if the effects of the other contributory factors are held constant.

- 'Managerial support' (0.421 degree),
- 'Sharing a unified vision and goals at both corporate level and project level' (0.3663 degree)
- 'Choosing suitable partners' (0.3383 degree)

These three factors account for 52.2% in the variability of the quality performance of product design output (*R square value is 0.522, Sig. F Change < .000).*

8.2.3.5 Findings 3-5: Definition of substantial factors affecting *the effectiveness and efficiency of design management*

Two factors were identified as factors, which substantially contribute to the effectiveness and efficiency of design management. These factors were found by means of giving a criterion of 95% probability of multiple regression analysis (Method = Forward, Criterion: Probability-of-F-to-enter <= .05). These two factors are prioritised according to the degree of significance influencing the effectiveness and efficiency of design management. Each value in parenthesis present the expected increasing degree

of effectiveness and efficiency of design management dependent on one degree of satisfaction of each factor increases. These interpretations could be true only if the effects of the other contributory factor are held constant.

- 'Managerial support' (0.4943 degree).
- 'Working logically and rationally' (0.3035-degree).

These two factors account for 30.2 % in the variability of the effectiveness and efficiency of design management performance (*R square value is 0.522, Sig. F Change <= .003).*

8.3 Discussion of the major findings of the research in relation to the developed new model of CFC

As has been noted, few studies have been carried out related to the issues of CFC (Cross-Functional Collaboration), nevertheless, there is a clear consensus that the issue is critical in new product design development (Hebruck & Umback, 1997; Davies-Cooper & Jones, 1996; Olson 1993, 1994; Gorb & Dumas, 1997; etc.).

Furthermore, from both the interview results of this research and Olson's statement (1993, 1994), there seem to be high barriers between a design group and other functional groups, particularly, in a functional organisation rather than a cross-functional team organisation. Besides, almost all of the previous research works, which were related to the issues of CFC in NPD was carried out focused on cross-functional teams, which is the most effective organisation type to collaborate among the other functional groups (Karl & Steven, 1995). But, there is a dearth of research which attempts to encourage CFC focused on the functional organisational structure, which is a type of organisation in which it is difficult to foster collaboration among other functional groups (Karl & Steven, 1995).

On the other hand, there was not empirical research, which proves whether CFC improves performance of design development of consumer electronics products or not on a practical level. This proof is essential premise to support the value of producing information for CFC.

For these reasons, this research was conducted to fill in the gap in the neglected research, which tries to contribute collaboration among functional groups for new product design development, particularly, in the global consumer electronics industry, which usually develops products under the functional organisation structure.

This empirical research has had two main aims. The first aim was to define the correlation between the level of CFC and the design development performance of

consumer electronics products. The second aim was to produce pragmatic information by means of a model which identifies factors affecting CFC, and to evaluate which factors are more important, and which factors substantially contribute to design development performance in several dimensions.

The above two main aims have been successfully achieved though this longitudinal research that was conducted with three complementary research methods: an extensive literature survey, qualitative and quantitative research in the field.

In conclusion, firstly, this research has proved there is a plus correlation between the level of CFC and the design development performance of consumer electronics products. Namely, the above findings of this research strongly support that CFC for the design development of consumer electronics products brings a range of benefits to the total performance of design development and the each performance of each design development item which is an element of total performance in this research. These are the time performance of design development, the cost performance of design development, the design quality performance of design output, and the effectiveness & efficiency of design management. This also supports the value of producing of information about CFC for product design development.

On the other hand, as a result of the achievement of the second aim, a new framework model, which contains group knowledge of CFC for design development of consumer electronics products after analyses through large retrospective data, was developed and proposed in a visual diagram. Three major findings of this research have been presented by means of this developed model of CFC. These are as follows:
Firstly, the factors affecting CFC for design development of consumer electronics products have been identified, and secondly, the priority of importance of these factors have been prioritised below (The values in parenthesis indicate the degree of importance of each factor from 1 (little importance) to 7 (extreme importance).

1. Building trust and cohesion (factor 6, value = 5.45)

2. A proper organisation and a flexible organisational culture for cross-functional collaboration (factor 2, value = 5.41)
3. Encouraging interaction between partners (factor 11, value = 5.27)
3. Having a close physical location between functional partners (factor 8, value = 5.27)
5. Sharing unified vision and goals at both corporate level and project level (factor 4, value = 5.23)
6. Working rationally and logically (factor 10, value = 5.21)
7. Choosing suitable partners (factor 7, value = 5.01)
8. Having an informal social relationship (or system) with other functional group partners (factor 5, value = 4.84)
9. Managerial support (factor 3, value = 4.80)
10. Unified culture with partners (common language, common geographic and ethnological culture) (factor 1, value = 4.20)
11. Managing and coordinating activities by senior manager (factor 9, value = 4.12)

In order to inform more precisely about issues affecting CFC for design development of consumer electronics products, 24 factors, which were source factors before being compressed into 11 factors, affecting CFC have been also presented and prioritised.

Secondly, factors contribute to design development performance are also identified in the model as follows:

a. Four factors were identified as factors substantially contributing to the total weighted performance of product design development. These four factors are
   - 'Building trust and cohesion',
   - 'Sharing unified vision and goals at both corporate level and project level',
   - 'Encouraging interaction between partners',
   - 'Having a proper organisation and a flexible organisational culture for CFC'
b. Two factors were identified as factors substantially contributing to the time performance of product design development
   - 'Interaction between partners'

- 'Sharing unified vision and goals at both corporate level and project level'

c. Only one factor was identified as being factor which substantially contributes to the cost performance of product design development
   - 'Interaction between partners'

d. Two factors were identified as factors substantially contributing to the quality performance of product design output
   - 'Managerial support'
   - 'Sharing unified vision and goals at both corporate level and project level'
   - 'Choosing suitable partners'

e. Two factors were identified as factors substantially contributing to the effectiveness and efficiency of design management
   - 'Managerial support'
   - 'Working logically and rationally'

Thirdly, this model also presented the priority of importance given to factors in relation to the above type of performance. These are displayed within the thickness of the linkage-line between each factor and the proximity to the core of the model in visual diagram (see Figure 49).

To sum up briefly, these findings suggest that seven factors of the eleven factors affecting CFC are further identified as significant factors contributing to design development performance. These factors are presented as central findings of this research below.

- 'Building trust and cohesion',
- 'Having a proper organisation and a flexible organisational culture for the CFC'
- 'Encouraging interaction between partners',
- 'Sharing unified vision and goals at both corporate level and project level'
- 'Working logically and rationally'
- 'Choosing suitable partners'
- 'Managerial support'

The framework model provides clear guideline information to someone who wants to improve the performance of product design development by building CFC. The findings of this research would inform to people what are valuable for building CFC climate and what are prior factor in a quandary concerning where to concentrate their efforts so as to successfully implement their CFC to improve their design development performance. In particular, the findings of this research could further help designers and design managers who lack the experience and knowledge of collaboration situations in the rigid inter-functional organisational boundaries, which have been a major source of problems in the new product design development process in the global consumer electronics industry. This is because the model of CFC was developed by focusing on the functional organisations structure, which many consumer electronics companies face.

8.4 Applications of the conceptual framework.

There are two mega trends we face related to this research issue. One of them is the continual development of ideas, related to detailed segmentation and specialisation so far, which are being integrated among the various departments while attempting to break down functional boundaries in the digital era (Hart, 1996; Yim J. T. 2000). The other one is that 'people oriented problem solving' issue, which has been ignored in NPD (Jassawalla 2000), particularly NPDD (New Product Design Development) field (Boddy & Buchanan 1986), is beginning to recognise as key as a significant issue in NPDD (Cooper& Kleinschmidt, 1996).

In this context collaboration among the different functional groups in NPDD is dealt with as key issue as both the integrated tool and the centre of human issue for successful NPDD. Although some recent empirical researches show how important collaboration in functional departments in the NPDD process is (Bebb H. B. 1992). However, there is a dearth of information on how to actually build collaboration among different functional group for the NPDD.

Therefore, this research produced the conceptual framework model for design development of consumer electronics products as a main finding in order to contribute to improving the environment for collaboration amongst the functional groups by providing clear guideline information to someone who wants to improve the performance of product design development by building CFC. In particular, the findings of this research could further help designers and design managers who lack the experience and knowledge of collaboration situations in rigid functional organisational boundaries, which have been a major source of problems in the new product design development process in the global consumer electronics industry. This is because the model of CFC was developed by focussing on the functional organisation structure, which many consumer electronics companies face.

To summarise, the five main applications of the developed conceptual framework model can be identified as follows:

1) This conceptual framework model provides the larger picture and conceptual guidelines, which helps to achieve a high level of CFC in design development situations. The model informs people what the valuable issues for building a CFC climate are.
2) 'First things first': prioritising factors affecting CFC in the model can be used to help decision-making related to improving the CFC situation. This conceptual model also clearly shows which factors should be dealt with first in the limited time and cost situation of their organisation.
3) Another vital aspect of the model, the identified factor(s) substantially affecting each individual performance of design development enable us to know what the prime factor(s) in a quandary concerning where to concentrate their efforts so as to successfully implement CFC in a company's organisation, eventually, lending to the improvement of their particular design development performance. Namely, this model helps organisations concentrate upon weak areas in design performance. For example, as Leslie Wynn who is a senior design mangers at Xerox pointed out, if there is some organisation which usually fails to fix a design development time performance, they need to improve, in particular, two factors: ' Interaction level between partners', and 'Sharing unified vision and goals', in their organisation. This proposed conceptual framework model of CFC gives this kind of information.
4) The model can be used as a tool to analyse the past performance of CFC in product design development. For example, the eleven factors, which are shown in the model as factors affecting CFC, can be used as items to assess the performance of CFC in an organisation. This was pointed out by, B. Y. Song, senior design manger at Samsung Elec. He was interested in using the eleven factors in this model to assess both the CFC level of his organisation and as an individual assessment tool. On the other hand, the eleven factors, which have been identified as factors affecting CFC, can also be used by other researchers

wanting to measure the level of CFC for their own future research. For example, a researcher who wants to examine the correlation between the level of CFC in NPDD and the types of organisation for their research project. They can use these eleven factors developed from this longitudinal research.

5) This model can be used as an education source in order to enhance CFC. The necessity of education about CFC was also emphasised by several interviewees during the evaluation stage of this research because there are not many good sources at the moment for learning how to improve CFC. In this kind of situation, this conceptual framework model can be used as an education source for sharing a unified vision to collaborate, particularly, with other functional groups in NPDD.

8.5 Limitations of the research

Like any exploratory research effort, this study contains a number of methodological strengths and limitations.

Although this longitudinal research was conducted under breadth of the investigation in this research scope (the consumer electronics industry sector), three limitations can be identified in the research procedure and on the application of the findings of this research as follows:

First, although the eleven factors affecting CFC were defined through using professional group knowledge in this research, there might exist some degree of metamorphosis of meaning of each factor during both the procedure of grouping amongst factors based on relationship and when definition of title for its factor groups was given.

In other words, the eleven factors finally identified as affecting CFC were compressed, and then defined from the ninety-four verbal data, which had been initially identified as factors affecting CFC, by a focus group to communicate issues associated with CFC effectively in a simple way.

In order to deal with this kind of diverse and intangible verbal data in an efficient way, this research undertook a qualitative analysis with qualitative techniques such as 'affinity diagram technique' in defining factors affecting CFC without metamorphosis as far as this was possible for the focus group. But it was inevitable to avoid some degree of metamorphosis of each factor's meaning during the procedure of grouping factors based on homogenate and similarity and when representative title for its factor cluster was created. This is why Schweiker M. (1999) pointed out

"the affinity diagram technique is a creative process rather than a logical process".

However, it is widely acknowledged that some degree of metamorphosis in this kind of qualitative data analysis is unavoidable in the field of social science.

Secondly, it might not be possible to apply the conceptual framework, which provides fundamental information for building CFC in design development of consumer electronics products, to the design development by outside design organisations such as design consultant agencies. Since, the findings of this research were generated by empirical data from the in-house design organisation rather than outside design consultant companies and the mixed organisation, that is a hybrid of in-house design organisation and outside design consultancies. General business climate and cultural aspects, etc, may be different. But a remarkable point is

that most product design developments in the consumer electronics industry (over 90%) are being developed under the in-house design organisation according to the findings of this research (see Table 18). This means that the model produced by this research can be applied in a large amount of NPDD in the consumer electronics industry.

Finally, the application of the findings of this research also might have geographical limitations. The strength of this research is that collected the practical data, which was the main source of producing the research results, from the top level of leading global consumer electronics industry in three countries (Japan, S. Korea, UK). These companies are Samsung, Hitachi, Toshiba, LG, Daewoo Xerox limited, Fuji Xerox, and KEC. Five of them (Samsung, Hitachi, Toshiba, LG, Daewoo) are in the top ten companies for net profit 1995/1996 in this industry sector (Euromoniter Report 1997; see Table 3). According to EACEM (European Association of Consumer Electronics Manufactures, 1996), the top ten companies in this industry account for three-quarters of world production, six of them being Japanese, two South Korean and two European. Thus, Japanese firms are the main producers of consumer electronics for the world market. However, there is a risk of applying this conceptual model produced by this research, to consumer electronics firms in other country other than the three countries mentioned above. Since, product design development situations can differ according to the varying business situation of each country.

8.6 Suggestions for future research.

This research is designed to help people find avenues through the developing map for building CFC, ultimately, for improving their performance of design development rather then how to get the avenues in an efficient way.

After completing this study, two finding related to collaboration among the different functional groups for design development are proposed. The two main finding here are that, firstly, CFC for the design development of consumer electronics products brings a range of benefits to the total performance of design development and the each individual performance (time, cost, quality of design output, effectiveness & efficiency of design management); secondly, this research helps that people cannot delineate outline knowledge of CFC for design development but also decide which factor has more prior value by proposed fundamental guideline framework model, ultimately, this model contributes to improving the CFC environment for new design development of consumer electronics products.

This exploratory research (because no similar research was found in the area of the enhancing CFC for new design development of consumer electronics products) could lead to more in depth studies for future research based on the above two fundamental findings.

As some of the design mangers already pointed out in the evaluation stage of this research, it is necessary to conduct further detailed research which aims to produce in-depth information about how to improve each factor affecting CFC in model efficiently in practice. The important issues for further future research work are, for example, 'what are the criteria for choosing the right or proper partners for design development, and how should they be matched', 'how the trust and cohesion level among the partners in design development can be enhanced', 'how the interaction level between partners can be improved' etc.

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Appendices

Appendices

Appendix 1 Agenda for Interview (English Version)

The information received is for use in a thesis which forms part of Ph.D. in Design Management at De Montfort University.

1. Title:

New model of cross-functional collaboration for a new product design development in global consumer electronics firms

2. The aim of the interview:

The aim of this interview is to discover and develop a conceptual definition and framework of those significant issues (contributory factors and obstacles) affecting CFC (cross-functional collaboration) within NPDD (new product design development) processes. This is in order to help the designer, particularly design managers and general managers who

B. In order to discover contributory factors affecting CFC (cross-functional collaboration)

Question 7-1. What are contributory factors affecting CFC (Cross Functional Collaboration) for product design development in general?

Question 7-2. Why do you think these contributory factors you mentioned are important?

Question 7-3. What are the obstacles affecting each of the above contributory factors?

C. To define the design development circumstances of consumer electronics products, such as, product design development forms and types of organisation structures (the following questionnaires (question 10) are also used here)

Question 8. How many projects does a designer usually undertake at the same time?

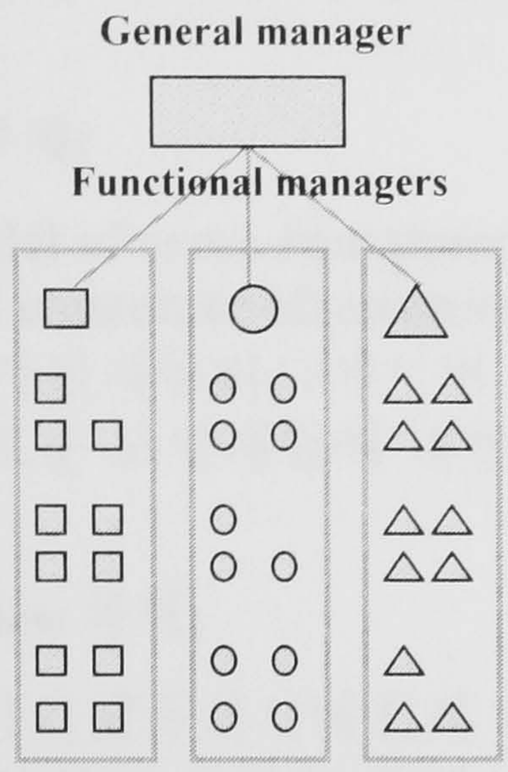
Question 9. What percentage of new product design development is conducted in each of the following categories in your company?

In-house design		**From design consultant**	**Etc.**
Cross-functional team	General organisation.		
%	%	%	%
Sum 100%			

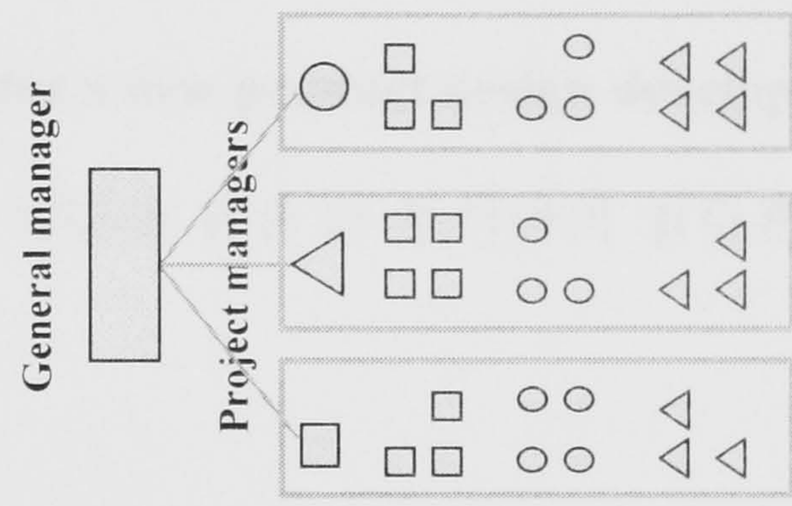
Questionnaire - **This questionnaire belongs to C-section of the interview.**

Question 10. What percentage of new product design development is conducted in each of the following categories in your company?

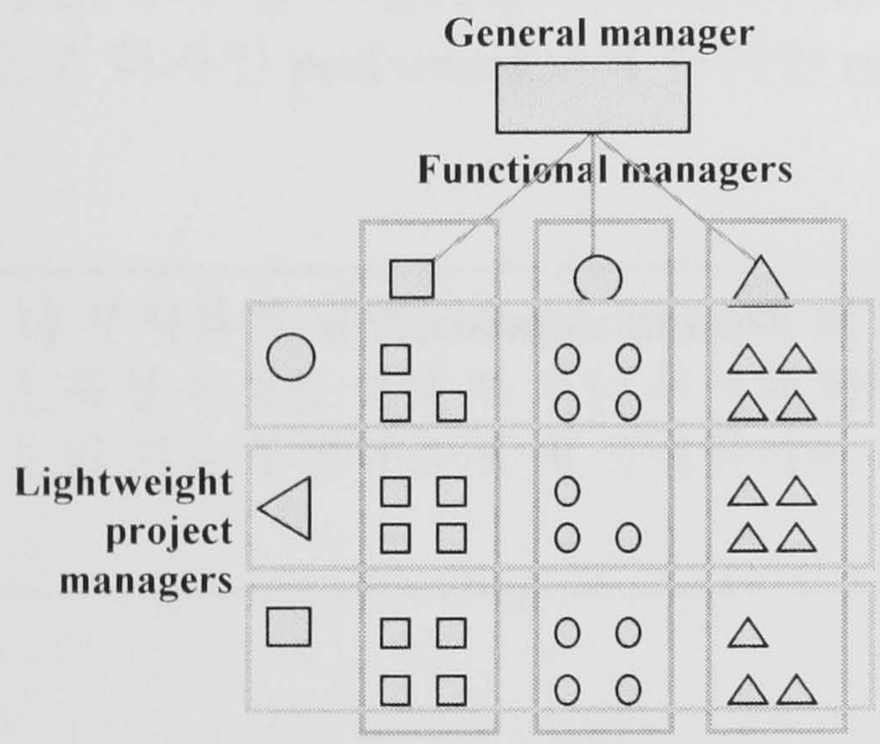
a) Functional organisation



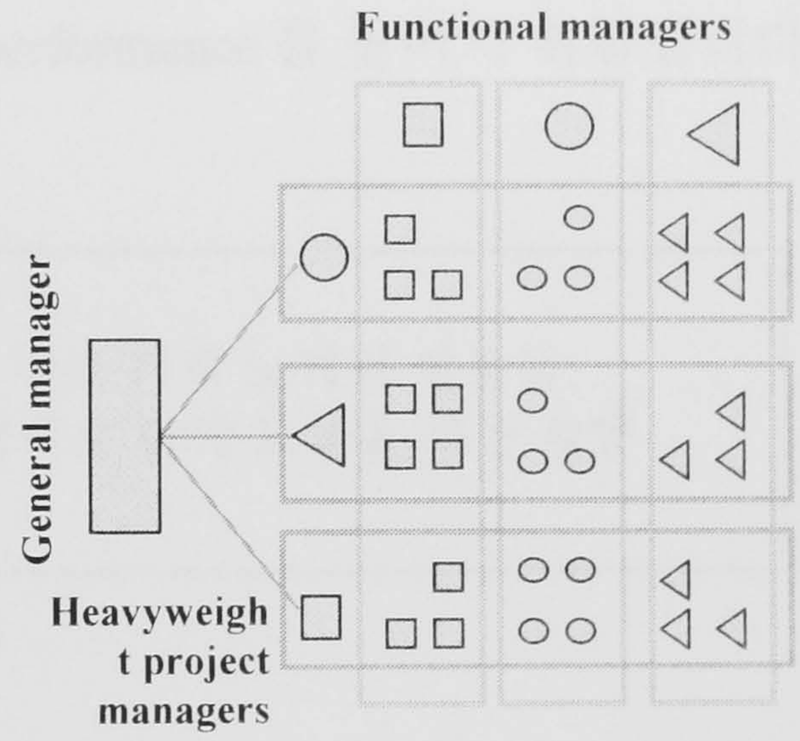
b) Project organisation



c) Lightweight project Matrix Organisation



d) Heavyweight project Matrix Organisation



D. In order to get pragmatic information from a real company setting, namely to get information about the measurement items (scales) for design development and design management.

Question 11. Does your company have any criteria or/and scales in order to measure the performance of product design and design management?

Appendix 2 Agenda for interview (Korean Version)

본 인터뷰로 얻어지는 모든 정보는 De Montfort University 의 디자인 메니지멘트 박사 논문을 위해 쓰여지게 될 것입니다.

1. 논문 주제:

New model of cross-functional collaboration for a new product design development in global consumer electronics firms
(Global 가전제품회사에서의 신제품 디자인 개발을 위한 타 부서와의 협력관계에 대한 새로운 모델개발에 대한 연구)

2. Interview 목적:

Global 가전제품회사에서의 신제품 디자인 개발과정에 있어서 타 부서와의 협력관계에 영향을 미치는 공헌, 기여 issues (공헌 요소 또는 장애요소 (factors))의 발견과 정의를 위해,
이 개념적으로 정의된 issues 들은 디자이너 (특히 design managers)에게 상호 기능적 조직의 협력 장애를 극복하고, 보다 협력적으로 상호 관계로 만들어고, 궁극적으로 디자인 performance 와 디자인 management performance 를 높이기 위함입니다.

타 부서와의 협력(collaboration)에 대한 정의
1. 특정 목적을 위해 타 기능 부서와 함께 일하는 것. 주로 지적 노력의 활동들.
2. 타 기능 부서와 주로 비 공식적이며, informal 한 형태로 함께 도움을 주는 활동

3. Interview 질문항목

A. Background information을 위한 질문 항목

질문1. 회사명?

질문2. 회사 전체 종업원 명수?

질문3. 총 디자이너 명수?

질문4. Interviewee의 직위는?

질문5. 근무 부서명은?

질문6. Interviewee의 직장 근무 년 수는?

B. 신제품 디자인 개발과정에 있어서 타 부서와의 협력관계에 영향을 미치는 issues (공헌, 기여 요소 또는 장애요소 (factors))의 발견과 정의를 위한 질문 항목

질문7-1. 신제품 디자인 개발과정에 있어서 타 부서와의 협력관계에 영향을 미치는 공헌, 기여 issues 요소 (factors)는 무엇 입니까?

질문 7-2. 질문 7-1의 답변에 대해 왜 그렇다고 생각 하십니까?

질문7-3. 신제품 디자인 개발과정에 있어서 타 부서와의 협력관계에 영향을 미치는 장애요소 issues (factors) 는 무엇 입니까?

C. Global 가전제품 회사에 대한 특징적 규정을 위한 질문 항목입니다.

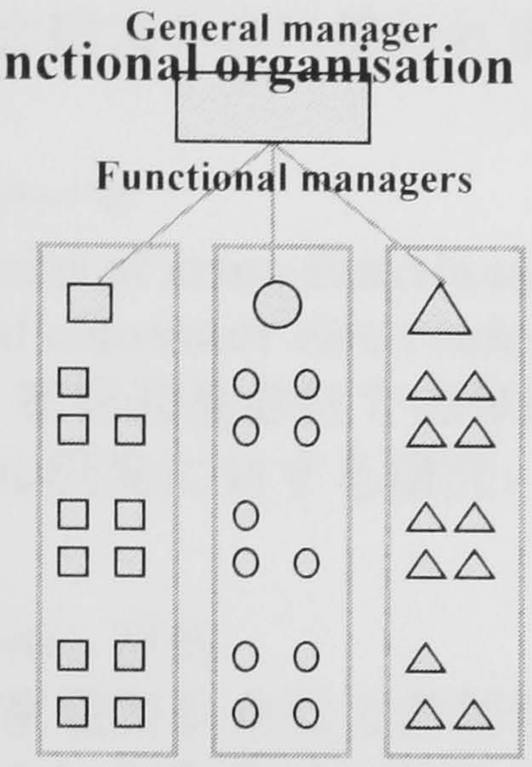
질문 8. 일반적으로 귀사의 경우 한명의 디자이너가 얼마나 많은 제품디자인 개발 project를 동시에 업무 수행하고 있습니까?

질문9. 몇 %의 신제품 디자인 개발이 복합기능부서로 이루어진 팀 안에서 이루어지는지요?

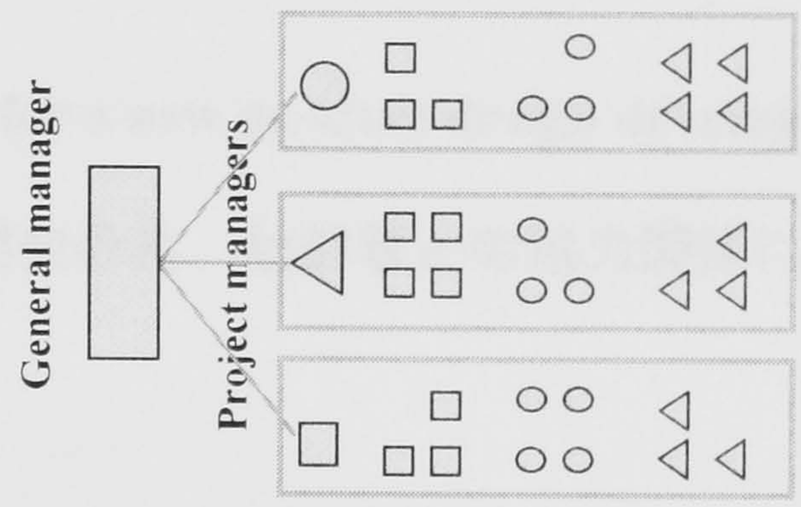
In-house design		From design consultant	Etc.
Cross-functional team	General organisation.		
%	%	%	%
			Sum 100%

질문 10. 기업내의 조직을 크게 아래와 같은 4 가지 조직도에 의해 분류 한다면, 귀하의 기업내 조직은 어는 형태의 조직도에 가장 가깝다고 생각하십니까? (적합한 보기에 V 표를 해 주시기 바랍니다.)

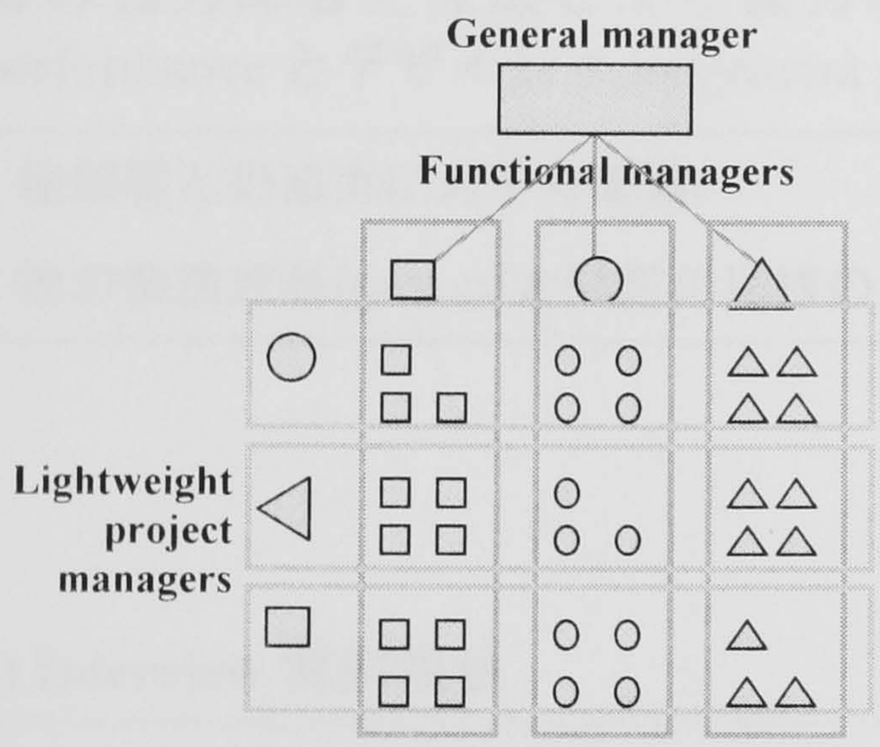
a) Functional organisation



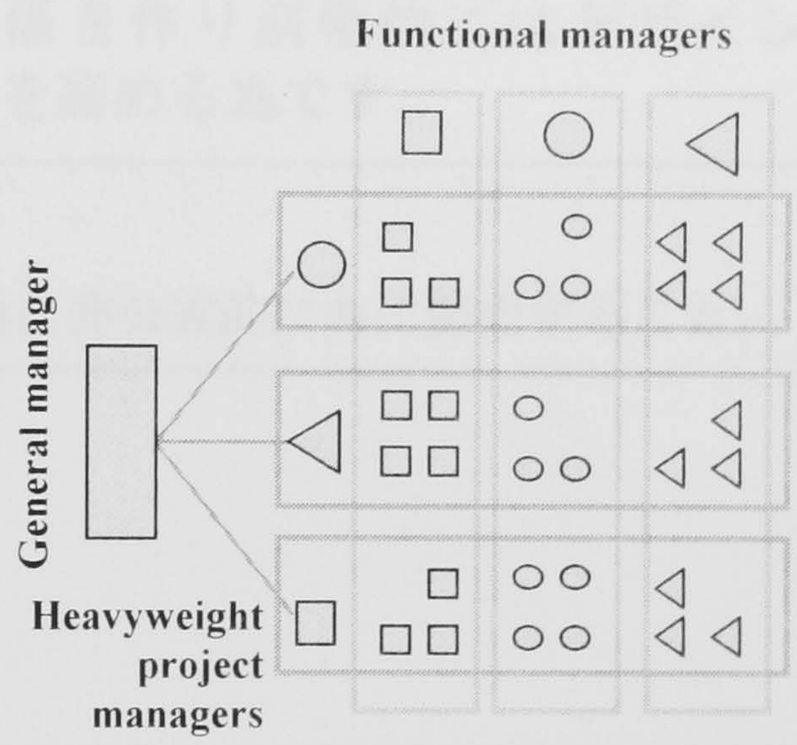
b) Project organisation



c) Lightweight project Matrix organisation



d) Heavyweight project Matrix organisation



D. 제품 디자인개발 성과와 디자인management 성과을 측정할items (scales)을 개잘하기위해서

질문 11. 당신의 회사에서는제품 디자인개발 성과와 디자인management 성과을 측을 위해 어떤한 방법을 사용하고 계시는 지요?

Appendix 3. Agenda for interview (Japanese Version)

本で interview で得られるすべての情報は Brunel University のデザインマネジメント博士論文の為に使われます。.

1. 論文テーマ
New model of cross-functional collaboration for a new product design development in global consumer electronics firms
(Global 家電製品会社での新製品デザイン開発の為、他部署との協力関係に対し新モデル開発に対する研究)

2. Interview 目的
Global 家電製品会社での新製品デザイン開発過程において他の部署と協力関係に影響を与える貢献、寄与 issues (貢献要素又は障害要素(factors))の発見と定義の為です。
概念的に定義された issues はデザイナー (特に design managers)に相互機能的組織の協力障害を克服しより協力的に相互関係を作り窮極的にはデザイン performance とデザイン management performance を高める為です。

他部署との協力に対する定義: 他の機能部署(group)と特定の目標のため公式、特に非公式的に共に努力すること。

c) Interview 質問項目

A. Background information

1. 会社名

2. 総従業員数

3. 総デザイナー数

4. Interviewee の職位

5. Interviewee の部署

6. Interviewee の勤務年数

B. 新製品デザイン開発過程において他部署との協力関係に営業を与える issues (貢献、寄与要素又は障害要素 (factors) の発見と定義の為の質問

7-1. 新製品デザイン開発過程において他部署との協力関係に影響を与える貢献、寄与 issues 要素 (factors) は何ですか?

7-2. 質問 7-1 の答えに対しなぜそうだと思いますか？

7-3. 新製品デザイン開発過程において他部署との協力関係に影響を与える障害要素は issues (factors)は何ですか？

C. Global 家電製品会社に対し特徴的規定をする為の質問項目です。

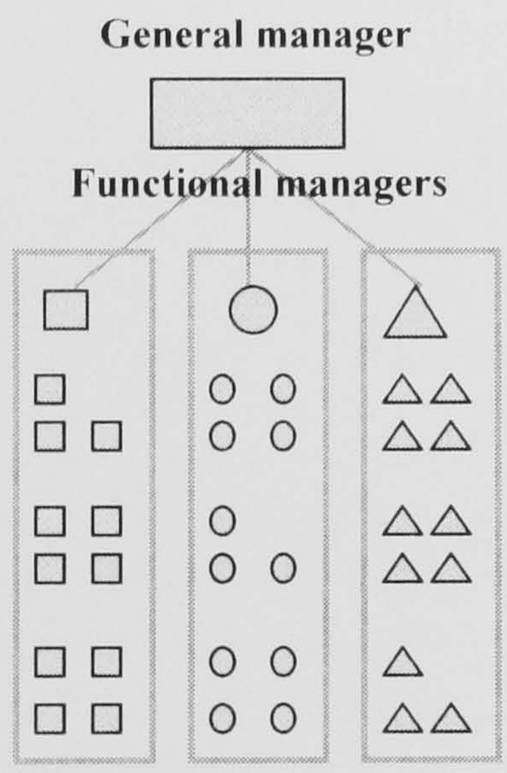
8. 一般的に御社の場合一人のデザイナーがどれくらいの多くの製品デザイン開発 project を同時にしていますか?

9. 新製品デザイン開発は以下の範疇中何%ずつでできていますか？

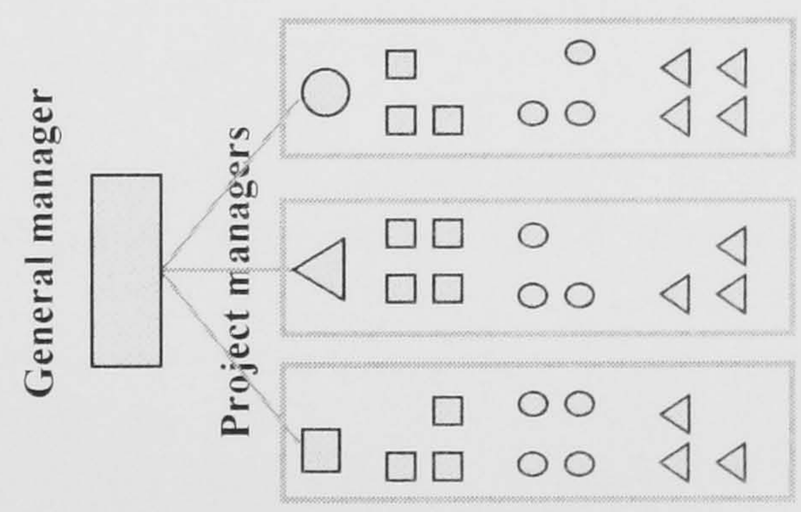
In-house design		From design consultant	Etc.
Cross-functional team	General organisation.		
%	%	%	%
			Sum 100%

10. 企業内の組織を大きく以下のような 4 つの組織図 により分類すると御社の企業内組織はどの形態の組織図に最も近いと思いますか (V で示して下さい.)

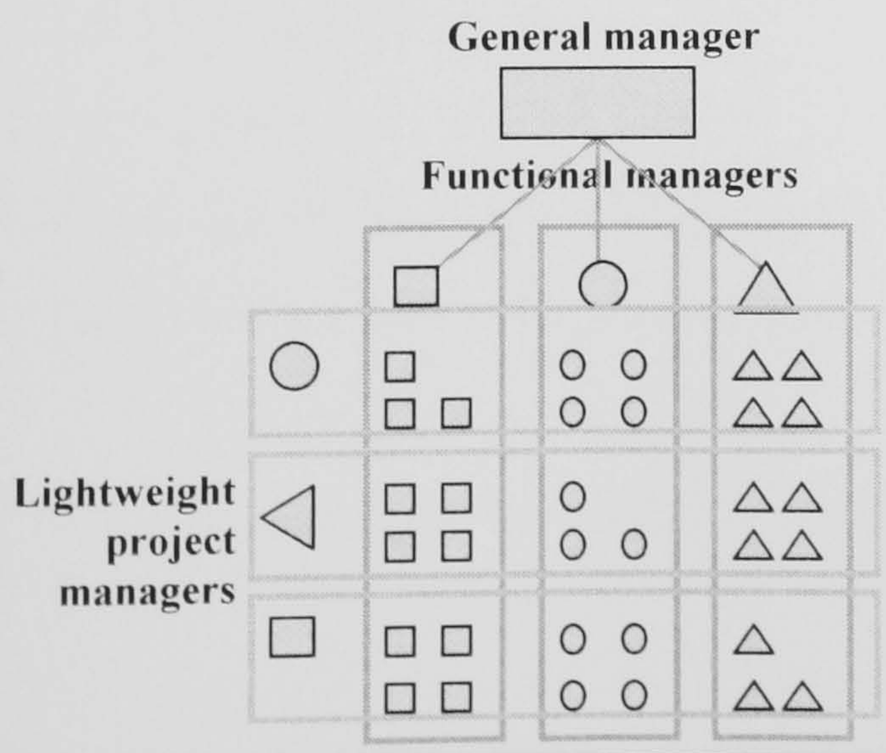
a) Functional organisation



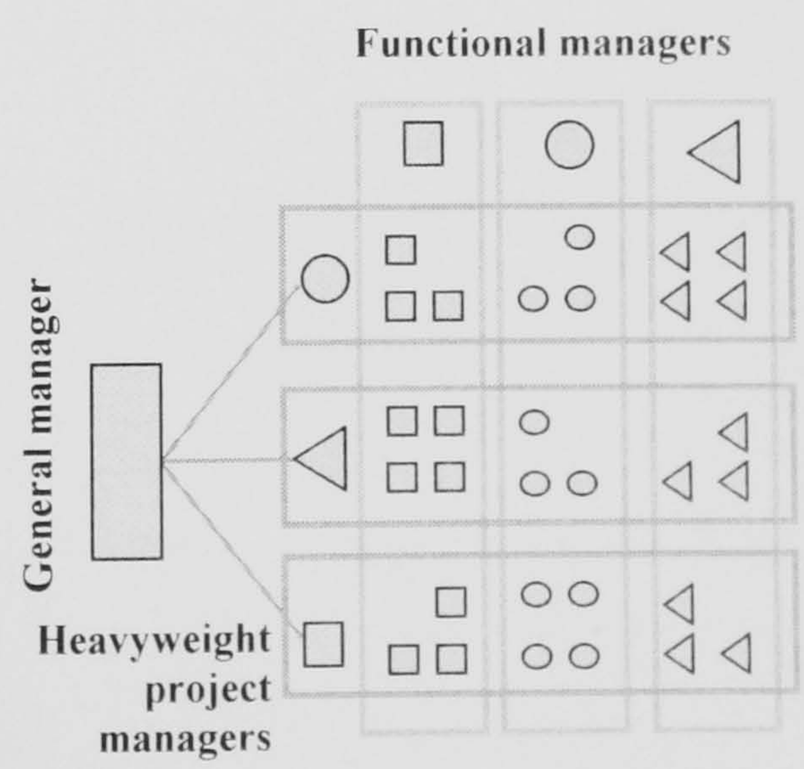
b) Project organisation



c) Lightweight project Matrix organisation



d) Heavyweight project Matrix organisation



D. In order to get the measurement items (scales) for design development and design management

Question 11. Does your company have any criteria or/and scales in order to measure a performance of product design and design management?

Appendix 4. Questionnaire (first design)

[Version One – Industrial (appearance) designers]

The information received from this questionnaire is only for use in a thesis which forms part of a Ph.D. in Design Management at Brunel University and for academic purposes.

1. Title:

A new model of cross-functional collaboration for new product design development in global consumer electronics firms

2. The main aims of the Questionnaire:

As a central purpose, this research questionnaire has two main aims as follows.
The first aim is to discover and develop a conceptual definition and framework of significant contributory factors (issues) affecting CFC (cross-functional collaboration). These proposed conceptual models will inform what is important and what are less important to design managers and other managers who want to create a more collaborative environment in NPDD (New Product Design Development)
The second aim of this research is to produce the description of the correlation between the level of cross-functional relationship and the performance of product design development and design management.

What is CFC (cross-functional collaboration)?

1. to work jointly with other functional departments (groups) especially in an intellectual endeavour for a special purpose
2. the unstructured, affective nature of interdepartmental relationships in functional departments (groups)

Supervisor: Mr. Ray Holland, Prof. Neville Stanton.

Advisor: Mr. Leslie Wynn

Researcher: Bum-Kyu Kang

Contact phone number: 44 – 01509 – 267 – 063;

Fax number: 82 (national number)-031(area number) -456-2477

Contact email address: bravo29@simmani.com / woodee4@hotmail.com

If you have any queries concerning this questionnaire, please contact BumKyu on the above contact phone number or email address.

3. Questionnaires:

A. In order to get general background information.

Question 1. Name of company?

Question 2. Which department do you belong to?

Question 3. Job title?

Question 4. How long have you been working as a specialist in your department?

Question 5.How long have you been working for this company?

B. In order to identify the priority of contributory factors affecting CFC (cross-functional collaboration) for product design development

1 Having a common culture (common language, common geographic and ethnological culture)	1 2 3 4 5 6 7 (little importance – extreme importance)
2. Proper organisation and flexible organisational culture for cross-functional collaboration	1 2 3 4 5 6 7 (little importance – extreme importance)
3. Equality of contribution	1 2 3 4 5 6 7 (little importance – extreme importance)
4. A mutual understanding of role and knowledge of other functional departments	1 2 3 4 5 6 7 (little importance – extreme importance)
5. Unified strategy and policy company from upstream to down stream	1 2 3 4 5 6 7 (little importance – extreme importance)
6. Sharing a common vision and values (corporate level)	1 2 3 4 5 6 7 (little importance – extreme importance)
7. Sharing unified goals & objectives of project (project level)	1 2 3 4 5 6 7 (little importance – extreme importance)
8. Informal social relationship with other functional group members	1 2 3 4 5 6 7 (little importance – extreme importance)
9.Trust and cohesion level between functional group members	1 2 3 4 5 6 7 (little importance – extreme importance)
10. Having a sense of belonging and cohesion between partners who belong to other functional department	1 2 3 4 5 6 7 (little importance – extreme importance)
11. Well developed management process and systems	1 2 3 4 5 6 7 (little importance – extreme importance)
12. Well planned schedule for product development	1 2 3 4 5 6 7 (little importance – extreme importance)
13.Well defined and organised design process	1 2 3 4 5 6 7 (little importance – extreme importance)

14. Joint rewards system rather than individual rewards system	1 2 3 4 5 6 7 (little importance – extreme importance)
15. Communication & information systems level (Support sufficient resource: hardware)	1 2 3 4 5 6 7 (little importance – extreme importance)
16. Close physical location between other partners who belong to other functional department	1 2 3 4 5 6 7 (little importance – extreme importance)
17. Choosing partners who have good collaborative experience and/or good interpersonal relationships with you in other functional department	1 2 3 4 5 6 7 (little importance – extreme importance)
18. Choosing partners who have professional skills and knowledge about his/her area in other functional department	1 2 3 4 5 6 7 (little importance – extreme importance)
19. Management and coordination of activities from senior manager	1 2 3 4 5 6 7 (little importance – extreme importance)
20. Frequent & rapid monitoring of development progress	1 2 3 4 5 6 7 (little importance – extreme importance)
21. Good quality communication (information sharing) between other functional group partners	1 2 3 4 5 6 7 (little importance – extreme importance)
22. Frequent (quantitative) communication (information sharing) between other functional group partners	1 2 3 4 5 6 7 (little importance – extreme importance)
23. Work logically and rationally	1 2 3 4 5 6 7 (little importance – extreme importance)
24. Taking a collective responcibility about a project	1 2 3 4 5 6 7 (little importance – extreme importance)

C. In order to measure the level of CFC (cross-functional collaboration) in your design development project.

Please, evaluate, according to the grading in each factor, the new design development situation related to your the latest completed design project.

1. Having a common culture (common language, common geographic and ethnological culture)	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
2. Proper organisation and flexible organisational culture for cross-functional collaboration	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
3. Equality of contribution	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)

4. A mutual understanding of role and knowledge of other functional departments	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
5. Unified strategy and policy company from upstream to down stream	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
6. Sharing a common vision and values (corporate level)	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
7.Sharing unified goals & objectives of project (project level)	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
8. Informal social relationship with other functional group members	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
9.Trust and cohesion level between functional group members	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
10. Having a sense of belonging and cohesion between partners who belong to other functional department	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
11. Well developed management process and systems	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
12. Well planned schedule for product development	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
13.Well defined and organised design process	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
14. Joint rewards system rather than individual rewards system	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
15. Communication & information systems level (Support sufficient resource: hardware)	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
16. Close physical location between other functional partners who belong to other functional department	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
17. Choosing partners who have good collaborative experience and/or good interpersonal relationships with you in other functional department	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
18. Choosing partners who have professional skills and knowledge about his/her area in other functional department	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
19. Management and coordination of activities from senior manager	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
20. Frequent & rapid monitoring of development progress	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
21. Good quality communication (information sharing) between other functional group partners	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)

22. Frequent (quantitative) communication (information sharing) between other functional group partners	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
23. Work logically and rationally	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
24. Taking a collective responsibility about a project	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)

D. In order to measure the performance of design development and design management

There are four measurement items in metrics below, in order to measure the performance of design development and design management. Please give your mark dependant on the weight of importance of the latest design development project, which was the same as above project, (the total sum should be 100). Also, please evaluate your degree of satisfaction about the project of new design development in each factor, according to the grading

Measurement items	Weight of importance (the total sum should be 100)	Measurement scale (degree of satisfaction)
Time: (Actual time against plan)		1 2 3 4 5 6 7 (Very dissatisfied – Very satisfied)
Cost: (Actual cost against plan, Cost comparisons between competitive models)		1 2 3 4 5 6 7 (Very dissatisfied – Very satisfied)
Total Design output Quality (e.g. A fitness for objectives, Good appearance, An effectiveness of manufacturing, How much easy to use, etc.)		1 2 3 4 5 6 7 (Very dissatisfied – Very satisfied)
Effectiveness and efficiency of design management		1 2 3 4 5 6 7 (Very dissatisfied – Very satisfied)

Appendix 5. Questionnaire (Second modified design)

[Version One – Industrial (appearance) designers]

The information received from this questionnaire is only for use in a thesis which forms part of a Ph.D. in Design Management at Brunel University and for academic purposes.

1. Title:

A new model of cross-functional collaboration for new product design development in global consumer electronics firms

2. The main aims of the Questionnaire:

As a central purpose, this research questionnaire has two main aims as follows.
The first aim is to discover and develop a conceptual definition and framework of significant contributory factors (issues) affecting CFC (cross-functional collaboration). These proposed conceptual models will inform what is important and what are less important to design managers and other managers who want to create a more collaborative environment in NPDD (New Product Design Development)
The second aim of this research is to produce the description of the correlation between the level of cross-functional relationship and the performance of product design development and design management.

What is CFC (cross-functional collaboration)?

3. to work jointly with other functional departments (groups) especially in an intellectual endeavour for a special purpose
4. the unstructured, affective nature of interdepartmental relationships in functional departments (groups)

Supervisor: Mr. Ray Holland, Prof. Neville Stanton.

Advisor: Mr. Leslie Wynn

Researcher: Bum-Kyu Kang

Contact phone number: 44 – 01509 – 267 – 063;

Fax number: 82 (national number)-031(area number) -456-2477

Contact email address: bravo29@simmani.com / woodee4@hotmail.com

If you have any queries concerning this questionnaire, please contact BumKyu on the above contact phone number or email address.

3. Questionnaires:

A. In order to get general background information.

Question 1. Name of company?

Question 2. Which department do you belong to?

Question 3. Job title?

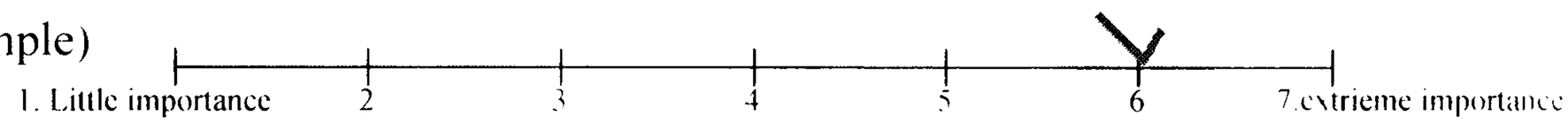
Question 4. How long have you been working as a specialist in your department?

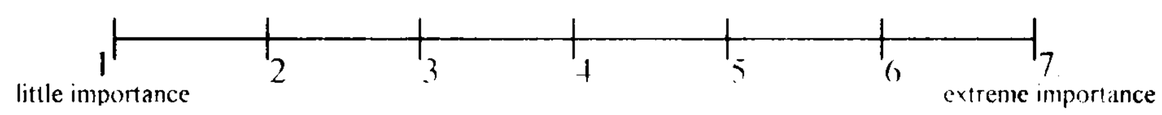
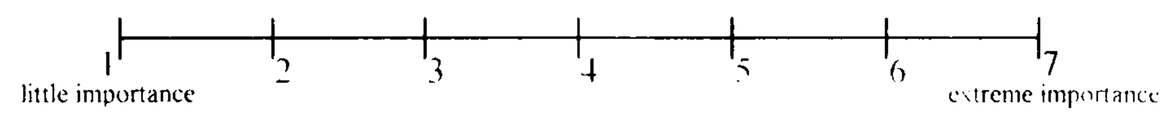
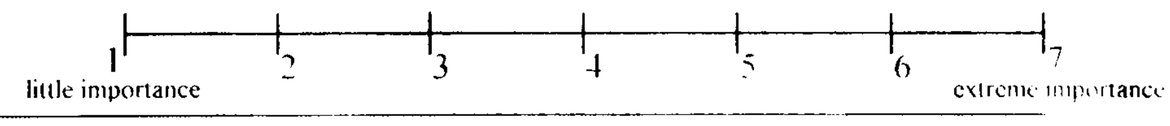
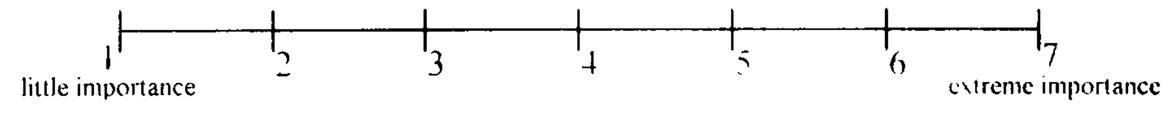
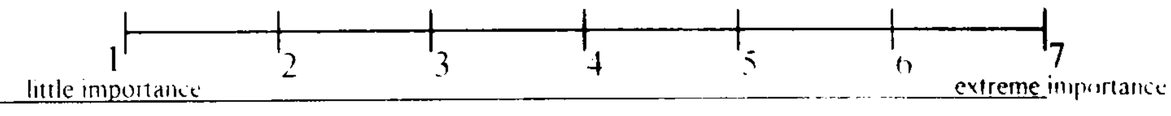
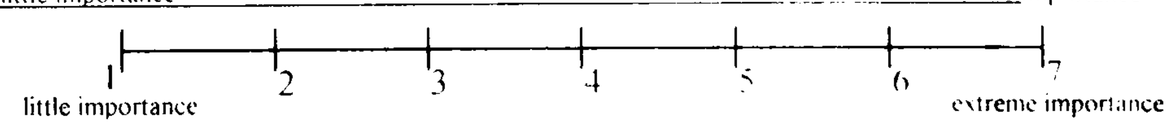
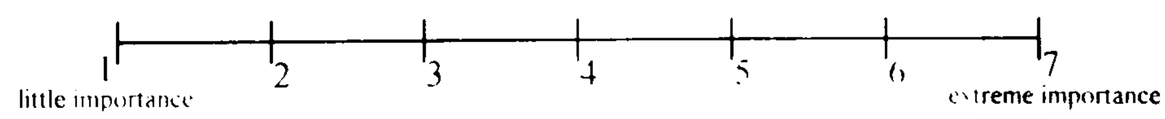
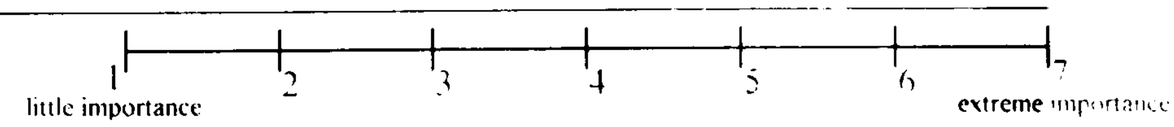
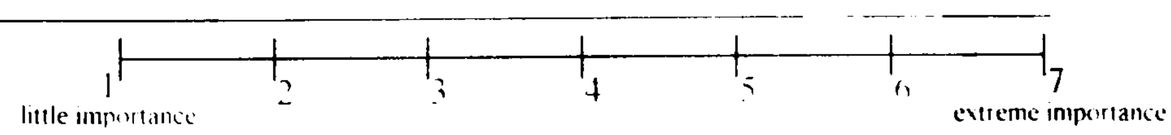
Question 5.How long have you been working for this company?

B. In order to identify the priority of contributory factors affecting CFC (cross-functional collaboration) for product design development

From your experiences, please give your grading about the degree of importance of each factor affecting cross-functional collaboration.

For example)



1 Having a common culture (common language, common geographic and ethnological culture)	
2. Proper organisation and flexible organisational culture for cross-functional collaboration	
3. Equality of contribution	
4. A mutual understanding of role and knowledge of other functional departments	
5. Unified strategy and policy company from upstream to down stream	
6. Sharing a common vision and values (corporate level)	
7. Sharing a unified goals & objectives of project (project level)	
8. Informal social relationship with other functional group members	
9.Trust and cohesion level between functional group members	

10. Having a sense of belonging and cohesion between partners who belong to other functional department

11. Well developed management process and systems

12. Well planned schedule for product development

13. Well defined and organised design process

14. Joint rewards system rather than individual rewards system

15. Communication & information systems level (Support sufficient resource: hardware)

16. Close physical location between other partners who belong to other functional department

17. Choosing partners who have good collaborative experience and/or good interpersonal relationships with you in other functional department

18. Choosing partners who have professional skills and knowledge about his/her area in other functional department

19. Management and coordination of activities from senior manager

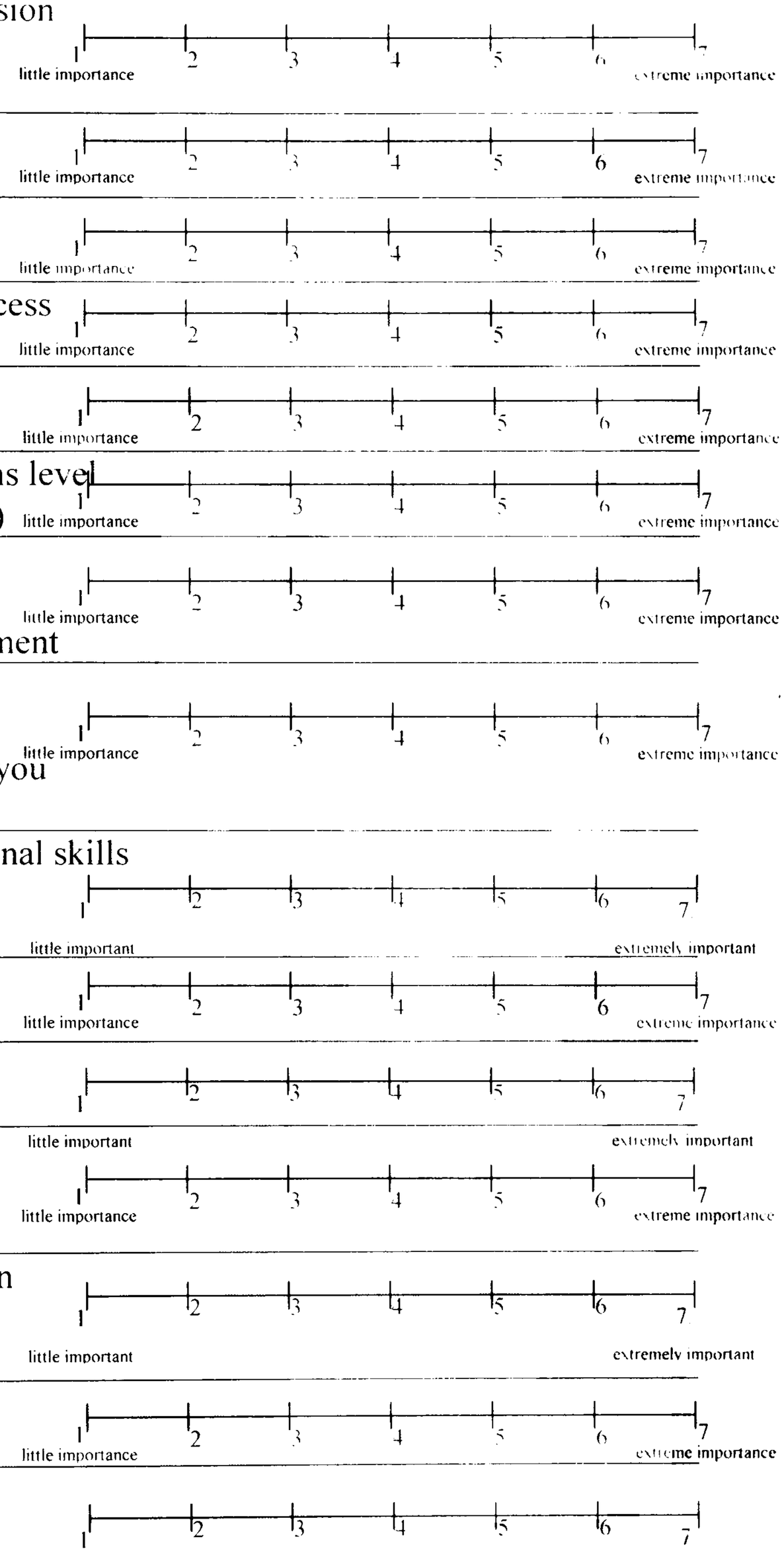
20. Frequent & rapid monitoring of development progress

21. Good quality communication (information sharing) between other functional group partners

22. Frequent (quantitative) communication (information sharing) between other functional group partners

23. Working logically and rationally

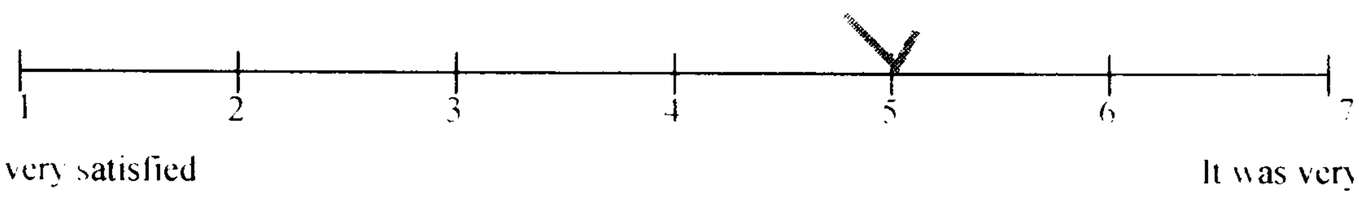
24. Taking a collective responcibility for a project



C. In order to measure the level of CFC (cross-functional collaboration) in your design development project.

Please, evaluate, according to the grading in each factor, the new design development situation related to your the latest completed design project.

For example)



1 Having a common culture (common language, common geographic and ethnological culture)	1 2 3 4 5 6 7 (little importance – extreme importance)
2. Proper organisation and flexible organisational culture for cross-functional collaboration	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
3. Equality of contribution	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
4. A mutual understanding of role and knowledge of other functional departments	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
5. Unified strategy and policy company from upstream to down stream	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
6. Sharing a common vision and values (corporate level)	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
7. Sharing unified goals & objectives of project (project level)	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
8. Informal social relationship with other functional group members	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
9.Trust and cohesion level between functional group members	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
10. Sense of belonging and cohesion between partners who belong to other functional department	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
11. Well developed management process and systems	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
12. Well planned schedule for product development	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
13.Well defined and organised design process	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
14. Joint rewards system rather than individual rewards system	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
15. Communication & information systems level (Support sufficient resource: hardware)	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)

16. Close physical location between other functional partners who belong to other functional department	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
17. Choosing partners who have good collaborative experience and/or good interpersonal relationships with you in other functional department	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
18. Choosing partners who have professional skills and knowledge about his/her area in other functional department	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
19. Management and coordination of activities from senior manager	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
20. Frequent & rapid monitoring of development progress	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
21. Good quality communication (information sharing) between other functional group partners	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
22. Frequent (quantitative) communication (information sharing) between other functional group partners	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
23. Work logically and rationally	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
24. Taking a collective responsibility for a project	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)

D. In order to measure the performance of design development and design management

There are four measurement items in metrics below, in order to measure the performance of design development and design management. Please give your mark dependant on the weight of importance of the latest design development project, which was the same as above project, (the total sum should be 100). Also, please evaluate your degree of satisfaction about the project of new design development in each factor, according to the grading

For example:

Measurement items	Weight of importance (the total sum should be 100)	Measurement scale (degree of satisfaction)
Time: (Actual time against plan)	**10**	1 2 3 4 5 6 7 (Very dissatisfied – Very satisfied)
Cost: (Actual cost against plan, Cost comparisons between competitive models)	**10**	1 2 3 4 5 6 7 (Very dissatisfied – Very satisfied)
Total Design output Quality (e.g. A fitness for objectives, Good appearance, Effectiveness of manufacturing, How easy to use, etc.)	**5**	1 2 3 4 5 6 7 (Very dissatisfied – Very satisfied)
Effectiveness and efficiency of design management.	**75**	1 2 3 4 5 6 7 (Very dissatisfied – Very satisfied)

Measurement items	Weight of importance (the total sum should be 100)	Measurement scale (degree of satisfaction)
Time: (Actual time against plan)		1 2 3 4 5 6 7 (Very dissatisfied – Very satisfied)
Cost: (Actual cost against plan, Cost comparisons between competitive models)		1 2 3 4 5 6 7 (Very dissatisfied – Very satisfied)
Total Design output Quality (e.g. A fitness for objectives, Good appearance, An effectiveness of manufacturing, How much easy to use, etc.)		1 2 3 4 5 6 7 (Very dissatisfied – Very satisfied)
Effectiveness and efficiency of design management.		1 2 3 4 5 6 7 (Very dissatisfied – Very satisfied)

Appendix 6: Questionnaire (third modified design-finial Version)

[Version One for a industrial (appearance) designer]

The information received from this questionnaire is only for use in a thesis which forms part of a Ph.D. in Design Management at Brunel University and for academic purposes.

1. Title:

A new model of cross-functional collaboration for new product design development in global consumer electronics firms

2. The main aims of the Questionnaire:

As a central aim, this research questionnaire has two main aims as follows.

The first aim is to discover and develop a conceptual definition and framework of significant contributory factors (issues) affecting CFC (cross-functional collaboration). These proposed conceptual models will inform what is important and what is less important to design managers and other managers who want to create a more collaborative environment in NPDD (New Product Design Development)

The second aim of this research is to produce a description of the correlation between the level of cross-functional relationship and the performance of product design development and design management.

What is CFC (cross-functional collaboration)?

1. To work jointly with other functional departments (groups) especially in an intellectual endeavour for a special purpose.
2. The unstructured, affective nature of interdepartmental relationships in functional departments (groups).

Supervisor: Mr. Ray Holland, Prof. Neville Stanton.
Advisor: Mr. Leslie Wynn
Researcher: Bum-Kyu Kang
Contact phone number: 44 – 01509 – 267 – 063;
Fax number: 82 (national number)-031(area number) -456-2477
Contact email address: bravo29@simmani.com / woodee4@hotmail.com

If you have any queries concerning this questionnaire, please contact BumKyu on the above contact phone number or email address.

3. Questionnaire:

A. In order to get general background information.

Question 1. Name of company?

Question 2. Which department do you belong to?

Question 3. Job title?

Question 4. How long have you been working as a specialist in your department?

Question 5.How long have you been working for this company?

B. In order to identify the priority of contributory factors affecting CFC (cross-functional collaboration) for product design development

From your experience, please give your grading about the degree of importance of each factor affecting cross-functional collaboration.
For example)

1. Little importance 2 3 4 5 6 7 extreme importance

* *Partner in this questionnaire means someone who not only belongs to other functional departments (groups) but also works jointly, especially in an intellectual capacity, for a special purpose. (For example, in the case of a designer, a marketer, an engineer, a manufacturer etc.)*

1 Having a common culture with partners. (e.g. having common geographical culture, having common ethnological culture,..)	1 little importance 2 3 4 5 6 7 extreme importance
2. Having a proper organisation (e.g. decentralised organisation,..) and a flexible organisational culture for cross-functional collaboration	1 little importance 2 3 4 5 6 7 extreme importance
3. Equality of contribution	1 little importance 2 3 4 5 6 7 extreme importance
4. Having a mutual understanding of the role and knowledge of other functional departments	1 little importance 2 3 4 5 6 7 extreme importance
5. Having a unified strategy and policy within company upstream and down stream	1 little importance 2 3 4 5 6 7 extreme importance
6. Sharing a common vision and values (corporate level)	1 little importance 2 3 4 5 6 7 extreme importance
7. Sharing a common goals & objectives (project level)	1 little importance 2 3 4 5 6 7 extreme importance

8. Having an informal social relationship with other functional group partners	1 2 3 4 5 6 7 (little importance – extreme importance)
9. Building trust and cohesion between functional group partners	1 2 3 4 5 6 7 (little importance – extreme importance)
10. Having a sense of belonging and cohesion between partners	1 2 3 4 5 6 7 (little importance – extreme importance)
11. Having a well developed management process and systems	1 2 3 4 5 6 7 (little importance – extreme importance)
12. Having a well planned schedule for product development	1 2 3 4 5 6 7 (little importance – extreme importance)
13. Having a well defined and organised design process	1 2 3 4 5 6 7 (little importance – extreme importance)
14. Having a joint rewards system rather than individual rewards system	1 2 3 4 5 6 7 (little importance – extreme importance)
15. Allocating sufficient resource (hardware)	1 2 3 4 5 6 7 (little importance – extreme importance)
16. Having a close physical location with partners	1 2 3 4 5 6 7 (little importance – extreme importance)
17. Choosing partners with whom there is a good collaborative experience and/or good interpersonal relationships	1 2 3 4 5 6 7 (little importance – extreme importance)
18. Choosing partners who have enough professional skills and knowledge within his/her own special area	1 2 3 4 5 6 7 (little importance – extreme importance)
19. Managing and coordinating of activities by senior manager	1 2 3 4 5 6 7 (little importance – extreme importance)
20. Monitoring development progress frequently and rapidly	1 2 3 4 5 6 7 (little importance – extreme importance)
21. Having good quality communication (information sharing) with other functional group partners	1 2 3 4 5 6 7 (little importance – extreme importance)
22. Having a frequent (quantitative) communication (information sharing) with other functional group partners	1 2 3 4 5 6 7 (little importance – extreme importance)
23. Working rationally and logically	1 2 3 4 5 6 7 (little importance – extreme importance)
24. Taking collective responsibility	

C. In order to measure the level of CFC (cross-functional collaboration) in your design development project.

Please, evaluate, according to the grading in each factor. the new design development situation related to your the latest completed design project.

For example)

1 2 3 4 5 6 7

It was not very satisfied — It was very satisfied

1 Having a common culture with partners. (e.g. having common geographical culture. having common ethnological culture...)	1 2 3 4 5 6 7 (It was not very satisfied — Very satisfied)
2. Having a proper organisation (e.g. decentralised organisation,..) and a flexible organisational culture for cross-functional collaboration	1 2 3 4 5 6 7 (It was not very satisfied — Very satisfied)
3. Equality of contribution	1 2 3 4 5 6 7 (It was not very satisfied — Very satisfied)
4. Having a mutual understanding of the role and knowledge of other functional departments	1 2 3 4 5 6 7 (It was not very satisfied — Very satisfied)
5. Having a unified strategy and policy within company upstream and down stream	1 2 3 4 5 6 7 (It was not very satisfied — Very satisfied)
6. Sharing a common vision and values (corporate level)	1 2 3 4 5 6 7 (It was not very satisfied — Very satisfied)
7. Sharing a common goals & objectives of project (project level)	1 2 3 4 5 6 7 (It was not very satisfied — Very satisfied)
8. Having an informal social relationship with other functional group partners	1 2 3 4 5 6 7 (It was not very satisfied — Very satisfied)
9. Building trust and cohesion between functional group partners	1 2 3 4 5 6 7 (It was not very satisfied — Very satisfied)
10. Having a sense of belonging and cohesion between partners	1 2 3 4 5 6 7 (It was not very satisfied — Very satisfied)
11. Having a well developed management process and systems	1 2 3 4 5 6 7 (It was not very satisfied — Very satisfied)
12. Having a well planned schedule for product development	1 2 3 4 5 6 7 (It was not very satisfied — Very satisfied)
13. Having a well defined and organised design process	1 2 3 4 5 6 7 (It was not very satisfied — Very satisfied)
14. Having a joint rewards system rather than individual rewards system	1 2 3 4 5 6 7 (It was not very satisfied — Very satisfied)

15. Allocating sufficient resource (hardware)	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
16. Having a close physical location with partners	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
17. Choosing partners with whom there is a collaborative experience and/or good interpersonal relationships	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
18. Choosing partners who have enough professional skills and knowledge within his/her own special area	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
19. Managing and coordinating of activities by senior manager	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
20. Monitoring development progresses frequently and rapidly	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
21. Having good quality communication (information sharing) with other functional group partners	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
22. Having frequent (quantitative) communication (information sharing) with other functional group partners	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
23. Working rationally and logically	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)
24. Taking collective responsibility for a project	1 2 3 4 5 6 7 (It was not very satisfied – Very satisfied)

D. In order to measure the performance of design development and design management

There are four measurement items in metrics below. In order to measure the performance of design development and design management, please give your mark dependent on the weight of importance of your latest design development project (the one considered in C-section). The total sum should be 100. Also, please indicate the level of satisfaction with the project in related to each factor, using the grading system.

For example:

Measurement items	Weight of importance (the total sum should be 100)	Measurement scale (degree of satisfaction)
Time: (Actual time against plan)	**10**	1 Very dissatisfied 2 3 4 5 6 7 Very satisfied
Cost: (Actual cost against plan, Cost comparisons between competitive models)	**10**	1 Very dissatisfied 2 3 4 5 6 7 Very satisfied
Total Design output Quality (e.g. A fitness for objectives, Good appearance, Effectiveness of manufacturing, How easy to use, etc.)	**5**	1 Very dissatisfied 2 3 4 5 6 7 Very satisfied
Effectiveness and efficiency of design management.	**75**	1 Very dissatisfied 2 3 4 5 6 7 Very satisfied

Measurement items	Weight of importance (the total sum should be 100)	Measurement scale (degree of satisfaction)
Time: (Actual time against plan)		1 Very dissatisfied 2 3 4 5 6 7 Very satisfied
Cost: (Actual cost against plan, Cost comparisons between competitive models)		1 Very dissatisfied 2 3 4 5 6 7 Very satisfied
Total Design output Quality (e.g. A fitness for objectives, Good appearance, An effectiveness of manufacturing, How much easy to use, etc).		1 Very dissatisfied 2 3 4 5 6 7 Very satisfied
Effectiveness and efficiency of design management.		1 Very dissatisfied 2 3 4 5 6 7 Very satisfied

Appendix 7: Questionnaire (Korean Version)

설문지

[Version One-디자인 부서 소속의 사람만, 이 설문지에 답해 주시기 바랍니다]

본 설문지는 영국 Brunel 대학, Design Management 박사 논문을 위한 것이며, 학술적인 목적 이외에는 사용되지 않을 것입니다.

1. 논문 주제:
A new model of cross-functional collaboration for a new product design development in global consumer electronics firms.

2. 설문 목적.
신제품 디자인 개발시 타 기능 부서와의 협력 관계에 영향을 미치는 요소의 정의와 그 요소들의 중요치를 설명하는 개념적 모델 개발.
디자인 부서와 타 기능 부서 사이의 협력 관계와 신제품 디자인 개발 성과(performance) 간의 관련성의 설명.

타 부서와의 협력에 대한 정의: 다른 기능부서(group)와 특정한 목표를 위해 공식, 특히 비공식적으로 함께 노력 하는 것

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3. 설문 내용

A. 설문 대상자의 기본정보를 위한 질문들.

질문 1. 회사 이름은?

질문 2. 근무 부서는 어디입니까?

질문 3. 직책명 (직급)은 무엇입니까?

질문 4. 당신은 현재의 분야에서 몇 년의 경력을 가지고 계십니까?

질문 5. 이 회사에서는 몇 년을 일하고 계십니까?

B. 제품 디자인 개발시, 타 부서와의 협력 관계에 영향을 미치는 요인 (issues)들의 중요성의 정도를 알기 위한 문항들입니다.

아래 24 개 문항은 타 부서와의 협력 관계에 영향을 미치는 요인들입니다. 당신의 경험을 바탕으로 그 중요성의 정도를 각각의 요인(issues)들에 V 표 해 주시기 바랍니다.

보기)

1. 약간 중요하다. 2 3 4 5 6 7. 매우 중요하다.

*이 설문지에서의 Partner 의 의미는 타 관련부서의 소속원으로 특별한 업무 목적을 위해 함께 협력을 해 나가는 타부서의 담당자를 의미 합니다. (예를 들면, 디자이너의 경우, 마케터, 엔지니어, 생산 기술 담당자들,...)

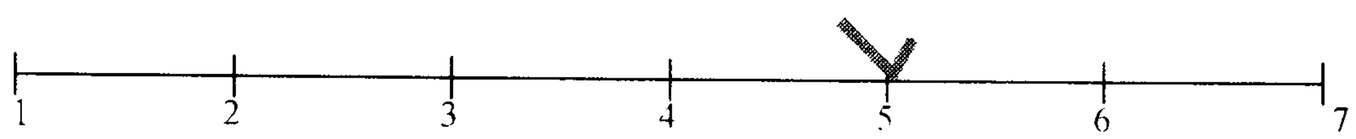
1 협력부서 partner 와의 단일화된 기업 문화 (예: 지역문화와 인종적, 국가적 문화 공유)	1 2 3 4 5 6 7 (약간 중요 ~ 매우 중요)
2. 협력에 적합한 조직 형태와 조직 문화 (예: 유연한 조직, 분권화된 조직,...)	1 2 3 4 5 6 7 (약간 중요 ~ 매우 중요)
3. 협력 부서 사이의 동등한 업무 기여를 위한 노력.	1 2 3 4 5 6 7 (약간 중요 ~ 매우 중요)
4. 상대 부서의 기본적 업무 성격과 역할에 대한 이해	1 2 3 4 5 6 7 (약간 중요 ~ 매우 중요)
5. 상위 부서 (Top manager)로부터 하위 부서까지의 단일화된 전략과 정책의 공유	1 2 3 4 5 6 7 (약간 중요 ~ 매우 중요)
6. 회사 전체의 비전과 가치를 타 부서와 함께 공유하는 정도	1 2 3 4 5 6 7 (약간 중요 ~ 매우 중요)
7. 각 제품 개발 프로젝트의 목적을 타 부서와 함께 공유하는 정도	1 2 3 4 5 6 7 (약간 중요 ~ 매우 중요)
8. 타 부서 (혹은 부서원)와의 비공식적 우호적 유대관계	1 2 3 4 5 6 7 (약간 중요 ~ 매우 중요)

9. 타 부서원 (partner)과의 신뢰 정도	1 2 3 4 5 6 7 (약간 중요)
10. 타 부서원 (Partner)과의 공동체 의식과 단결 의지에 대한 정도	1 2 3 4 5 6 7 (약간 중요)
11. 잘 개발 되어진 회사 전체의 management process 와 Systems	1 2 3 4 5 6 7 (약간 중요, 매우 중요)
12. 잘 계획되어진 제품 개발 Schedule	1 2 3 4 5 6 7 (약간 중요)
13. 잘 정의되어진 디자인 개발 process.	1 2 3 4 5 6 7 (약간 중요, 매우 중요)
14. 개인과 개별 부서 중심보다는 공동 보상제도 (예, Project 별 보상제도)	1 2 3 4 5 6 7 (약간 중요, 매우 중요)
15. 회사 내의 Communication과 정보 교환 System 시설의 level (Hardware 측면)	1 2 3 4 5 6 7 (약간 중요, 매우 중요)
16. 상호 협력 부서와의 가까운 지역적 위치 (가능하면 같은 지역, 같은 빌딩, 같은 층)	1 2 3 4 5 6 7 (약간 중요, 매우 중요)
17. 타 부서의 담당자를 개인적으로 상호 좋은 인간 관계를 가지고 있는 사람의 선택	1 2 3 4 5 6 7 (약간 중요, 매우 중요)
18. 전문 업무 지식과 기술이 풍부한 타 부서의 사람을 partner 로 선택	1 2 3 4 5 6 7 (약간 중요, 매우 중요)
19. 제품 개발 책임 메니져로부터의 관리 지원과 조율(coordination)	1 2 3 4 5 6 7
20. 주기적이며 빠른 디자인 개발 과정의 모니터링.	little important 1 2 3 4 5 6 7 extremely important
21. 타 부서와의 상호 질적 (quality) 커뮤니케이션과 정보교환(예, 옳은 정보, 효율적 커뮤니케이션, 고급 정보의 교환)	little important 1 2 3 4 5 6 7 extremely important
22. 타 부서와의 상호 많은 양의 (quantitative) 커뮤니케이션과 정보 교환	little important 1 2 3 4 5 6 7 extremely important (약간 중요, 매우 중요)
23. 합리적 스타일의 업무진행	1 2 3 4 5 6 7
24. Project 에 대한 공동 책임 의식	little important 1 2 3 4 5 6 7 extremely important (약간 중요, 매우 중요)

C. 타 기능 부서와의 협력 관계의 정도와 제품 디자인 성과 (performance) 간의 관계를 알아보기 위한 '타 기능 부서와의 협력 관계 정도'를 묻는 문항들입니다.

최근 마지막 이루어진 신제품 디자인 개발시, 각 요소들에 대해 어떠한 환경 하에서 제품 디자인 개발이 이루어졌는지 평가해 주시기 바랍니다.

보기)



1 협력부서 partner 와의 단일화된 기업 문화 (예: 지역문화와 인종적, 국가적 문화 공유)	
2. 협력에 적합한 조직 형태와 조직 문화를 취하고 있었다 (예: 유연한 조직, 분권화된 조직,...)	
3. 협력 부서 사이의 동등한 업무기여를 위한 노력이 이루어졌었다	
4. 상대 부서의 기본적 업무 성격과 역할에 대한 이해를 하고 있었다	
5. 상위 부서 (Top manager)로부터 하위 부서까지의 단일화된 전략과 정책을 공유했다	
6. 회사 전체의 비전과 가치를 타 부서와 충분히 공유하고 있었다.	
7. 각 제품 개발 프로젝트의 목적을 타부서와 공유하고 있었다	
8. 타 부서 (partner 부서 혹은 부서원)와의 비공식적 우호적 유대 관계가 깊다	
9. 타 부서원 (partner)과의 신뢰 정도가 높다	
10. 타 부서원 (partner)과의 공동체 의식과 단결의식이 강했다	
11. 잘 개발 되어진 회사 전체의 management process 와 System 을 갖추고 있었다	
12. 잘 계획 되어진 제품 개발 Schedule 을 가지고 있었다	
13. 잘 정의 되어진 디자인 개발 process 를 가지고 있었다	
14. 개별 부서나 개인보다는 공동 보상제도를 가지고 있었다	
15. 회사내의 Communication과 정보 교환 Hardware system 이 잘 가추어져 있었다	

16. 상호 협력 부서와의 지역적 위치가 매우 가까웠다	1 2 3 4 5 6 7
17. 타 부서의 담당자가 개인적으로 상호 좋은 인간 관계를 가지고 있는 사람이였다	1 2 3 4 5 6 7
18. 타 부서의 담당자가 전문 업무 지식과 기술이 풍부한 사람이였다	1 2 3 4 5 6 7
19. 제품 개발 책임 메니져로부터의 관리지원과 조율(coordination)이 충분히 있었다.	1 2 3 4 5 6 7
20. 주기적이고, 빠른 디자인 개발 과정의 모니터링이 있었다.	1 2 3 4 5 6 7
21. 타 부서와의 상호 질적 (quality) 커뮤니케이션과 정보 교환이 있었다 (예, 옳은 정보, 고급 정보의 교환 등)	1 2 3 4 5 6 7
22. 타 부서와의 상호 많은 양의 (quantitative) 커뮤니케이션과 정보 교환이 있었다	1 2 3 4 5 6 7
23. 합리적인 업무진행이 이루어 졌다.	1 2 3 4 5 6 7
24. 타 부서와의 Project 에 대한 공동 책임 의식이 강했다	1 2 3 4 5 6 7

D. 타 기능 부서와의 협력 관계의 정도와 제품 디자인 성과(Product Design Performance) 간의 관계를 알아보기 위한 '제품 디자인 성과(Product Design performance)'를 묻는 문항들입니다.

최근 마지막 이루어진 신제품 디자인 개발시, 각 요소들에 대해 어떠한 결과가 있었는지 평가해 주시기 바랍니다. 또한 전체 제품 디자인 성과(Product Design performance)를 100으로 할 때, 도표 안의 4가지 제품 디자인을 위한 성과평가 척도 사이에 가중치(중요도) 정도를 점수로 기입해 주시기 바랍니다. (합이 100이 되어야 합니다)

보기 (예제):

성과평가 척도(Items for performance evaluations)	가중치 (총합: 100)	의미 공간상의 만족도
1.예정되었던 시간 안에 디자인 개발이 이루어졌다.	10	1 2 3 4 5 6 7 (전혀 그렇지 않았다 ~ 매우 그러했다)
2.디자인 개발 비용이 예정된 범위 안에서 집행되었다	10	1 2 3 4 5 6 7 (전혀 그렇지 않았다 ~ 매우 그러했다)
3.디자인 개발(quality)이 성공적으로 이루어졌다. (조형성, 합목적성, 경제성, 제작성 등)	5	1 2 3 4 5 6 7 (전혀 그렇지 않았다 ~ 매우 그러했다)
4. 디자인 진행이 효율적이며 효과적으로 이루어졌다. (예: 불필요한 feedback 과정이 없었다)	75	1 2 3 4 5 6 7 (전혀 그렇지 않았다 ~ 매우 그러했다)

성과평가 척도(Items for performance evaluations)	가중치 (총합: 100)	의미 공간상의 만족도
1.예정되었던 시간 안에 디자인 개발이 이루어졌다.		1 2 3 4 5 6 7 (전혀 그렇지 않았다 ~ 매우 그러했다)
2.디자인 개발 비용이 예정된 범위 안에서 집행되었다		1 2 3 4 5 6 7 (전혀 그렇지 않았다 ~ 매우 그러했다)
3.디자인 개발(quality)이 성공적으로 이루어졌다. (조형성, 합목적성, 경제성, 제작성 등)		1 2 3 4 5 6 7 (전혀 그렇지 않았다 ~ 매우 그러했다)
4. 디자인 진행이 효율적이며 효과적으로 이루어졌다. (예: 불필요한 feedback 과정이 없었다		1 2 3 4 5 6 7 (전혀 그렇지 않았다 ~ 매우 그러했다)

Appendix 8: Questionnaire (Japanese Version)

アンケート

[Version One-デザイン部署所属の人だけ、このアンケートに答えてください。]

本アンケートはイギリスの Brunel 、 Design Management 博士の論文のためのものであり、学術的目的以外には使用しません。

1. 論文主題:
A new model of cross-functional collaboration for a new product design development in global consumer electronics firms.

2. アンケート目的
   a. 新製品デザイン開発時、他機能部署との協力関係に影響を及ぼす要素の定義とその要素の重要値を説明する概念的モデル開発。
   b. デザイン部署と他機能部署との協力関係と新製品デザイン開発成果(performance) 間の関連性の説明。

他部署との協力に対する定義: 他の機能部署(group)と特定の目標のため公式、特に非公式的に共に努力すること。

Supervisors: Mr. Ray Holland, Prof. Neville Stanton

Adviser: Mr. Leslie Wynn

Researcher: カン. ポンギュ

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容　　3. アンケ□

象者の基A本情報のための質問

質問 1. 会社名は?

質問 2. 勤務部署はどこですか?

質問 3. 職責名 (職級)は何ですか?

質問 4. あなたは現在の分野で何年の経歴をお持ちですか?

質問 5. この会社で何年働いていますか?

B. 製品デザイン開発時、他部署との協力関係に影響を及ぼす要因 (issues) の重要性の程度を知る為の項目です。

下の 24 個の項目は他部署との協力関係に影響を及ぼす要因です。あなたの経験を土台にその 重要性の程度 を各々の要因(issues)に V で表示してください。

表示)

1. 若干重要だ.　2　3　4　5　6　7. 非常に重要だ.

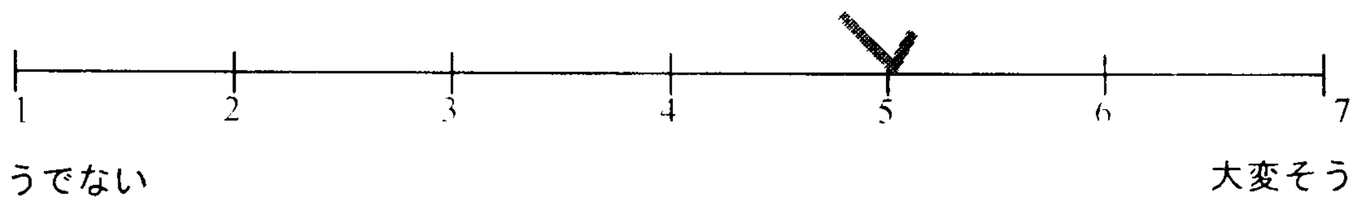
*このアンケートでの Partner の意味は他関連部署の所属員として特別な業務目的のため共に協力をしていく他部署の担当者を意味します。 (例えばデザイナーの場合、マーケター、エンジニア、生産技術担当者達..)

1 協力部署 partner との単一化された企業文化 (例: 地域文化と人種的、国家的文化共有)	1 若干重要 2 3 4 5 6 7 大変重要
2. 協力に適合した組織形態と組織文化 (例: 柔軟な組織、分権化された組織、..)	1 若干重要 2 3 4 5 6 7 大変重要
3. 協力部署間の同等な業務寄与のための努力。	1 若干重要 2 3 4 5 6 7 大変重要
4. 相手部署の基本的業務性格と役割に対する理解	1 若干重要 2 3 4 5 6 7 大変重要
5. 上位部署 (Top manager) から下位部署までの単一化された戦略と政策の共有	1 若干重要 2 3 4 5 6 7 大変重要
6. 会社全体のビジョンと価値を他部署と共に共有する程度	1 若干重要 2 3 4 5 6 7 大変重要
7. 各製品開発プロジェクトの目的を他部署と共に共有する程度	1 若干重要 2 3 4 5 6 7 大変重要
8. 他部署 (或いは部署員) との非公式的友好的紐帯関係	1 若干重要 2 3 4 5 6 7 大変重要
9. 他部署員 (partner) との信頼程度	1 若干重要 2 3 4 5 6 7 大変重要

10. 他部署員 (Partner) との 共同体意識と 団結意志に対する程度	1 2 3 4 5 6 7 (若干重要 / 大変重要)
11. よく開発する会社全体の management process と Systems	1 2 3 4 5 6 7 (若干重要 / 大変重要)
12. よく計画された製品開発 Schedule	1 2 3 4 5 6 7 (若干重要 / 大変重要)
13. よく定義されたデザイン開発 process.	1 2 3 4 5 6 7 (若干重要 / 大変重要)
14. 個人と個別部署中心より 共同報償制度 (例、 Project 別報償制度)	1 2 3 4 5 6 7 (若干重要 / 大変重要)
15. 会社内の Communicationと 情報交換 System 施設の level (Hardware 側面)	1 2 3 4 5 6 7 (若干重要 / 大変重要)
16. 相互協力部署との 近い地域的位置 (可能ならば同じ地域、同じビル、同じ階)	1 2 3 4 5 6 7 (若干重要 / 大変重要)
17. 他部署の担当者を個人的に 相互いい人間関係を持っている 人の選択	1 2 3 4 5 6 7 (若干重要 / 大変重要)
18. 専門業務知識と技術が豊富な 他部署の人を partner に選択	1 2 3 4 5 6 7 (若干重要 / 大変重要)
19. 製品開発責任マネージャーからの 管理支援と調律(coordination)	1 2 3 4 5 6 7 (若干重要 / 大変重要)
20. 周期的で早いデザイン開発 過程のモニターリング	1 2 3 4 5 6 7 (若干重要 / 大変重要)
21. 他部署との相互質的 (quality) コミュニケーションと情報交換(例、正しい 情報、効率的ｺﾐｭﾆｹｰｼｮﾝ、高級情報の交換)	1 2 3 4 5 6 7 (若干重要 / 大変重要)
22. 他部署との相互多い量の (quantitative) コミュニケーションと情報交換	1 2 3 4 5 6 7 (若干重要 / 大変重要)
23. 合理的スタイルの業務進行	1 2 3 4 5 6 7 (若干重要 / 大変重要)
24. Project に対する共同責任意識	1 2 3 4 5 6 7 (若干重要 / 大変重要)

C. 他機能部署との協力関係の程度と製品デザイン成果 (performance)間の関係を知るため、他機能部署との協力関係程度を問う項目です。
最近行われた新製品デザイン開発時、各要素に対しどのような環境下で製品デザイン開発が行われたか評価してください。

表示）



1 単一化された企業文化	1 2 3 4 5 6 7 (全くそうでない / 大変そうだった)
2. 協力に適合した組織形態と組織文化を取っていた (例: 柔軟な組織、分権化された組織、..)	1 2 3 4 5 6 7 (全くそうでない / 大変そうだった)
3. 協力部署間の同等な業務寄与のための努力が成されていた	1 2 3 4 5 6 7 (全くそうでない / 大変そうだった)
4. 相手部署の基本的業務性格と役割に対する理解をしていた	1 2 3 4 5 6 7 (全くそうでない / 大変そうだった)
5. 上位部署 (Top manager)から下位部署までの単一化された戦略と政策を共有した	1 2 3 4 5 6 7 (全くそうでない / 大変そうだった)
6. 会社全体のビジョンと価値を他部署と充分に共有していた。	1 2 3 4 5 6 7 (全くそうでない / 大変そうだった)
7. 各製品開発プロジェクトの目的を他部署と共有していた	1 2 3 4 5 6 7 (全くそうでない / 大変そうだった)
8. 他部署 (partner部署または部署員)との非公式的友好的紐帯関係が深い	1 2 3 4 5 6 7 (全くそうでない / 大変そうだった)
9. 他部署員 (partner)との信頼程度が高い	1 2 3 4 5 6 7 (全くそうでない / 大変そうだった)
10. 他部署員 (partner)との共同体意識と団結意識が強かった	1 2 3 4 5 6 7 (全くそうでない / 大変そうだった)
11. よく開発された会社全体の management process と System を持っていた	1 2 3 4 5 6 7 (全くそうでない / 大変そうだった)
12. よく計画された製品開発 Schedule を持っていた	1 2 3 4 5 6 7 (全くそうでない / 大変そうだった)
13. よく定義されたデザイン開発 process を持っていた	1 2 3 4 5 6 7 (全くそうでない / 大変そうだった)
14. 開発部署や個人より共同報償制度を持っていた	1 2 3 4 5 6 7 (全くそうでない / 大変そうだった)
15. 会社内の Communicationと情報交換 Hardware system がよく整っていた	1 2 3 4 5 6 7 (全くそうでない / 大変そうだった)
16. 相互協力部署との地域的位置が大変近かった	1 2 3 4 5 6 7 (全くそうでない / 大変そうだった)

17. 他部署の担当者が個人的に相互いい人間関係をもっている人だった	1 2 3 4 5 6 7 全くそうでない　大変そうだった
18. 他部署の担当者が 専門業務知識と技術が豊富な人だった	1 2 3 4 5 6 7 全くそうでない　大変そうだった
19. 製品開発責任マネージャーの管理支援と調律(coordination)が充分にあった	1 2 3 4 5 6 7 全くそうでない　大変そうだった
20. 周期的で早いデザイン開発過程のモニターリングがあった	1 2 3 4 5 6 7 全くそうでない　大変そうだった
21. 他部署との相互質的 (quality) コミュニケーションと情報交換があった (例、正しい情報、高級情報の交換等)	1 2 3 4 5 6 7 全くそうでない　大変そうだった
22. 他部署との相互多くの量の (quantitative) コミュニケーションと情報交換があった	1 2 3 4 5 6 7 全くそうでない　大変そうだった
23. 合理的な業務進行だった	1 2 3 4 5 6 7 全くそうでない　大変そうだった
24. 他部署との Project に対する共同責任意識が強かった	1 2 3 4 5 6 7 全くそうでない　大変そうだった

D. 他機能部署との協力関係の程度と製品デザイン成果(Product Design Performance)間の関係を知る為 '製品デザイン成果(Product Design performance)'を尋ねる項目です。

最近行われた新製品デザイン開発時、各要素に対しどのような結果があったか評価してください。また全体製品デザイン成果(Product Design performance)を 100 とすると図表内の 4 つの製品デザインのための成果の評価程度間に加重値(重要度)程度を点数で記入してください。(合計が 100 にならなければなりません)

(例題):

成果評価尺度 (Items for performance evaluations)	加重値 (総合: 100)	意味空間性の満足度
1.予定された時間内に デザイン開発が なされた。	10	1 2 3 4 5 6 7 全くそうでない 大変そうたった
2.デザイン開発費用が 予定の範囲内で 行われた。	10	1 2 3 4 5 6 7 全くそうでない 大変そうたった
3.デザイン開発(quality)が 成功的になされた。 (造形性、合目的性、 経済性、製作性、等)	5	1 2 3 4 5 6 7 全くそうでない 大変そうたった
4. デザイン執行が効率的 で効果的に成された。 (例:不必要な feedback 過程が なかった。)	75	1 2 3 4 5 6 7 全くそうでない 大変そうたった

成果評価尺度 (Items for performance evaluations)	加重値 (総合: 100)	意味空間性の満足度
1.予定された時間内に デザイン開発が 成された。		1 2 3 4 5 6 7 全くそうでない 大変そうたった
2.デザイン開発費用が 予定の範囲内で 行われた。		1 2 3 4 5 6 7 全くそうでない 大変そうたった
3.デザイン開発(quality)が 成功的に成された。 (造形性、合目的性、 経済性、製作性等)		1 2 3 4 5 6 7 全くそうでない 大変そうたった
4. デザイン執行が効率的 で効果的に成された。 (例:不必要な feedback 過程が なかった。		1 2 3 4 5 6 全くそうでない 大変そうたった

Appendix 9: Agenda for interview with design managers in order to test the usability of the framework model

1. Propose

This interview is designed to test the usability of the framework model (information) of CFC (Cross-Functional Collaboration) for design development of consumer electronics products.

2. Explanation of the framework model of CFC

This final framework model shows condensed information of this research work in a visual diagram. This model mainly shows the information below:

1. The priority of importance of contributory factors affecting CFC in new design development of consumer electronics products.
2. Contributory factors (issues) affecting design development performance in new design development of consumer electronics products.
   - 2.1 Contributory factors affecting total design development performance, which was assessed using the sum of each weighted measurement item below.
   - 2.2 Contributory factors affecting the time of design development performance
   - 2.3 Contributory factors affecting the cost of design development performance
   - 2.4 Contributory factors affecting the quality performance of design output.
   - 2.5 Contributory factors affecting the effectiveness and efficiency of design management performance

3. Questions

3.1 To what extent does this theoretical model support and challenge existing thinking in your organisation

3.2 Which areas in relation to CFC(Cross-Functional Collaboration) need to be changed in your company: Base your answers on the factors in the model?

3.3 Please comment on the relative values attributed to other factors.

3.4 How can this theoretical model be used to improve practice in order to enhance CFC (Cross-Functional Collaboration) for the design development?

3.4 Do you have any comments on the results which are shown in the proposed new model of CFC?

Appendix 10 Result of Factor Analysis (Rotated Component Matris:Varimax with Kaiser Normalisation)

	Component						
	1	2	3	4	5	6	7
12.Well planned schedule for product development	.640						
19.Management and coordinatin of activities from senior manager	.640						
20.Frequent and rapid monitoring of progress	.639						
13.Well defined and organised design process	.620						
11.Well developed management process & systems	.619						
4.Mutual understanding of role and knowledge of partner's departments		.629					
2.Proper oranisation & flexible organisational culture for CFC		.591				.447	
3.Equality of contribution & benefit		.554					
21.Good quality communication (information sharing) between other functional group partners		.534					
14.Joint rewards system than individual rewards system			.643				
22.Frequent (quantitative) communication (information sharing) between other functional group partners			.605				
16.Close physical location between other functional group partners			.526				
23.Work logically and rationally			.481				
15.Conmunication and information hardware system level			.446				
9.Trust level between functional group partners				.822			
8.Informal social relationship with other functional group partners				.740			
10.Having a sence of belonging & cohesion			.411	.638			
6.Sharing a common vision & values (company level)					.751		
5.Unified strategy & policy company from up stream to down stream					.622		
24.Have a responsibilities about a project			.460		.470		
7.Share unified goals & objectives of project							
1.Unified culture						.794	
17.Choosing partners who have a good interpersonal relationship with you and good experience of CFC							.788
18.Choosing partners who have professional skills and knowledge about his/her area				.492			.518

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a Rotation converged in 15 iterations.

Appendix 11 Result of Factor Analysis (Total Variance Explained)

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Compo-nent	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.331	18.047	18.047	4.331	18.047	18.047	2.710	11.292	11.292
2	2.701	11.254	29.301	2.701	11.254	29.301	2.199	9.161	20.453
3	1.466	6.109	35.410	1.466	6.109	35.410	2.173	9.055	29.509
4	1.342	5.590	40.999	1.342	5.590	40.999	1.970	8.209	37.717
5	1.269	5.289	46.289	1.269	5.289	46.289	1.771	7.378	45.095
6	1.213	5.054	51.343	1.213	5.054	51.343	1.314	5.473	50.569
7	1.055	4.395	55.738	1.055	4.395	55.738	1.241	5.169	55.738
8	.992	4.135	59.873						
9	.935	3.895	63.767						
10	.891	3.713	67.480						
11	.851	3.544	71.024						
12	.760	3.167	74.190						
13	.739	3.078	77.269						
14	.723	3.015	80.283						
15	.713	2.972	83.255						
16	.595	2.480	85.735						
17	.562	2.340	88.076						
18	.500	2.083	90.159						
19	.472	1.965	92.124						
20	.464	1.933	94.057						
21	.394	1.642	95.700						
22	.376	1.565	97.265						
23	.372	1.548	98.813						
24	.285	1.187	100.000						

Extraction Method: Principal Component Analysis

Appendix 12 Group statistics between a design group and a non-design group based on each factor affecting CFC

	Designers versus Non-designers	N	Mean	Std. Deviation	Std. Error Mean
1.Unified culture	Designer's group	110	4.35	1.33	.13
	Non-designer's group	131	4.08	1.56	.14
2.Having a proper organisation and a flexible organisational culture for CFC	Designer's group	109	5.44	1.17	.11
	Non-designer's group	133	5.39	1.15	9.951E-02
3.Equality of contribution	Designer's group	108	5.19	1.24	.12
	Non-designer's group	133	4.89	1.25	.11
4.Having a mutual understanding of roles and knowledge of partners' departments and/or partner	Designer's group	110	5.42	1.20	.11
	Non-designer's group	133	5.13	1.14	9.86E-02
5.Having a unified strategy and company policy upstream and down stream	Designer's group	110	5.19	1.32	.13
	Non-designer's group	133	4.88	1.26	.11
6.Sharing a common vision and values (corporate level)	Designer's group	110	5.06	1.15	.11
	Non-designer's group	133	4.98	1.29	.11
7.Sharing unified goals & objectives (project level)	Designer's group	110	5.69	1.18	.11
	Non-designer's group	133	5.61	1.10	9.541E-02
8.Having an informal social relationship (or system) with other functional group members	Designer's group	110	4.68	1.35	.13
	Non-designer's group	133	4.98	1.38	.12
9. Building trust between functional group partners	Designer's group	110	5.45	1.19	.11
	Non-designer's group	133	5.58	1.21	.10
10. Having a sense of belonging and cohesion	Designer's group	110	4.82	1.26	.12
	Non-designer's group	133	5.23	1.13	9.821E-02
11. Having well-developed management processes and systems	Designer's group	110	4.85	1.14	.11
	Non-designer's group	133	4.53	1.33	.12
12. Having a well-planned schedule for product development	Designer's group	110	4.93	1.11	.11
	Non-designer's group	133	4.46	1.20	.10
13. Having a well-defined and organised design process	Designer's group	110	5.13	1.17	.11
	Non-designer's group	133	4.62	1.17	.10
14.Having a joint rewards system rather than individual rewards system	Designer's group	110	4.27	1.35	.13
	Non-designer's group	133	4.80	1.18	.10
15. Allocating sufficient resources (hardware)	Designer's group	110	5.13	1.06	.10
	Non-designer's group	133	4.94	1.24	.11
16.Having a close location between other functional partners	Designer's group	110	5.16	1.26	.12
	Non-designer's group	133	5.36	1.24	.11
17.Choosing partners with whom there is a good interpersonal relationship	Designer's group	110	4.80	1.23	.12
	Non-designer's group	133	4.98	1.08	9.361E-02
18.Choosing partners who have professional skills and knowledge within his/her area	Designer's group	110	5.33	1.11	.11
	Non-designer's group	133	4.94	1.14	9.881E-02
19.Managing and coordinating activities by senior manager	Designer's group	110	4.51	1.24	.12
	Non-designer's group	132	3.80	1.31	.11
20. Monitoring progress frequently and rapidly	Designer's group	110	4.47	1.13	.11
	Non-designer's group	131	4.29	1.20	.10
21.Having good quality communication (information sharing) with other functional group partners	Designer's group	110	5.53	1.08	.10
	Non-designer's group	132	5.40	1.12	9.791E-02
22.Having a frequent (quantitative) communication (information sharing) with other functional group partners	Designer's group	109	5.00	1.11	.11
	Non-designer's group	132	5.14	1.21	.11

23. Working rationally and logically	Designer's group 109	5.26	1.15	.11
	Non-designer's group 132	5.17	1.32	.12
24. Having collective responsibility for a project	Designer's group 110	5.58	1.08	.10
	Non-designer's group 132	5.94	1.08	9.36E-02

Appendix 13 Independent T-test: between a design group and a non-design group based on each factor affecting CFC

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
1.Unified culture	Equal variances assumed	1.895	.170	1.424	239	.156	.27	.19	-.10	.64
	Equal variances not assumed			1.444	238.948	.150	.27	.19	-9.79E-02	.64
2. A proper organisation	Equal variances assumed	.009	.923	.330	240	.742	4.94E-02	.15	-.25	.34
	Equal variances not assumed			.329	228.604	.742	4.94E-02	.15	-.25	.35
3.Equality of	Equal variances assumed	.080	.777	1.906	239	.058	.31	.16	-1.04E-02	.62
	Equal variances not assumed			1.907	229.365	.058	.31	.16	-1.03E-02	.62
4.Mutual understa	Equal variances assumed	1.044	.308	1.932	241	.054	.29	.15	-5.62E-03	.59
	Equal variances not assumed			1.923	227.543	.056	.29	.15	-7.20E-03	.59
5.Unified strategy	Equal variances assumed	.017	.896	1.877	241	.062	.31	.17	-1.55E-02	.64
	Equal variances not assumed			1.869	228.548	.063	.31	.17	-1.69E-02	.64
6.Sharing common	Equal variances assumed	1.770	.185	.498	241	.619	7.87E-02	.16	-.23	.39
	Equal variances not assumed			.503	239.425	.615	7.87E-02	.16	-.23	.39
7.Sharing unified	Equal variances assumed	1.036	.310	.559	241	.577	8.19E-02	.15	-.21	.37
	Equal variances not assumed			.556	225.792	.579	8.19E-02	.15	-.21	.37
8.Informal socia	Equal variances assumed	.136	.713	-1.677	241	.095	-.30	.18	-.64	5.16E-02
	Equal variances not assumed			-1.681	234.690	.094	-.30	.18	-.64	5.07E-02
9.A trust level	Equal variances assumed	.019	.891	-.804	241	.422	-.12	.15	-.43	.18
	Equal variances not assumed			-.805	233.480	.422	-.12	.15	-.43	.18
10.Sence of belonging	Equal variances assumed	.755	.386	-2.655	241	**.008**	-.41	.15	-.71	-.11
	Equal variances not assumed			-2.629	221.828	**.009**	-.41	.15	-.71	-.10
11.Well developed	Equal variances assumed	3.762	.054	2.042	241	**.042**	.33	.16	1.16E-02	.64
	Equal variances not assumed			2.072	240.666	**.039**	.33	.16	1.62E-02	.64
12.Well planned schedule	Equal variances assumed	5.030	.026	3.144	241	**.002**	.47	.15	.17	.76
	Equal variances not assumed			3.167	237.992	**.002**	.47	.15	.18	.76
13.Well defined an	Equal variances assumed	.289	.592	3.330	241	**.001**	.50	.15	.21	.80
	Equal variances not assumed			3.329	232.353	**.001**	.50	.15	.21	.80
14.Joint rewards	Equal variances assumed	.931	.336	-3.225	241	**.001**	-.52	.16	-.84	-.20
	Equal variances not assumed			-3.184	217.849	**.002**	-.52	.16	-.85	-.20
15.Communication	Equal variances assumed	1.031	.311	1.255	241	.211	.19	.15	-.11	.48
	Equal variances not assumed			1.273	240.683	.204	.19	.15	-.10	.48

16.Close physical	Equal variances assumed	.159	.690	-1.226	241	.221	-.20	.16	-.51	.12
	Equal variances not assumed			-1.224	231.044	.222	-.20	.16	-.51	.12
17.Choosing partn	Equal variances assumed	1.738	.189	-1.246	241	.214	-.18	.15	-.48	.11
	Equal variances not assumed			-1.231	218.596	.220	-.18	.15	-.48	.11
18.Choosing partn	Equal variances assumed	.215	.643	2.669	241	**.008**	.39	.15	.10	.67
	Equal variances not assumed			2.676	234.678	**.008**	.39	.14	.10	.67
19.Management	Equal variances assumed	.415	.520	4.320	240	**.000**	.71	.17	.39	1.04
	Equal variances not assumed			4.342	236.213	**.000**	.71	.16	.39	1.04
20.Frequent and	Equal variances assumed	.333	.564	1.209	239	.228	.18	.15	-.12	.48
	Equal variances not assumed			1.215	235.772	.226	.18	.15	-.11	.48
21.Good quality	Equal variances assumed	.145	.703	.881	240	.379	.13	.14	-.16	.41
	Equal variances not assumed			.885	235.131	.377	.13	.14	-.15	.41
22.Frequent	Equal variances assumed	4.104	.044	-.955	239	.341	-.14	.15	-.44	.15
	Equal variances not assumed			-.963	236.590	.336	-.14	.15	-.44	.15
23.Working logic	Equal variances assumed	1.421	.234	.512	239	.609	8.26E-02	.16	-.24	.40
	Equal variances not assumed			.519	238.339	.604	8.26E-02	.16	-.23	.40
24.Taking a responsibilities	Equal variances assumed	1.724	.190	-2.572	240	**.011**	-.36	.14	-.63	-8.37E-02
	Equal variances not assumed			-2.572	231.968	**.011**	-.36	.14	-.63	-8.36E-02

Appendix 14 Group statistics: A less experienced specialists group and a more experienced specialists group based on each factor.

	A career as a specialist	N	Mean	Std. Deviation	Std. Error Mean
1.Unified culture	Less experienced	122	4.34	1.46	.13
	More experienced	119	4.06	1.46	.13
2.Having a proper organisation and a flexible organisational culture for CFC	Less experienced	123	5.53	1.10	9.95E-02
	More experienced	119	5.29	1.20	.11
3.Equality of contribution	Less experienced	124	5.13	1.27	.11
	More experienced	117	4.91	1.23	.11
4.Having a mutual understanding of role and knowledge of partners' departments and/or partner	Less experienced	124	5.23	1.15	.10
	More experienced	119	5.29	1.20	.11
5.Having a unified strategy and company policy upstream and down stream	Less experienced	124	5.01	1.32	.12
	More experienced	119	5.03	1.27	.12
6. Sharing a common vision and values (corporate level)	Less experienced	124	5.01	1.24	.11
	More experienced	119	5.03	1.21	.11
7.Sharing unified goals & objectives (project level)	Less experienced	124	5.75	1.12	.10
	More experienced	119	5.54	1.14	.10
8.Having an informal social relationship (or system) with other functional group members	Less experienced	124	4.83	1.35	.12
	More experienced	119	4.86	1.40	.13
9. Building trust between functional group partners	Less experienced	124	5.53	1.25	.11
	More experienced	119	5.51	1.16	.11
10. Having a sense of belonging and cohesion	Less experienced	124	5.01	1.17	.10
	More experienced	119	5.08	1.25	.11
11. Having well-developed management processes and systems	Less experienced	124	4.69	1.31	.12
	More experienced	119	4.66	1.20	.11
12. Having a well-planned schedule for product development	Less experienced	124	4.55	1.16	.10
	More experienced	119	4.80	1.19	.11
13. Having a well-defined and organised design process	Less experienced	124	4.87	1.23	.11
	More experienced	119	4.83	1.17	.11
14.Having a joint rewards system rather than individual rewards system	Less experienced	124	4.56	1.28	.11
	More experienced	119	4.55	1.30	.12
15. Allocating sufficient resources (hardware)	Less experienced	124	**5.19**	1.05	9.40E-02
	More experienced	119	**4.86**	1.25	.11
16.Having a close location between other functional partners	Less experienced	124	5.33	1.27	.11
	More experienced	119	5.21	1.23	.11
17.Choosing partners with whom there is a good interpersonal relationship	Less experienced	124	4.89	1.24	.11
	More experienced	119	4.92	1.05	9.66E-02
18.Choosing partners who have professional skills and knowledge within his/her area	Less experienced	124	4.99	1.15	.10
	More experienced	119	5.24	1.12	.10
19.Managing and coordinating activities by senior manager	Less experienced	123	4.18	1.41	.13
	More experienced	119	4.06	1.24	.11
20. Monitoring progress frequently and rapidly	Less experienced	122	4.38	1.22	.11
	More experienced	119	4.37	1.13	.10
21.Having good quality communication (information sharing) with other functional group partners	Less experienced	123	5.50	1.13	.10
	More experienced	119	5.42	1.08	9.88E-02
22. Having a frequent (quantitative) communication (information sharing) with other functional group partners	Less experienced	123	5.02	1.02	9.23E-02
	More experienced	118	5.14	1.30	.12
23.Working rationally and logically	Less experienced	123	**5.39**	1.25	.11

	More experienced	118	**5.03**	1.22	.11
24. Having collective responsibility for a project	Less experienced	123	5.75	1.14	.10
	More experienced	119	5.81	1.04	9.57E-02

Appendix 15 Independent T-test: A less experienced specialists group and a more experienced specialists group based on each factor.

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
1.Unified culture	Equal variances assumed	.094	.759	1.473	239	.142	.28	.19	-9.34E-02	.65
	Equal variances not assumed			1.473	238.898	.142	.28	.19	-9.34E-02	.65
2. A proper organisation	Equal variances assumed	.132	.717	1.580	240	.115	.23	.15	-5.78E-02	.53
	Equal variances not assumed			1.578	236.666	.116	.23	.15	-5.83E-02	.53
3.Equality of	Equal variances assumed	.191	.662	1.332	239	.184	.21	.16	-.10	.53
	Equal variances not assumed			1.333	238.832	.184	.21	.16	-.10	.53
4.Mutual understanding of	Equal variances assumed	.254	.614	-.453	241	.651	-6.83E-02	.15	-.37	.23
	Equal variances not assumed			-.453	239.099	.651	-6.83E-02	.15	-.37	.23
5.Unified strategy &	Equal variances assumed	.215	.643	-.154	241	.878	-2.55E-02	.17	-.35	.30
	Equal variances not assumed			-.154	241.000	.878	-2.55E-02	.17	-.35	.30
6.Sharing common	Equal variances assumed	.915	.340	-.162	241	.871	-2.55E-02	.16	-.34	.28
	Equal variances not assumed			-.162	240.900	.871	-2.55E-02	.16	-.34	.28
7.Sharing unified goals	Equal variances assumed	.239	.625	1.461	241	.145	.21	.15	-7.40E-02	.50
	Equal variances not assumed			1.460	240.229	.146	.21	.15	-7.41E-02	.50
8.Informal social	Equal variances assumed	.301	.584	-.150	241	.881	-2.65E-02	.18	-.37	.32
	Equal variances not assumed			-.150	239.389	.881	-2.65E-02	.18	-.37	.32
9.A trust level	Equal variances assumed	.738	.391	.127	241	.899	1.97E-02	.15	-.28	.32
	Equal variances not assumed			.128	240.734	.899	1.97E-02	.15	-.28	.32
10.Sence of belonging	Equal variances assumed	1.376	.242	-.436	241	.663	-6.76E-02	.15	-.37	.24
	Equal variances not assumed			-.435	238.056	.664	-6.76E-02	.16	-.37	.24
11.Well developed	Equal variances assumed	.774	.380	.134	241	.894	2.16E-02	.16	-.30	.34
	Equal variances not assumed			.134	240.542	.893	2.16E-02	.16	-.30	.34
12.Well planned schedule	Equal variances assumed	.043	.836	-1.660	241	.098	-.25	.15	-.55	4.671-02
	Equal variances not assumed			-1.659	239.844	.098	-.25	.15	-.55	4.691-02
13.Well	Equal variances assumed	.579	.447	.254	241	.800	3.90E-02	.15	-.26	.34

defined and	Equal variances not assumed			.254	240.971	.800	3.90E-02	.15	-.26	.34
14.Joint rewards system	Equal variances assumed	.018	.894	.060	241	.952	9.89E-03	.17	-.32	.34
	Equal variances not assumed			.060	240.154	.952	9.89E-03	.17	-.32	.34
15.Communication and	Equal variances assumed	1.049	.307	2.223	241	**.027**	.33	.15	3.74E-02	.62
	Equal variances not assumed			2.215	230.170	**.028**	.33	.15	3.62E-02	.62
16.Close physical location	Equal variances assumed	.318	.573	.751	241	.453	.12	.16	-.20	.44
	Equal variances not assumed			.751	240.945	.453	.12	.16	-.20	.44
17.Choosing partners who	Equal variances assumed	1.813	.179	-.195	241	.846	-2.89E-02	.15	-.32	.26
	Equal variances not assumed			-.195	237.388	.845	-2.89E-02	.15	-.32	.26
18.Choosing partners who have	Equal variances assumed	.880	.349	-1.727	241	.085	-.25	.15	-.54	3.54E-02
	Equal variances not assumed			-1.728	240.955	.085	-.25	.15	-.54	3.52E-02
19.Management and coord	Equal variances assumed	3.378	.067	.703	240	.482	.12	.17	-.22	.46
	Equal variances not assumed			.705	237.801	.482	.12	.17	-.22	.46
20.Frequent and rapid	Equal variances assumed	.799	.372	.048	239	.961	7.30E-03	.15	-.29	.30
	Equal variances not assumed			.048	238.388	.961	7.30E-03	.15	-.29	.30
21.Good quality commu	Equal variances assumed	.477	.491	.533	240	.595	7.58E-02	.14	-.20	.36
	Equal variances not assumed			.533	239.927	.594	7.58E-02	.14	-.20	.36
22.Frequent (quantitative	Equal variances assumed	5.704	.018	-.851	239	.396	-.13	.15	-.42	.17
	Equal variances not assumed			-.847	222.563	.398	-.13	.15	-.43	.17
23.Working logically	Equal variances assumed	.435	.510	2.293	239	**.023**	.36	.16	5.15E-02	.68
	Equal variances not assumed			2.295	238.965	**.023**	.36	.16	5.17E-02	.68
24.Having a responsibilty	Equal variances assumed	1.726	.190	-.419	240	.676	-5.88E-02	.14	-.34	.22
	Equal variances not assumed			-.419	239.388	.675	-5.88E-02	.14	-.33	.22

Appendix 16 Correlations of multiple regression analysis: between the total performance of design development and each factor, and between the factors (variables)

		Total weigh	1.Unified	2.proper	3.Managria	4.Share unified	5.Informal	6.Trust and	7.Choose	8.Close	9.Manageme	10.Work	11.Interacti
Pearson Correlation	Total weighted	1.000	.300	.516	.676	.618	.339	.686	.486	.278	.474	.593	.651
	1.Unified	.300	1.000	.422	.275	.303	-.010	.220	.199	-.052	.258	.264	.184
	2.proper	.516	.422	1.000	.572	.467	.272	.410	.334	.119	.261	.373	.367
	3.Manag	.676	.275	.572	1.000	.561	.464	.707	.481	.372	.520	.500	.638
	4.Share	.618	.303	.467	.561	1.000	.318	.527	.197	.219	.580	.524	.419
	5.Inform	.339	-.010	.272	.464	.318	1.000	.555	.362	.114	.253	.312	.376
	6.A trust	.686	.220	.410	.707	.527	.555	1.000	.575	.371	.497	.578	.681
	7.Choos	.486	.199	.334	.481	.197	.362	.575	1.000	.300	.251	.357	.517
	8.Close	.278	-.052	.119	.372	.219	.114	.371	.300	1.000	.191	.141	.300
	9.Mnage	.474	.258	.261	.520	.580	.253	.497	.251	.191	1.000	.481	.461
	10.Work)	.593	.264	.373	.500	.524	.312	.578	.357	.141	.481	1.000	.583
	11.Intera	.651	.184	.367	.638	.419	.376	.681	.517	.300	.461	.583	1.000
Sig. (1-tailed)	Total	.	.001	.000	.000	.000	.000	.000	.000	.002	.000	.000	.000
	1.Unified	.001	.	.000	.002	.001	.459	.013	.022	.301	.004	.003	.031
	2.proper	.000	.000	.	.000	.000	.003	.000	.000	.116	.004	.000	.000
	3.Managl	.000	.002	.000	.	.000	.000	.000	.000	.000	.000	.000	.000
	4.Share	.000	.001	.000	.000	.	.001	.000	.023	.013	.000	.000	.000
	5.Inform	.000	.459	.003	.000	.001	.	.000	.000	.126	.005	.001	.000
	6.A trust	.000	.013	.000	.000	.000	.000	.	.000	.000	.000	.000	.000
	7.Choos	.000	.022	.000	.000	.023	.000	.000	.	.001	.005	.000	.000
	8.Close	.002	.301	.116	.000	.013	.126	.000	.001	.	.027	.078	.001
	9.Mnage	.000	.004	.004	.000	.000	.005	.000	.005	.027	.	.000	.000
	10.Work)	.000	.003	.000	.000	.000	.001	.000	.000	.078	.000	.	.000
	11.Intera	.000	.031	.000	.000	.000	.000	.000	.000	.001	.000	.000	.
N	Total	103	103	103	103	103	103	103	103	103	103	103	103
	1.Unified	103	103	103	103	103	103	103	103	103	103	103	103
	2.proper	103	103	103	103	103	103	103	103	103	103	103	103
	3.Manag	103	103	103	103	103	103	103	103	103	103	103	103
	4.Share	103	103	103	103	103	103	103	103	103	103	103	103
	5.Inform	103	103	103	103	103	103	103	103	103	103	103	103
	6.A trust	103	103	103	103	103	103	103	103	103	103	103	103
	7.Choos	103	103	103	103	103	103	103	103	103	103	103	103
	8.Close	103	103	103	103	103	103	103	103	103	103	103	103
	9.Mnage	103	103	103	103	103	103	103	103	103	103	103	103
	10.Work)	103	103	103	103	103	103	103	103	103	103	103	103
	11.Intera	103	103	103	103	103	103	103	103	103	103	103	103

Appendix 17 Correlations of multiple regression analysis: between the *time performance* of design development and independent factor (variable). and between each factor (variable)

		Time perfo r	1.Unif ied	2.pro per	3.Ma nager ia	4.Share unified	5.Info rmal	6.Tru st and	7.Cho ose	8.Clos e	9.Ma nage me	10.W ork	11.Int eracti
Pearson Correla tion	Time performa nce	1.000	.112	.358	.487	.466	.135	.468	.311	.088	.363	.501	.507
	1.Unified	.112	1.000	.436	.283	.297	-.007	.206	.207	-.059	.262	.259	.200
	2.proper	.358	.436	1.000	.585	.474	.263	.413	.354	.106	.287	.386	.365
	3.Manag	.487	.283	.585	1.000	.569	.452	.704	.499	.355	.535	.509	.625
	4.Share	.466	.297	.474	.569	1.000	.328	.542	.228	.223	.601	.535	.404
	5.Inform	.135	-.007	.263	.452	.328	1.000	.556	.361	.133	.264	.311	.366
	6.A trust	.468	.206	.413	.704	.542	.556	1.000	.585	.372	.515	.590	.660
	7.Choos	.311	.207	.354	.499	.228	.361	.585	1.000	.291	.295	.376	.499
	8.Close	.088	-.059	.106	.355	.223	.133	.372	.291	1.000	.189	.139	.292
	9.Mnage	.363	.262	.287	.535	.601	.264	.515	.295	.189	1.000	.496	.433
	10.Work)	.501	.259	.386	.509	.535	.311	.590	.376	.139	.496	1.000	.570
	11.Intera	.507	.200	.365	.625	.404	.366	.660	.499	.292	.433	.570	1.000
Sig. (1-tailed)	Time performal	.	.125	.000	.000	.000	.083	.000	.001	.184	.000	.000	.000
	1.Unified	.125	.	.000	.002	.001	.472	.017	.016	.273	.003	.004	.020
	2.proper	.000	.000	.	.000	.000	.003	.000	.000	.139	.001	.000	.000
	3.Managl	.000	.002	.000	.	.000	.000	.000	.000	.000	.000	.000	.000
	4.Share	.000	.001	.000	.000	.	.000	.000	.009	.011	.000	.000	.000
	5.Inform	.083	.472	.003	.000	.000	.	.000	.000	.086	.003	.001	.000
	6.A trust	.000	.017	.000	.000	.000	.000	.	.000	.000	.000	000	.000
	7.Choos	.001	.016	.000	.000	.009	.000	.000	.	.001	.001	.000	.000
	8.Close	.184	.273	.139	.000	.011	.086	.000	.001	.	.026	.076	.001
	9.Mnage	.000	.003	.001	.000	.000	.003	.000	.001	.026	.	.000	.000
	10.Work)	.000	.004	.000	.000	.000	.001	.000	.000	.076	.000	.	.000
	11.Intera	.000	.020	.000	.000	.000	.000	.000	.000	.001	.000	.000	.
N	Time	107	107	107	107	107	107	107	107	107	107	107	107
	1.Unified	107	107	107	107	107	107	107	107	107	107	107	107
	2.proper	107	107	107	107	107	107	107	107	107	107	107	107
	3.Manag	107	107	107	107	107	107	107	107	107	107	107	107
	4.Share	107	107	107	107	107	107	107	107	107	107	107	107
	5.Inform	107	107	107	107	107	107	107	107	107	107	107	107
	6.A trust	107	107	107	107	107	107	107	107	107	107	107	107
	7.Choos	107	107	107	107	107	107	107	107	107	107	107	107
	8.Close	107	107	107	107	107	107	107	107	107	107	107	107
	9.Mnage	107	107	107	107	107	107	107	107	107	107	107	107
	10.Work)	107	107	107	107	107	107	107	107	107	107	107	107
	11.Intera	107	107	107	107	107	107	107	107	107	107	107	107

Appendix 18 Correlations of multiple regression analysis: between the cost performance of design development and each independent factor (variable), and between the factors

		Cost perfor	1.Unified	2.proper	3.Managerial	4.Share unified	5.Informal	6.Trust and	7.Choose	8.Close	9.Mnagem en	10.Work	11.Interacti
Pearson Correlation	Cost performance	1.000	.184	.301	.405	.280	.124	.405	.260	.074	.245	.334	.476
	1.Unified	.184	1.000	.436	.283	.297	-.007	.206	.207	-.059	.262	.259	.200
	2.proper	.301	.436	1.000	.585	.474	.263	.413	.354	.106	.287	.386	.365
	3.Manag	.405	.283	.585	1.000	.569	.452	.704	.499	.355	.535	.509	.625
	4.Share	.280	.297	.474	.569	1.000	.328	.542	.228	.223	.601	.535	.404
	5.Inform	.124	-.007	.263	.452	.328	1.000	.556	.361	.133	.264	.311	.366
	6.A trust	.405	.206	.413	.704	.542	.556	1.000	.585	.372	.515	.590	.660
	7.Choos	.260	.207	.354	.499	.228	.361	.585	1.000	.291	.295	.376	.499
	8.Close	.074	-.059	.106	.355	.223	.133	.372	.291	1.000	.189	.139	.292
	9.Mnage	.245	.262	.287	.535	.601	.264	.515	.295	.189	1.000	.496	.433
	10.Work)	.334	.259	.386	.509	.535	.311	.590	.376	.139	.496	1.000	.570
	11.Intera	.476	.200	.365	.625	.404	.366	.660	.499	.292	.433	.570	1.000
Sig. (1-tailed)	Cost performa	.	.029	.001	.000	.002	.102	.000	.003	.225	.005	.000	.000
	1.Unified	.029	.	.000	.002	.001	.472	.017	.016	.273	.003	.004	.020
	2.proper	.001	.000	.	.000	.000	.003	.000	.000	.139	.001	.000	.000
	3.Managl	.000	.002	.000	.	.000	.000	.000	.000	.000	.000	.000	.000
	4.Share	.002	.001	.000	.000	.	.000	.000	.009	.011	.000	.000	.000
	5.Inform	.102	.472	.003	.000	.000	.	.000	.000	.086	.003	.001	.000
	6.A trust	.000	.017	.000	.000	.000	.000	.	.000	.000	.000	.000	.000
	7.Choos	.003	.016	.000	.000	.009	.000	.000	.	.001	.001	.000	.000
	8.Close	.225	.273	.139	.000	.011	.086	.000	.001	.	.026	.076	.001
	9.Mnage	.005	.003	.001	.000	.000	.003	.000	.001	.026	.	.000	.000
	10.Work)	.000	.004	.000	.000	.000	.001	.000	.000	.076	.000	.	.000
	11.Intera	.000	.020	.000	.000	.000	.000	.000	.000	.001	.000	.000	.
N	Cost	107	107	107	107	107	107	107	107	107	107	107	107
	1.Unified	107	107	107	107	107	107	107	107	107	107	107	107
	2.proper	107	107	107	107	107	107	107	107	107	107	107	107
	3.Manag	107	107	107	107	107	107	107	107	107	107	107	107
	4.Share	107	107	107	107	107	107	107	107	107	107	107	107
	5.Inform	107	107	107	107	107	107	107	107	107	107	107	107
	6.A trust	107	107	107	107	107	107	107	107	107	107	107	107
	7.Choos	107	107	107	107	107	107	107	107	107	107	107	107
	8.Close	107	107	107	107	107	107	107	107	107	107	107	107
	9.Mnage	107	107	107	107	107	107	107	107	107	107	107	107
	10.Work)	107	107	107	107	107	107	107	107	107	107	107	107
	11.Intera	107	107	107	107	107	107	107	107	107	107	107	107

Appendix 19 Correlations of multiple regression analysis: for the quality of final design output and the independent variable, and between variables

		Quality	1.Unified	2.proper	3.Managerial	4.Share unified	5.Informal	6.Trust and	7.Choose	8.Close	9.Manage me	10.Work	11.Interacti
Pearson Correlation	Quality performance	1.000	.299	.472	.630	.560	.305	.607	.519	.319	.427	.445	.532
	1.Unified	.299	1.000	.436	.283	.297	-.007	.206	.207	-.059	.262	.259	.200
	2.proper	.472	.436	1.000	.585	.474	.263	.413	.354	.106	.287	.386	.365
	3.Manag	.630	.283	.585	1.000	.569	.452	.704	.499	.355	.535	.509	.625
	4.Share	.560	.297	.474	.569	1.000	.328	.542	.228	.223	.601	.535	.404
	5.Inform	.305	-.007	.263	.452	.328	1.000	.556	.361	.133	.264	.311	.366
	6.A trust	.607	.206	.413	.704	.542	.556	1.000	.585	.372	.515	.590	.660
	7.Choos	.519	.207	.354	.499	.228	.361	.585	1.000	.291	.295	.376	.499
	8.Close	.319	-.059	.106	.355	.223	.133	.372	.291	1.000	.189	.139	.292
	9.Mnage	.427	.262	.287	.535	.601	.264	.515	.295	.189	1.000	.496	.433
	10.Work)	.445	.259	.386	.509	.535	.311	.590	.376	.139	.496	1.000	.570
	11.Intera	.532	.200	.365	.625	.404	.366	.660	.499	.292	.433	.570	1.000
Sig. (1-tailed)	Time performal	.	.001	.000	.000	.000	.001	.000	.000	.000	.000	.000	.000
	1.Unified	.001	.	.000	.002	.001	.472	.017	.016	.273	.003	.004	.020
	2.proper	.000	.000	.	.000	.000	.003	.000	.000	.139	.001	.000	.000
	3.Managl	.000	.002	.000	.	.000	.000	.000	.000	.000	.000	.000	.000
	4.Share	.000	.001	.000	.000	.	.000	.000	.009	.011	.000	.000	.000
	5.Inform	.001	.472	.003	.000	.000	.	.000	.000	.086	.003	.001	.000
	6.A trust	.000	.017	.000	.000	.000	.000	.	.000	.000	.000	000	.000
	7.Choos	.000	.016	.000	.000	.009	.000	.000	.	.001	.001	.000	.000
	8.Close	.000	.273	.139	.000	.011	.086	.000	.001	.	.026	.076	.001
	9.Mnage	.000	.003	.001	.000	.000	.003	.000	.001	.026	.	.000	.000
	10.Work)	.000	.004	.000	.000	.000	.001	.000	.000	.076	.000	.	.000
	11.Intera	.000	.020	.000	.000	.000	.000	.000	.000	.001	.000	.000	.
N	Time	107	107	107	107	107	107	107	107	107	107	107	107
	1.Unified	107	107	107	107	107	107	107	107	107	107	107	107
	2.proper	107	107	107	107	107	107	107	107	107	107	107	107
	3.Manag	107	107	107	107	107	107	107	107	107	107	107	107
	4.Share	107	107	107	107	107	107	107	107	107	107	107	107
	5.Inform	107	107	107	107	107	107	107	107	107	107	107	107
	6.A trust	107	107	107	107	107	107	107	107	107	107	107	107
	7.Choos	107	107	107	107	107	107	107	107	107	107	107	107
	8.Close	107	107	107	107	107	107	107	107	107	107	107	107
	9.Mnage	107	107	107	107	107	107	107	107	107	107	107	107
	10.Work)	107	107	107	107	107	107	107	107	107	107	107	107
	11.Intera	107	107	107	107	107	107	107	107	107	107	107	107

Appendix 20 Correlations between the effectiveness & efficiency of design management and each independent variable, and between variables

		Design mana	1.Unified	2.proper	3.Managria	4.Share unified	5.Informal	6.Trust and	7.Choose	8.Close	9.Manageme	10.Work	11.Interacti
Pearson Correlation	Design management	1.000	.287	.366	.490	.444	.195	.455	.287	.199	.318	.467	.485
	1.Unified	.287	1.000	.436	.283	.297	-.007	.206	.207	-.059	.262	.259	.200
	2.proper	.366	.436	1.000	.585	.474	.263	.413	.354	.106	.287	.386	.365
	3.Manag	.490	.283	.585	1.000	.569	.452	.704	.499	.355	.535	.509	.625
	4.Share	.444	.297	.474	.569	1.000	.328	.542	.228	.223	.601	.535	.404
	5.Inform	.195	-.007	.263	.452	.328	1.000	.556	.361	.133	.264	.311	.366
	6.A trust	.455	.206	.413	.704	.542	.556	1.000	.585	.372	.515	.590	.660
	7.Choos	.287	.207	.354	.499	.228	.361	.585	1.000	.291	.295	.376	.499
	8.Close	.199	-.059	.106	.355	.223	.133	.372	.291	1.000	.189	.139	.292
	9.Mnage	.318	.262	.287	.535	.601	.264	.515	.295	.189	1.000	.496	.433
	10.Work)	.467	.259	.386	.509	.535	.311	.590	.376	.139	.496	1.000	.570
	11.Intera	.485	.200	.365	.625	.404	.366	.660	.499	.292	.433	.570	1.000
Sig. (1-tailed)	Design managem	.	.001	.000	.000	.000	.022	.000	.001	.020	.000	.000	.000
	1.Unified	.001	.	.000	.002	.001	.472	.017	.016	.273	.003	.004	.020
	2.proper	.000	.000	.	.000	.000	.003	.000	.000	.139	.001	.000	.000
	3.Managl	.000	.002	.000	.	.000	.000	.000	.000	.000	.000	.000	.000
	4.Share	.000	.001	.000	.000	.	.000	.000	.009	.011	.000	.000	.000
	5.Inform	.022	.472	.003	.000	.000	.	.000	.000	.086	.003	.001	.000
	6.A trust	.000	.017	.000	.000	.000	.000	.	.000	.000	.000	.000	.000
	7.Choos	.001	.016	.000	.000	.009	.000	.000	.	.001	.001	.000	.000
	8.Close	.020	.273	.139	.000	.011	.086	.000	.001	.	.026	.076	.001
	9.Mnage	.000	.003	.001	.000	.000	.003	.000	.001	.026	.	.000	.000
	10.Work)	.000	.004	.000	.000	.000	.001	.000	.000	.076	.000	.	.000
	11.Intera	.000	.020	.000	.000	.000	.000	.000	.000	.001	.000	.000	.
N	Design m	107	107	107	107	107	107	107	107	107	107	107	107
	1.Unified	107	107	107	107	107	107	107	107	107	107	107	107
	2.proper	107	107	107	107	107	107	107	107	107	107	107	107
	3.Manag	107	107	107	107	107	107	107	107	107	107	107	107
	4.Share	107	107	107	107	107	107	107	107	107	107	107	107
	5.Inform	107	107	107	107	107	107	107	107	107	107	107	107
	6.A trust	107	107	107	107	107	107	107	107	107	107	107	107
	7.Choos	107	107	107	107	107	107	107	107	107	107	107	107
	8.Close	107	107	107	107	107	107	107	107	107	107	107	107
	9.Mnage	107	107	107	107	107	107	107	107	107	107	107	107
	10.Work)	107	107	107	107	107	107	107	107	107	107	107	107
	11.Intera	107	107	107	107	107	107	107	107	107	107	107	107