Chapter 4 Key Findings and Discussion

This chapter presents principal findings from the primary research. The findings can be divided into two groups: qualitative and quantitative results. Figure 4.1 illustrates how these two types of results are integrated. According to this figure, the qualitative results, namely methods to balance all contributions, overcome the creative boundaries and achieve a successful integration, are placed in the quantitative results, which are a context of Smart Clothing and future design directions based on the user requirements. Finally, a conclusion demonstrating an integration of qualitative and quantitative results is deduced. There are many overlapping findings between each primary research method; therefore, the findings are divided into four groups: 1) methods to balance all contributions, 2) methods to overcome existing creative constraints, 3) methods to achieve full integration, and 4) Smart Clothing's context. The results shown in this chapter have already been processed and analysed, and the raw findings are presented in Appendix B. Most quotes and examples are drawn from the interviews and the focus groups. Further results of the case studies are demonstrated in the last published paper in the Appendix.

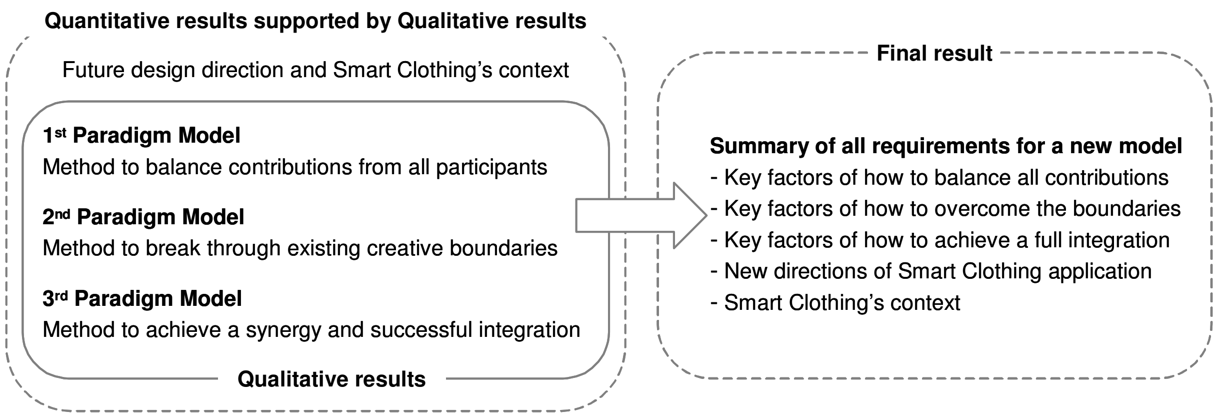

Figure 4.1: Integration of qualitative results and quantitative results

4.1 Methods to Balance All Contributions

In order to establish practical methods to balance all contributions, it is important to identify the causes of this imbalanced contribution. The problems and practical methods are identified through an analysis of the results from the interviews, focus groups and case studies. Consequently, this section describes three key issues: 1) main problems of Smart Clothing development, 2) alternative ways to solve the problems, and 3) conclusion.

4.1.1 Main Problems of Smart Clothing Development

A summary of the main problems deduced from the primary research is shown as follows.

1. **Smart Clothing's development works had not been integrated**.

   Most interviewees reported that they did not have to change the way they work when developing Smart Clothes, as the tasks were assigned according to their expertise. For example, a textile scientist stated that while goals and specifications were planned together, each task was carried out separately. All partners in a collaborative project met only three or four times a year to report the progress. The development tasks were carried out in linear order. Firstly the fashion design team designed and produced a prototype garment. Secondly, the textile technicians analysed the prototype, sourced and tested several materials to find out the appropriate ones, and applied smart textiles according to the design. Next, the electronic engineers developed hardware and software based on the specifications. Finally, all the parts were assembled together.

2. **Every discipline had a very different approach to a design problem**.

   It was difficult to change the ways each discipline worked and the design approaches they took. Most interviewees reported no problems working with other disciplines.

However, many of them admitted that it was difficult to express what they wanted from other disciplines without knowing some technical terms. For instance, an electronic engineer described that he had to visit a textile factory in another country and go through several samples of the fabrics in order to explain what was the knitting structure that he wanted. Moreover, some disciplines were very difficult to understand. For example, a fashion designer stressed *'all fashion designers have radically different approaches to design. Unlike other design fields, there are no accepted methodologies. Therefore, they are extremely intangible disciplines.'*

3. **Long distances and separate workplaces caused communication problems**.
   In most cases, the developers worked on their own in separate locations, as Smart Clothing development project was often a collaboration of different organisations. Generally, one organisation provided one or two types of expertise/disciplines. This situation led to many problems. Moreover, most partners had only a few meetings in one year. Since most communications were done by telephone, it was difficult to understand what the others wanted. Only one interviewee reported no problems, since he worked in a Smart Clothing company that had all the required disciplines in one place. If he had any problems, he simply went to ask an expert in that particular field.

4. **Every designer found it difficult to develop a design with other individuals**.
   It was not common for different types of designers to work together. A professional designer stated that through her eight-years work experience she never worked with any other designers. In most cases, she worked with a project manager or an engineer. A focus group respondent with experience of working with other designers described

'six designers got together. We tried to get a solution, but we just argued all the time. We tried to designate a team leader but it didn't work because we didn't agree with his opinions. Everybody wanted to have opinions about materials and so on. Design was easy, but dealing with people was difficult because meetings never worked. We took the brief and separated it. Each person worked on different areas and different specifications. We split up and came back after a while. That was better because it gave you more time to think rather than arguing. Sometimes we paired up. You worked in the way that suited you, but at the same time, you worked together.'

5. **The target market and their latent needs had not been recognised**.

   Most respondents of the focus groups agreed that Smart Clothing applications were difficult to develop because the target audiences and their requirements had not been identified. Hence, the function and appearance of the product could not be specified and designed. Although it was common for all designers to develop their own briefs based on the ones given by their clients, they found it difficult to create an 'extended' brief for Smart Clothing products due to its unclear and unfocussed design direction.

There are certain conditions that are difficult to change due to the nature of the project. For instance, it is difficult to form a child organisation for every collaborative project in order to locate all disciplines in one place. Moreover, it may be appropriate to separate the development tasks and work independently, since all disciplines agree that they have to work on their own in the ways that suit their styles. Besides, it is difficult to carry out design work together. All disciplines agreed that it was easier to discuss when each work became concrete, as the idea can be examined by other participants. As a result, the long distance communication and separated development task are considered as the ‘fixed conditions’ of this collaboration. However, other major problems; 1) linear structure of the NPD process; 2) conflicts caused by differences among participants; and 3) imbalanced contribution resulting from separated tasks and unclear goal, can be solved.

4.1.2 Alternative Ways to Solve Identified Problems

A summary of alternative methods to solve the identified problems is presented below:

1. **The design task must be developed from multiple views of all participants**.

   A design manager reported that he employed an interdisciplinary approach to ensure the balanced contributions. Each member of his development team was selected due to their multi-skills and ability to understand and communicate with other disciplines, as he described, *‘although they are different disciplines. I’d been particularly careful to make sure that my human factor person was also trained as user interface. I’ve got a cover engineer who was trained as an engineer in his first degree and his second degree was industrial design. I’ve got an industrial designer who did his first degree in human factor and second degree in industrial design. I have a graphic designer who did his first degree in graphics and spent most of his time in media and user interface.’* Since all members could exchange ideas effectively, the design and development were developed from multiple perspectives. As a result, all contributions were integrated and balanced. Despite the linear structure of the NPD process due to the nature of the organisation, a large international electronic company, the designs and developments were carried out in concurrent manner.

2. **A clear goal and expected contributions of all participants is needed**.

Results from the interviews, focus groups and case studies suggested that a precisely described goal clarified the contribution expected from each discipline. A clear goal could be achieved through idea visualisation. For instance, the electronic engineer described that, in order to persuade a clothing company to join in the Smart Clothing project, his team designed and produced some prototype garments to demonstrate their visions of Smart garments. As the ideas became concrete, the apparel company was able to see the opportunities of this project. Idea visualisation also clarified the contributions expected from each partner. In this way, all contributions were balanced. However, in this case, the outcome was not fully integrated, since the original idea only came from the electronic company. This indicates that the goal must be created from the visions of all partners in order to achieve a successful collaboration.

3. **Each participant should be aware of other disciplines' capabilities and processes**.
   Many interviewees recommended that the every participant should be aware of other disciplines' work procedures, technical terms and in some cases, a production process of the partners. For instance, the electronic engineer explained that he studied the clothing manufacturing process and developed electronic hardware accordingly.

4. **A new culture as well as a new way of thinking and working is required**.
   To develop a product from multiple views, certain interviewees and focus group respondents indicated that a new framework and new culture must be embedded into all participants. For example, the sportswear educator stated that she tried to embed 'Sportswear Culture' into her students before they started designing. As the students focused on a final outcome, the key elements of sportswear design, namely technical

product design (e.g. functionality, usability, etc.) and fashion design (e.g. fabric, colours, etc.), were balanced. The framework and culture could be embedded through an education or establishment of a development basis. For a joint-venture project like Smart Car, it was important to develop a collaboration basis. This basis allowed the team to exchange ideas, measure progress and evaluate an outcome. It contained a clear goal, criteria, milestones and expected contributions from all participants.

To summarise, in order to balance all the contributions, a clear goal is required. As a result, a contribution expected from each discipline can be developed. However, the participants should focus on the final outcome rather than the contributions they can provide. Experts suggest that the goal should result from a shared vision of all disciplines (Cooper, 1996). Besides, it must be visualised and comprehensible to all participants. A new culture and framework are needed to ensure that the product is developed from multiple perspectives. This new culture and framework can be embedded through education or establishment of a collaboration basis. As the task is carried out separately in different places, all participants must be able to communicate their ideas clearly. Thus, each participant should understand the other disciplines' work procedures and technical terms to some extent. The grounded theory analysis is employed to analyse these findings. The results are presented below.

Table 4.1: Properties and dimension range of 'Balanced Contribution' Phenomenon

Category	**Properties**	**Dimension**
1. Balance contribution	• Mutual understanding of a development goal • Ability to communicate and exchange idea effectively • Product is developed from multiple perspectives	High High High
2. Activities	• Creating a clear statement of a goal and objectives • Visualising the development goal	High High

Category	Properties	Dimension
2. Activities	• Making sure the goal is clearly understood by all participants	High
	• Being aware of other disciplines' procedures and technical terms	High
	• Establishing a basis for collaborative development project	High
	• Clearly defining the expected contributions from all participants	High
	• Embedding new culture and new framework into all participants	High
	• Developing idea based on the multiple perspectives	High
	• Focusing on a final outcome, not the key elements or contributions	High

Causal condition →	**Phenomenon**	
Separated work, unclear goal, different approaches and procedures	Achieve balance contributions from all participants	
Properties of Balanced Contribution	**Specific Dimensional of Balance Contribution**	
- Mutual understanding of a goal	Goal and objectives are clearly defined	High
	The goal is clearly understood by all participants	High
	Expected contributions of all parties are precisely defined	High
- Ability to exchange idea effectively	Everyone is aware of other discipline's capabilities	High
	Everyone is aware of other discipline's work procedures	High
	Everyone understands some technical terms of other areas	High
	All disciplines are able to share ideas and knowledge	High
- Multiple-perspective development	New framework of thinking and working is embedded	High
	Design and development is created from multiple views	High

Balanced Contribution Context

Under conditions where contributions are from very different industries, namely fashion and electronic sectors, and an optimum balance of the contributions is required, there is a need for a practical method to ensure that an outcome is developed based on the multiple perspectives of all participants

Strategies for Balanced Contribution

1. Create a clear statement of a goal and objectives
2. Visualise the goal and objectives
3. Ensure the goal is understood by all participants
4. Be aware of other disciplines' procedures
5. Establish a basis for the collaborative development
6. Clarify expected contributions of all parties
7. Embed new culture and framework into all disciplines
8. Develop a product based on multiple views
9. Focus on a final outcome, not the key elements

Intervening Conditions

There are certain problematic conditions that cannot be changed due to the nature of the project. Firstly, the work has to be separated and carried out in different locations. Secondly, all participants prefer to work on their own in the style that suits them. All disciplines do not want to change the way they approach to a -

Intervening Conditions
- problem and work procedure entirely. Moreover, they believe that a design work cannot be carried out together. Currently, the consumer latent needs have not been recognised. As a result, a development goal cannot be defined. Without a precise goal, it is difficult to specify expected contributions of each discipline.

Consequences
The user's requirements must be identified before a new framework can be created. The framework must be developed based on existing procedures of all participants; therefore, it is not difficult for them to adopt.

Figure 4.2: Paradigm Model – phenomenon of balancing contributions of all disciplines

Conclusion – Methods to Balance All Contributions

Currently, Smart Clothing development is unable to balance the contributions from all participants because of 1) disintegrated or separated development caused by long distance communication and separate workplace, 2) differences among participants in terms of work procedures and approaches to design problems, and 3) unclear goals and design direction. The long distance communication and separate workplace is difficult to change, since it requires a lot of investment to form a child organisation where all participants can work together. Moreover, most participants found it difficult to carry out design and development tasks together, as they preferred to work on their own in the styles that suit them. Although working together in the same place has a significant impact on the success of the integration, it can be seen that some investors and stakeholders might feel reluctant to adopt this method, since it requires large amount of financial support and a great deal of changes in terms of working procedure and behaviour. As a result, the researcher continues to explore other aspects, which can improve the balance of the contributions, and require less effort and investment. The grounded theory analysis suggests practical methods to balance the contributions from different sectors as follows:

1. Create a clear statement of a goal of a collaborative project

2. Visualise the goal and objectives of a particular project
3. Ensure the goal is clearly understood by all participants
4. Be aware of other disciplines' work procedures and some technical terms
5. Establish a basis for the collaborative development
6. Clarify the contributions expected from all disciplines
7. Embed new cultures and new framework into all participants
8. Develop ideas based on the multiple perspectives
9. Focus on a final outcome, not its key elements or contributions

To follow these recommendations, it is important to develop a clear goal based on the user requirements as well as the visions of all participants. The new framework should be developed from the goal and work procedures the participants currently employ. Thus, it is easier for them to adopt. This framework should be addressed in a NPD model to ensure that the new way of working and thinking is synchronised with the NPD process.

4.2 Methods to Overcome Creative Constraints

One major problem of Smart Clothing development is that the application is developed within the conventional design boundary. Therefore, the application is designed as a fashion item or electronic device, but rarely as a Smart Clothing product (Ariyatum and Holland, 2003). In this research, the creative constraints refer to all factors, e.g. pattern of thinking, perception, and design approach, that prevent a person from exploring new ways of thinking and working. Therefore, a creative-constraint breakthrough is an ability to develop and express an idea in a new way that is different from educational backgrounds or previous work experiences. It probably involves lateral thinking. A good example is the idea suggested by one of the focus group respondents *'there is no point for Smart Clothes to have electronic functions that people already have. The electronic technology should solve specific problems in the Smart Clothing field, that is a long development time versus short lifecycle of a garment. For example, it should provide a mechanism that allows the user to change colour and style due to the changing trends. The technology that can adapt itself is more suitable and smart.'* Apparently, this idea expressed a breakthrough in terms of conventional perception of electronic technology. Practical methods to overcome the creative constraints are deduced from the results of the case studies and focus groups.

4.2.1 Alternative Ways to Overcome the Creative Constraints

A summary of the practical methods drawn from the primary research is shown below.

1. **Change an approach and work procedure within a boundary of basic principles**. Most respondents in the focus groups explained that designers approached every project differently due to the different requirements and specifications. However, their basic principles remained the same for every design project. These principles were based on their personal belief and educational background. In the case of product design, the designers normally started with the user requirements, as the principle of most designers was *'value for the end user.'* For the Smart Clothing project, for which user requirements and product context were underdeveloped, the product designers stated that they would approach this project by exploring the utility of technologies, which arguably means starting with the functionality and usability for the end users.

2. **Changing certain principles and procedures to match a new project's context**. Although maintaining basic principles is useful for a collaborative project because it

ensures that the values of particular disciplines are transferred to the project, it represents a constraint to some extent. This research reveals that the influence of the educational background is very strong in the area where its culture is well established and embedded into the way of thinking. For example, all product designers gave practical and functional suggestions for the Smart Clothing application, while the designers in other fields (e.g. architect, fashion designers and graphic designer) provided more experimental and radical ideas. Many respondents agreed that these constraints could be overcome by familiarisation with a new project. For instance, all product designers stressed that they needed to get accustomed to the technology and target market of a particular field before they could start designing. One focus group respondent with an Automation background currently working on an emotional fashion website project reported that she faced many problems caused by her linear thinking process. As she realised that the logical method prevented her from thinking in a more emotional way, she tried to forget her conventional process and absorb fashion senses by visiting fashion shops, reading fashion magazines, etc. In this way, she was able to think in a more fashion-oriented manner. However, some respondents noted that absorbing too much information could lead to confusion and misdirection.

3. **Replace a conventional framework of thinking and working with a new one**.
   In order to think and work in a different way, a new framework is required. For instance, all sportswear design students learn a new way of thinking and working. As a result, sportswear products were developed based on sport practitioner’s needs involving both clothing design considerations, e.g. providing comfort and supporting movement, and product design considerations, such as increasing performance.

This research discovers that there are three different levels of breakthrough. However, all of them start from a realisation of the need for a new way of thinking or working. In the first level, there is a need for a new way of working only. Although, the approach and work procedure are changed, the design work is carried out within an existing framework of thinking or basic principles of an individual designer. In the second level, there is a need to adjust the way of working and thinking partly. Consequently, certain principles and work procedures are changed to match the new requirements and context of the new project. In the third level, there is a need for a whole new way of thinking and working. As a result, a new framework is employed. Even though a new framework can be educated, it is not likely that all Smart Clothing developers will adopt it through this way. The new framework should be based on the context of the project. Moreover, it should address certain principles and work procedures of all the disciplines in order to ensure that it is comprehensible and can be used by all the participants. Therefore, it is important to present the principles and procedures the participants employ currently (table 4.2). The grounded theory is used to analyse all findings as presented in table 4.3 and figure 4.3.

Table 4.2: Principles and work procedures of all disciplines involved

Discipline	Principles and Procedures
Design manager	**Principles**: Product and technology should be developed from user's perspective. He controlled a process of transforming marketing requirements into a ready-to-manufacture product. The company's stage-gate process contained: planning, technology development, design, implementation and sale. Currently, his team including graphic design, user interface cover engineering, industrial design and human factor was responsible for the design stage. However, he aimed to extend the team's role to other stages. At present, he received design briefs from marketing department, planned the projects and then assigned works to his team. An interdisciplinary approach was used to address multiple views. He stressed that the role of design in electronic sector was crucial, as the values of technology were illustrated by design.

Discipline	Principles and Procedures
Smart Clothing designer	**Aim**: Seeking new ways to make everyday life easier through body-adapted devices. He worked with a company that produced concepts, products and systems of wearable technology for athletes, professionals and ordinary people. His job included developing concepts, generating design drawings and producing prototype garments. He worked with many disciplines: industrial design, clothing design, textile engineering, software and hardware development, telecommunication, production, marketing and sales. As all disciplines worked in the same place, it was easy to ask question and get immediate feedback. Due to its small size, young interdisciplinary members and good communication, his team was flexible, up-to-date and able to develop radical ideas for Smart Clothing applications.
Fashion designer	**Key point**: *'People want beautiful things and to wear clothes that make them desirable.'* Fashion designers were at the top of the hierarchy in the apparel product development process. They were responsible to conduct a research, which was pretty much the same process as an artist getting an inspiration, preview new fabrics and trends by visiting fabric trade fairs or fabric agents, and design a collection with customer's profile in mind. The task of transforming design into prototype garments, grading patterns into different sizes, controlling a production, and sampling the samples from the suppliers were carried out by other disciplines. In a small studio, communication was casual and most works were still done by hand. In a large company, fashion designers never met a pattern cutter or a machinist.
Product designer	**Main concern**: Inherent function and user perception, market demands, and user interface Firstly, she had a meeting with a client to get the information, plan a product development and define an entity of a new product, key problems and design direction. Secondly, the market research and product research were conducted. Next, concepts and strategies were generated. The preliminary concepts were evaluated in the first screen meeting with the clients. After the first screen, the concepts were narrowed down to two to three designs that would be developed further in details. Finally, one design was chosen and its technical drawings were created. In a large-scale project, another designer was hired to support in terms of computer modelling. In most cases, she worked with a product manager and engineer. As she worked closely with the engineers, her designs could achieve both innovative mechanism and attractive appearance.
Electronic engineer	**Comment**: Technology should be developed based on the user's requirements His job was to develop hardware for wearable application. The process was an iterative, since hardware was developed and tested until it meets all criteria. Most tests aimed to measure product performance. The process included a lot of minor modifications, as his team wanted to see the effect of every small aspect. However, his team did not conduct any user research. Although his company had both designers and engineers, they worked in separate places. He was not involved in any design work but in technology development. He worked closely with the manufacturers to make sure that all electronic parts fit in clothing production process.

Discipline	Principles and Procedures
Textile scientists	**Main focus**: Explore technical textile area and utilise new textile materials They often worked in collaboration with a private company, electronic engineers and fashion design team. The whole collaborative team planned about the targets and design specifications together but each group worked separately. The team met three to four times per year to show the progress. The original idea could come from any group. If these textile technicians were an initiator, they started by creating a scenario based on the practical test on a real situation, interview, and observation. Their job was to source, test and apply textile materials according to the design produced by the fashion team. They focused on integrating electronic functions into textiles, as they tried to achieve certain properties through the choice of textiles rather than using electronic components. This way, textile materials became more than just a fabric.
Intelligent textile designer	**Role**: *'My job is to solve a client's problem in the field of textile.'* She took care of a new field of production, which was totally different from a conventional textile design. The clients were engineers from varied areas. The development team also included marketers and production staffs. The team and the clients met regularly. The process was slow and full of uncertainties, which was similar to a scientific experiment. Firstly, the theoretical background about materials and structures was studied. Secondly, materials were sourced out and tested. Certain weaves with several combinations of materials were designed. The weave samples were produced and tested. Next, the test results were analysed. Then, the design was modified accordingly. The work was repeated until the design met all criteria.

Table 4.3: Properties and dimension range of 'Creative Constrain Breakthrough'

Category	Properties	Dimension
1. Creative constraint breakthrough	• Understanding the requirements of a particular project • Understanding the principles and procedures of all participants involved • Realising a need for a new way of thinking and working • Carrying out design task within a new principles and procedures	High High High High
2. Activities	• Define a context of a particular project • Describe the requirements of that project • Learn the principles and procedures of all participants involved • Clarify a need for a new thinking and working framework • Make sure every discipline realises the need for new framework • Identify the specifications of a new framework • Develop a new framework of thinking and working • Make sure every discipline understands the new framework • Employ this new framework when carrying out development task	High High High High High High High High High

Causal condition →	**Phenomenon**	
People stick to conventional principle and process	Breakthrough an existing creative constraint	
Properties of Creative Constraint Breakthrough	**Specific Dimensional of a Breakthrough**	
- Understanding project's requirements	Clearly defining a project's context	High
	Clearly describing the project's requirements	High
	Ensuring mutual understanding about the project	High
- Understanding all principles and procedures	Being aware of all disciplines' principles	High
	Being aware of all disciplines' work procedures	High
- Realising of a need for a new method	Realising a need for a new work procedure	High
	Ensuring mutual understanding about this need	High
- Carrying out development task in a new way	Ensuring mutual understanding about a method	High
	Being able to think and work in the new way	High

Context of Creative Constraint Breakthrough

Under a condition where conventional ways of thinking and working prevent the members of development teams to fulfil their goal; that is creating a radical outcome outside electronic and fashion boundary, there is a need for a new framework of thinking and working in order to break through existing creative constraints.

Strategies for Creative Constrain Breakthrough

1. Define a context of a particular project	2. Describe requirements of this project
3. Learn all disciplines' principles and processes	4. Clarify a need for a new framework
5. Make sure everybody realise this need	6. Identify the specification of a new framework
7. Develop the new framework accordingly	8. Ensure the framework can be used by to all disciplines
9. Employ the new way of thinking and working	

Intervening Conditions

It is difficult to change people's principles and procedures. Thus, the new framework should require as less effort as possible to adopt. Although all participants realise the need for a new framework, and their process and principles are identified, Smart Clothing's context and user requirements have yet been recognised.

Consequences

The context and requirements must be defined before a new framework can be created. To make sure that the new framework is synchronised with the NPD process, it should be addressed in NPD model of Smart Clothing. Moreover, it should be developed based on the principles and procedures of all participants.

Figure 4.3: Paradigm Model – phenomenon of the creative constraint breakthrough

4.2.2 Conclusion – Methods to Overcome the Constraints

Currently, the conventional way of thinking and working prevents Smart Clothing developers from delivering a radical idea. In order to overcome the existing creative constraints, it is important that all participants realise the need for a new way of thinking and working. This need is best described by one of the interviewees, a fashion designer, as she commented *'We need to get beyond stereotyping creatives and tekkies, some creative processes can be extremely technical and complex and some technology can be extremely creative and in its own way, beautiful. We need to have the end user or consumer in mind at all times, and not get seduced by tech for tech's sake, an all-to-easy trap. Just because we can create a jacket that acts like a phone doesn't mean there is a market for it.'*

The highest level of breakthrough or adopting a whole new way of thinking and working is required for the Smart Clothing development. This new framework must be developed based on the Smart Clothing context. Furthermore, it should include certain existing principles and work procedures of the developers. As a result, the new framework is comprehensible and can be used by all participants. Besides, it should be part of the Smart Clothing NPD model to ensure that the new procedure synchronises with the NPD process. The practical methods to overcome the creative constraints are suggested as follows:

1. Define a context of a particular project
2. Identify the requirements of the project
3. Try to understand all disciplines' principles and work procedures
4. Clarify a need for a new framework of thinking and working
5. Make sure every participant realises the need for a new framework
6. Create the specification of a new framework
7. Develop the new framework according to the specification
8. Make sure the framework is comprehensible and can be used by all disciplines

9. Employ the new framework when carrying out the development task

4.3 Methods to Achieve Full Integration

This research focuses on a full integration in terms of design. Therefore, a convergence of electronic and textile technologies is excluded. The methods to achieve a full integration of the fashion design and electronic product design are deduced from the results of the case studies investigating previous ‘integrated’ projects and focus groups conducted with Smart Clothing’s major design contributors, fashion and product designers. As a result, this section describes 1) contributions from fashion designers, 2) contributions from product designers, 3) alternative ways to achieve a full integration, and 4) conclusion.

4.3.1 Contributions from Fashion Designers

In this part, the core values of fashion design, the contributions of fashion design to a general design collaboration, and the contributions of fashion design to a Smart Clothing development project are presented as follows:

1. **The core values of fashion design: fulfilling emotional needs of the consumers**.

   All respondents in the focus group agreed that the core value of fashion design was to fulfil emotional needs of the consumer. One fashion designer emphasised that fashion design was to provide *‘pleasure’* to the user. As a result, all fashion designers started their projects by identifying the emotional feeling their customers wanted to have. Some designers obtained the ideas about the desirable feelings directly from their target audiences by discussing with their customers and observing their purchasing process. However, some designers’ processes were similar to an artist’s, as they started by looking for anything to inspire them or asking themselves what they want to wear.

This was because certain designers thought that they should lead their customers. Moreover, they did not need to convince people to try their clothes, as they believed that there were enough consumers who share the same lifestyle, interest and taste with them. All respondents stressed that the initial ideas did not have to be restricted to the fashion area. Nevertheless, these ideas must be based on people's lifestyle.

2. **Contributions to a general collaboration: individual design under one theme**.

It was not common for fashion designers to work in the collaborative team. Many of them reported that they only worked with other fashion designers in the group projects in the design schools. According to their experiences, most designers did not actually work together but rather shared a collection. In other words, they worked on their own, but made sure that every design went well together. For instance, one of them described *'in my company, we separated the target groups, such as office ladies, campus girls and so on. There were three collections for women. Thus, we had three main designers. Before we started the design, we had a meeting to decide the key trends and colours. So each designer created their own designs but followed the trends and colours. The three collections were matched because we used the same colour and so on. Because the shapes were different, the designs were not too similar.'* In the case where designers developed a design together, firstly they set up a goal. Secondly, each designer developed the designs on their own and presented to the group. Next, the team selected the best design, separated the tasks and assigned them due to the special expertise of the members. Once the tasks were assigned, each designer completed their work separately. To summarise, the fashion designers provided an individual design under the selected concept or theme of collection.

3. **Contributions of fashion design to Smart Clothing development project: providing aesthetic sense and fashion consideration**

   All designers suggested that they could provide some aesthetic sense to Smart Clothing applications and make it more acceptable for the consumers. This was because they believed that the fashionable look was still lacking. Because a final outcome was an apparel product, Smart Clothes should be designed with fashion consideration. For example, one designer suggested *‘ I can make it more valuable, suitable and maybe comfortable. Not just function. You can feel very good when you wear it.’* They noted that they could bring the knowledge about how people interact with clothes and consumer’s lifestyle to Smart Clothing development teams. Some designers stressed that the most important thing for a clothing product was to make people like it and want to buy it. Since the price of Smart Clothes was still high, the respondents believed that it should provide more than high-tech functions. As a result, they recommended that Smart Clothing’s design direction should be rethought or reconsidered, as one designer said *‘I will tell the group’s members that maybe the direction is not about technical things at all, but how to make people really buy it.’* Moreover, another respondent added *‘Just two words. Simple but smart.’*

4.3.2 Contributions from Product Designers

In this part, the core values of product design, the contributions of product design to general design collaboration, and the contributions of product design to a Smart Clothing development project are demonstrated respectively as follows.

1. **The core values of product design: finding a right solution for all stakeholders**

   Most respondents stated that product design was user-centred. The core value was to fulfil user needs and wants, respond to emerging trends, and help a company gain benefits and win the competition through product differentiation. While marketers focused on 'macro' things, product designers concentrated on 'micro' things or small details, such as a particular interaction between user and product. Since product designers were also concerned about technology, they were able to bring together the user's point of view and technology point of view. The respondents agreed that product design was to solve a problem. Therefore, they started by identifying the 'real' problem. The solution did not have to be a product, as sometimes, they suggested strategic solutions instead. The ability to think strategically allowed the designers to visualise the product that did not exist. Some respondents suggested that product designers should be called 'multi-talented', as they had a wide range of knowledge and were concerned about many different things. Consequently, their way of thinking was flexible and was not restricted to the particular area they were working on.

2. **Contributions to a general collaboration: knowledge about user and technology**
   It was not common for product designers to work with other designers, as most respondents reported that they normally worked with marketeers, project managers or engineers. They explained that product designers could help balance technology and user requirements. Moreover, they could provide the knowledge in terms of materials, technologies, and new applications of materials. Besides, they could bring logical thinking to the collaborative teams. As product designers were concerned about many aspects beyond the design stage, they could provide strategic thinking and develop an 'extended' brief for the teams. Their knowledge about technologies, company requirements and engineering techniques could help reduce the cost of the product.

Due to their realistic and practical approach, product designers frequently tested and corrected their designs. As a result, they could also bring practical testing methods and an iterative development process to their teams, which could improve the results.

3. **The contributions for Smart Clothing project: objective approach, logical and realistic thinking, and knowledge of materials, human factors and technologies**. Since product designers often worked with many constraints, most respondents described that developing Smart Clothes was similar to working in a big project. Different people contributed different things according to their different expertise and different stages. One respondent used ‘concept car’ and ‘commercial car’ as an example to illustrate different contributions. For him, fashion design was similar to the concept vehicle design. Since there was no constraint, fashion designers could use their full imagination. On the contrary, product design was similar to the commercial vehicle design, as the design team must be concerned about safety, production process and so on. This respondent concluded that fashion designers should contribute in terms of concept design and vision of the future, whilst product designers and engineers could contribute to the design embodiment and production. Because product designers had knowledge in both design and technology, the respondents believed that they could bridge the gap between fashion and technology and make the result more integrated. Their objective approach could be employed in design and decision-making, such as selecting the best solution. Besides, all respondents noted that they could suggest Smart Clothing teams to consider upcoming matters, such as sustainability and environmental legislations.

To summarise, the contributions from fashion and product design complement each other. Whilst fashion designers can contribute to the concept design due to their expertise in emotional feelings and radically creative ideas, product designers could bring their logical thinking, user-centred approach, and knowledge about technologies and business requirements to this collaboration. Therefore, there is potential for these contributions to be combined successfully. Nevertheless, the integration has yet to be achieved, since the contributions from both areas are separated. Both types of designer seldom carry out design work with other designers. They tend to develop an individual design under a selected concept. As a result, all designs could go together well, but are not integrated.

4.3.3 Alternative Ways to Achieve Full Integration

From technical point of views, most interviewees and focus group respondents described a full integration of electronic technology and clothing as a condition where all electronic components were made with textile materials and could be treated like ordinary clothes. From the design point of view, the full integration referred to a circumstance where fashion clothing design and electronic product design could not be separated. In other words, every piece of electronic function was considered a clothing component and each part of a garment supported the electronic function(s). This assumption is supported by the results of the case studies, as they reveal that previous successfully 'integrated' products resulted from an ability to develop technological components from fashion elements or as fashion elements and vice versa. Accordingly, each part of the 'integrated' product shares the characteristics of fashion clothes and high-tech products.

In Sportswear Design, the clothing elements, e.g. pattern, cutting and fabrics, are designed or selected according to the functions. For instance, the patterns on both sides of sport shoes are designed to make certain parts of the fabric become more rigid in order to ensure that the feet are fixed in the right place and right position, and protect the ankles from twisting. One of the sportswear educators explained *'if you are the designer of functional sport shoes, you need to know how the foot moves on that special sport activity, what is the performance of the shoes, and then you can find out where you need to support, where you need it to be loose, where you need shock absorption and where you need to have it very tight. That's why there is a pattern here (on both sides of Nike Shox shoes – Boing models). That's a very technical idea. It looks like a pattern design, but there is a function. You need to know where you're not allowed to put any design and where you can put the pieces of pattern – the one that looks good, but it also functions.'* Furthermore, the components serving technical functions, such as the soft padding in Marc Saddle's safety jacket (1994), which protected the wearer from a serious joint injury in varied activities, e.g. horseback riding, skiing, and motorcycling, were designed with fashion consideration. Holt (1998) describes this safety jacket as *'a piece of high-fashion armour'* because it not only protects the wearer but also intimidates the opponents.

Moreover, all functions are achieved through textile materials and clothing techniques, as another sportswear educator expressed *'in this area, design is fabric-driven. The cutting is the main part of design. The special cutting is very important to sportswear because the ability to move freely and comfortably come first in this type of garment. Sportswear is very much the application of technical textiles. We are people that know how to use them and how to match what the end user needs with the right textile and the right shape of garment.'* This also demonstrates that a full integration requires a clear goal/purpose.

In Smart Car design, the fashion design concepts, such as ability to personalise the exterior design through the choices of two-colour chassis and colourful panels, are supported by advanced technology, a strong structure chassis that can hold all panels without any support from other components (Van Hoek and Weken, 2000). At the same time, the values of Smart Car's high technology are presented through its fashion design concepts. Since Mercedes Benz AG and SMH (the producer of Swatch) had developed their own designs up to the prototype, they were well aware of what the other partner could contribute to this project (Lillford, 2003). To make sure that all contributions were delivered as expected, a basis for this collaboration was established (Weernink, 1997). As a child organisation was formed, the development teams from both partners worked together in the same space. As a result, the knowledge and resources, as well as the characteristics of both partners, were shared. It is important to point out that the key factor that made these two partners able to form the child organisation successfully was due to their shared motivation and vision – producing a radical environmental-friendly car (BBC, 1994). The condition of a shared goal made them commit themselves to the project and willing to work together. The results of the case studies illustrate an overlapping between the boundaries of fashion design and technical product design, as both product and fashion designers have to consider certain aspects from other areas (see figure 4.4).

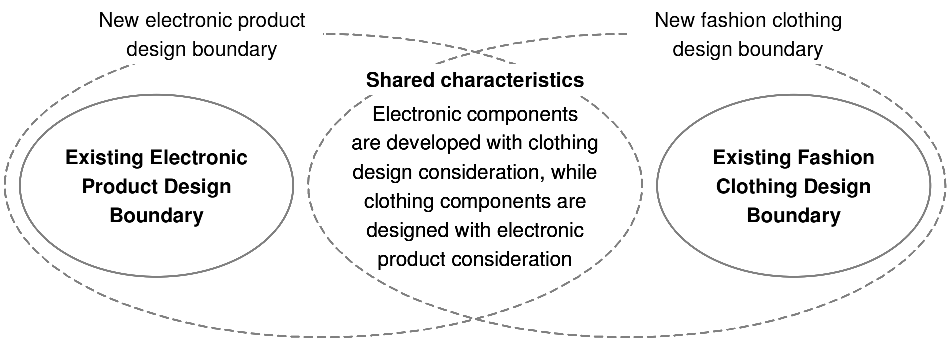

Figure 4.4: The overlapping of electronic product design and clothing design

To conclude, the results of the case studies illustrate that each part of Smart Clothes should be developed from the shared characteristics of its major design inputs, namely fashion design and electronic product design. Therefore, no component is designed purely from the electronic point of view or fashion point of view. Nonetheless, the characteristics of both areas must be selected and balanced based on the purpose of the product. As a result, a clear goal is required. Accordingly, an existing creative boundary of each designer must be stretched, since both product and fashion designer need to take important aspects from other areas into consideration. This demonstrates that balance contributions and creative-constraint breakthrough support the achievement of full integration. However, the ability to develop designs based on the shared characteristics is probably the most crucial factor. For instance, Sportswear Design has the creative characteristic of the fashion design and realistic and practical approach of product design, as described by the sportswear educator *'it is about designing things that have to function and part of function is to look good. It's a very straightforward practical approach and the same time you need to be innovative and exciting. It's not innovative if it doesn't work.'* The grounded theory analysis is used to analyse the research results. The analytical result is presented below.

Table 4.4: Properties and dimension range of 'Full Integration' Phenomenon

Category	Properties	Dimension
1. Full integration	• Product shares the characteristics of its major design inputs • Characteristics of the major design inputs are balanced due to the goal • Creative boundaries of both design disciplines are expanded to support the shared characteristics of a final outcome	High High High
2. Activities	• Define the goal of the final outcome • Identify what are product designers and fashion designers' characteristics • Indicate what are product designers and fashion designers' contributions • Specify what characteristics should be addressed in Smart Clothes	High High High High

Category	Properties	Dimension
2. Activities	• Make sure the characteristics are balance based on the goal/purpose • Expand existing boundary by taking other areas into consideration • Develop product based on the shared characteristics of both areas	High High High

Causal condition →	**Phenomenon**	
Contributions of both designers are separated	Full integration of fashion and electronic product design	
Properties of a full integration	**Specific Dimensional of a full integration**	
- Product share characteristics of both areas	Understand the characteristics of both areas	High
	Understand the contributions of both fields	High
	Understand the goal or purpose of the product	High
	Identify which characteristics are needed	High
	Ensure that characteristics of both areas are shared	High
- Characteristics of both areas are balanced	Balance all characteristics due to the goal/purpose	High
- Existing creative boundary is expanded	Understand important aspects of other areas	High
	Take the key factors of other areas into consideration	High

A Full Integration Achievement Context

Under conditions where the major design contributors are fashion designer and electronic product designer and a full integration of the contributions of both designers is required, there is a need to overcome the separated contributions currently prevent development team from achieving a fully integrated outcome.

Strategies for Full Integration Achievement

1. Define the goal of the final outcome
2. Identify characteristics of fashion and electronic design
3. Clarify the contributions of both areas
4. Specify characteristics should be addressed in this project
5. Make sure the characteristics are balanced
6. Take key aspects of other areas into consideration
7. Develop product based on the shared characteristics of both fashion design and electronic product design

Intervening Conditions

Although, there is a potential to combine the contributions from product designers and fashion designer, it is difficult to make these designers develop a design together, as all designers prefer to work on their own.

Consequences

A method that makes each designer takes key aspects of other areas into consideration while carrying out work on their own is required. Since all designers are able to develop individual design under the same theme, it is possible to create the theme based on the shared characteristics of electronic product and fashion design. However, the characteristics to be addressed must be chosen and balanced according to the goal.

Figure 4.5: Paradigm Model – phenomenon of a full integration achievement

4.3.4 Conclusion – Methods to Achieve Full Integration

According to the focus group results, the characteristics and contributions from product designers and fashion designers compliment each other. While the creative and emotional nature of fashion design plays an important role in concept design, a user-centred approach and technical knowledge of product design turn these radical ideas into a realistic and commercial product. Nevertheless, it is not common for both types of designers to carry out a design work with other designers; therefore, their contributions are not fully integrated. The case studies demonstrate that successful integration results from an ability to develop a design based on the shared characteristics of the major design inputs. As a result, the methods must enable both fashion designers and product designers to address important aspects from each other's fields while working separately. Since all designers are used to develop individual designs under one selected concept, it is possible to create this concept based on the shared characteristics of the major design contributors.

However, the characteristics from both areas must be chosen and balanced according to the goal or purpose of the end product. For instance, if the development team aims to produce a medical application, they must decide which fashion characteristics should be addressed in this product, e.g. make it unrecognisable by other people and look attractive when being used. Furthermore, product design characteristics, such as safety, user interaction, etc, must be incorporated to ensure that the product is practical and safe to use. The analytical results suggest the methods to achieve a full integration as follows:

1. Define the goal or purpose of the final outcome
2. Identify characteristics of fashion and electronic design
3. Clarify the contributions of both fashion and electronic designer

4. Specify the characteristics that need to be addressed according to the goal
5. Make sure the characteristics from both areas are balanced due to the goal
6. Expand existing creative boundary of each designer by taking important aspects of other areas into consideration when carrying out design work
7. Develop product based on the shared characteristics of both design areas

4.4 Smart Clothing's Context

In order to develop the context of Smart Clothing, the target market, user requirements and new design direction of Smart Clothing applications must be clarified. As a result, the findings can be divided into three groups: 1) consumer profile and requirements, 2) future lifestyle scenario and 3) new design direction. The first two groups are developed based on the questionnaire findings, while the last category are created based on the focus group results supported by the information from the interviews. Finally, the product context of Smart Clothes is generated. (The findings presented in this section are already sorted and analysed, the raw findings of the questionnaires are presented in Appendix B.)

4.4.1 User Profile and Requirements

The findings from the questionnaires reveal that the personality of this group is different from what some Smart Clothing developers expected. The target audiences did not perceive themselves as 'high-tech' as described by several developers. For example, the highest score in terms of self-perceived personality is sporty and health-concerned (18.6%), followed by practical and price-concerned (17.1%), and fashion-conscious (14.3%). None of the respondents expressed an interest in people with 'high-tech' lifestyle, as their role models are either celebrities in the entertainment business (31.4%), top athletes (20%) or successful professionals, such as famous designers, chief executives of leading companies and writers (20%). Moreover, the role models are chosen either due to their personality (31.4%), success (15.7%) or physical appearance (11.4%). Although the high-tech gadgets appealed to the respondents, electronic devices did not come first in the list of favourite objects. Fashion items received the top score (24.3%), followed by personal electronic devices (21.4%) and work related products (18.6%). Nonetheless, these objects were chosen either because of their usefulness and practical function (37.1%), personal values such as bringing back a childhood memory (20%), or a unique design and beauty of the product (18.6%), and not high-tech features.

A chi-square test assessed the two-tailed prediction, that there would be an association between the type of products (a mobile phone, a fashion garment and sport shoes) and purchasing criteria, to be significant ($X^2 = 59.65$, df = 14; $P<0.05$). Hence, there was a significant association between the product type and the reason why it was purchased. A breaking down of the different purchasing criteria to assess which criteria was dictating purchase illustrated that 'good design' influenced the purchase of all products (see table 4.5), for example, 31.4% of respondents selected a mobile phone due to its 'good design'; 44.3% of respondents declared that 'good design' affected the purchase of sport shoes; and 21.4% of the respondents reported that 'good design' was a key factor when purchasing a fashion garment. However, there were some differences in the way people perceive, purchase and use different products, especially electronic devices and clothes (see figure 4.6). For instance, the fashion clothes are purchased frequently compared to electronic devices (see table 4.6) and they are mainly selected based on emotional values, e.g.

matching the user's lifestyle (51.3%). In contrast, many consumers purchased an electronic device due to its practical functions (17.1%) and provision of various features (22.9%).

Table 4.5: Desirable factors affecting consumer's purchasing

Criteria	**Mobile phone**		**Fashion garment**		**Sport shoes**	
Good design	**22**	31.4%	**15**	21.4%	**31**	44.3%
Practicality	**12**	17.1%	2	2.9%	**11**	15.7%
Newness/Trendiness	1	1.4%	2	2.9%	0	0.0%
Reliability/High quality	4	5.7%	4	5.7%	**8**	11.4%
Match your lifestyle	8	11.4%	**36**	51.4%	7	10.0%
Value for money	5	7.1%	4	5.7%	7	10.0%
Famous brand	0	0.0%	0	0.0%	0	0.0%
Varied features/Multipurpose	**16**	22.9%	**6**	8.6%	4	5.7%
Other	2	2.9%	1	1.4%	2	2.9%

Table 4.6: Comparison of the frequencies of purchasing

Frequency of purchasing mobile phones		**Frequency of purchasing clothes**	
When the old one is broken	39.2%	Once a month	33.9%
Once every year	30.4%	Every two-three weeks	19.6%
Every two-three years	23.2%	Every two-three months	12.5%

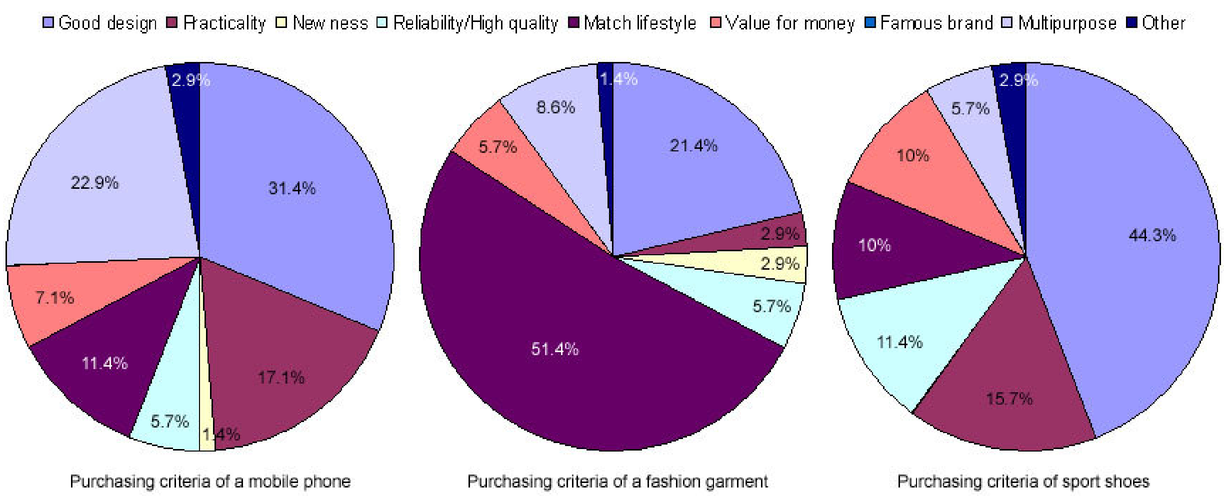

Figure 4.6: Pie charts illustrating purchasing criteria of three different products

Undesirable factors were also investigated, since certain factors that had a small impact on purchasing could have a great influence on rejecting a particular product (see figure 4.6-7). For instance, only 5.7% of the respondents reported that 'high quality' and 'value for money' influenced the purchase of a fashion garment (see table 4.5). However, 15.7% of the respondents declared that they would reject a fashion garment if it had an unreasonable price and 18.7% of respondents stated that low quality influenced their decision to reject a particular brand (see table 4.7). Furthermore, the factors that had no effect on sport shoes' purchasing criteria, such as newness and famous brand, had some impact on the decision to reject particular shoes. For example, 7.1% of respondents affirmed that they would reject sport shoes if they were old-fashioned and 4.3% of respondents proclaimed they would not buy no-named sport shoes (see table 4.7). A chi-square test was also conducted to assess the two-tailed prediction, that there would be an association between the type of products and undesirable factors, to be significant (X^2 = 53.63, df = 16; $P<0.05$). Thus, there was a significant association between the product type and the reason why it was rejected. (Further information is shown in Appendix C.)

Table 4.7: Undesirable factors affecting consumer's purchasing

Criteria	**Mobile phone**		**Fashion garment**		**Sport shoes**	
Unattractive design	**34**	48.6%	**23**	32.9%	**25**	35.7%
Impracticality	**15**	21.4%	2	2.9%	5	7.1%
Dated or old-fashioned	6	8.6%	1	1.4%	5	7.1%
Low quality	0	0.0%	**13**	18.5%	**13**	18.5%
Do not match your lifestyle	3	4.3%	**16**	22.9%	4	5.7%
Unreasonable price	**8**	11.4%	11	15.7%	**13**	18.5%
No-name brand	0	0.0%	0	0.0%	3	4.3%
Limited function	3	4.3%	3	4.3%	1	1.4%
Other	1	1.4%	1	1.4%	1	1.4%

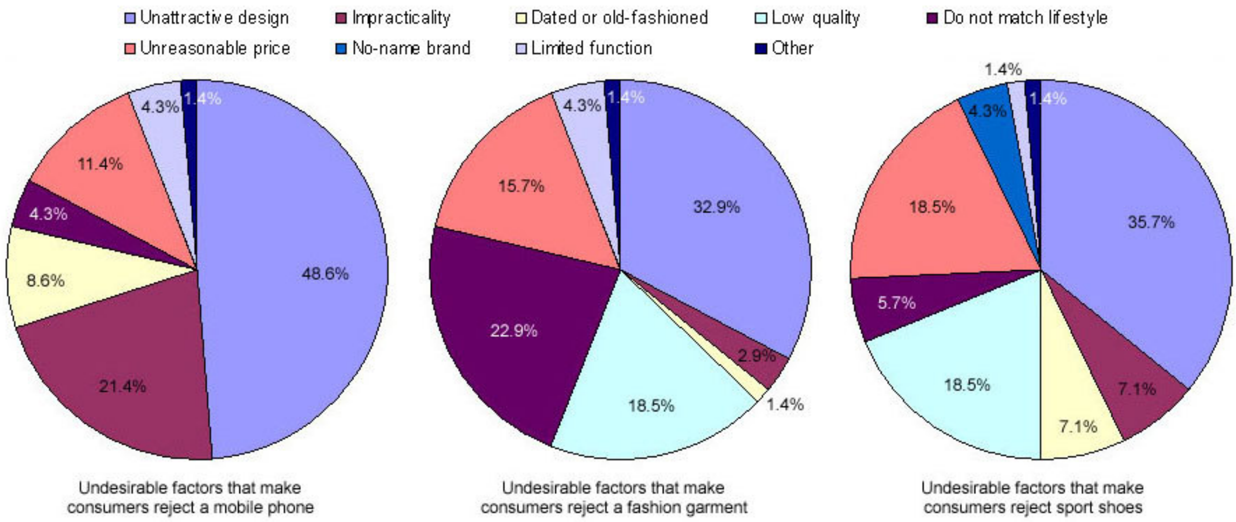

Figure 4.7: Pie charts demonstrating undesirable factors influencing purchasing behaviour

A wilcoxon test was carried out to assess the difference between the two product types (a mobile phone - a fashion garment; a fashion garment - sport shoes; a mobile phone - sport shoes). The result indicated that there was a significant difference between the purchasing criteria of a mobile phone and a fashion garment ($z = 0.92$; $p < 0.05$), a fashion garment and sport shoes ($z = 3.29$; $p < 0.05$) and a mobile phone and sport shoes ($z = 2.37$;$p < 0.05$). Therefore, it can be conclude that there was a significant difference between the purchasing criteria of different product types. The difference between the purchasing criteria of different products illustrates a potential problem of a hybrid product like Smart Clothing. Whilst the clothing parts of Smart Clothes may be selected according to a fashion garment's criteria, such as matching lifestyle and attractive design, the electronic parts of Smart Clothing application may be chosen due to the number of features and practicality. In addition, the frequency of purchase is significantly different. For instance, 33.9% the respondents reported that they purchased new garments every month, while 32.9% of respondents stated that they would not buy a new mobile phone until the old one broke down. Nevertheless, there was a possibility to reconcile the difference, since the key factors influence the purchase of these three products were similar (see figure 4.6-7).

According to the pie charts, it can be seen that sportswear's purchasing criteria was a combination of those of an electronic device and a fashion garment, as it addressed factors that influenced the purchase of a fashion garment, namely good design, high quality and matching users' lifestyle, as well as factors that affected the purchase of an electronic device, such as practicality. Moreover, the favourite choice of each category was a combination of fashionable design, lifestyle matching and practical function. For example a Nokia mobile phone and Nike shoes (see table 4.8). Noticeably, the respondents' preference of fashionable design and practicality was applied across different products.

Table 4.8: Users' preference – comparison between three different products

Mobile phone			**Fashion garment**			**Sport shoes**		
Nokia	34	48.6%	Gap	18	25.7%	Nike	42	60.0%
Sony Ericsson	18	25.7%	Other	13	18.5%	Adidas	10	14.3%
Samsung	8	11.4%	DKNY	12	17.1%	Puma	8	11.4%
Siemens	3	4.3%	Topshop	9	12.9%	Converse	4	5.7%
Panasonic	2	2.9%	H&M	9	12.9%	Other	3	4.3%
Sharp	2	2.9%	NEXT	7	10.0%	Reebok	1	1.4%
Other	2	2.9%	Versace	2	2.9%	Fila	1	1.4%
NEC	1	1.4%	M&S	0	0.0%	Mizuno	1	1.4%
Motorola	0	0.0%	Matalan	0	0.0%	Ellesse	0	0.0%

Considering these results, a spectrum of purchasing criteria was constructed (see figure 4.8). 'Practical function and features' comprised one end, and 'emotions and lifestyle' comprised the other end. On this spectrum, the various products such as electronic, sportswear and fashion items were placed as a result of the questionnaire survey. Figure 4.8 conveys that the position of sportswear on the spectrum is probably the appropriate place for Smart Clothes, as the Smart Clothes must address practical function like electronic devices do, and attractive design and emotional values as fashion clothes do.

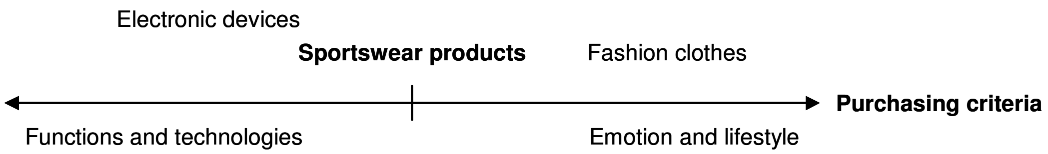

Figure 4.8: Spectrum of purchasing criteria illustrating position of three different products

To summarise, according to the choices of role models and their personalities, it can be assumed that the targets are interested in sports, health, and their looks. Although, the targets chose the products due to their physical appearance, they were also concerned about the usability and price. Besides, the products must match and express desirable lifestyle, and address both functional and emotional aspects like sportswear products.

4.4.2 Vision of Future Lifestyle

The questionnaire results reveal that the consumers' vision of future lifestyle is different from the existing scenarios created by Smart Clothing developers. From the developers' point of view, Smart Clothes should provide appropriate services at the right place and time according to the environmental context it senses without user conscious operation. The functions that the application should perform range from location sensor and navigation, entertainment, shop assistant, memory enhancement, etc. Nevertheless, the consumers are more concerned about how the product can enhance their quality of life in terms of health and well-being (44.3%). These findings support the user profile described earlier. Only a few targets believe that future lifestyle is about artificial intelligence (2.9%) and avant-garde design (2.9%). In contrast, many respondents pay more attention to environmental issues (22.9%) and how to enrich their sensory experiences (10%).

4.4.3 New Design Direction

The future design direction is the only area where all primary research overlaps. The research structure is conceptually similar to the 'Delphi technique', which was developed to obtain a consensus view on a given subject. Baxter (1995) summarises that, in the Delphi technique, firstly, structured questionnaires are developed and sent to selected experts in a particular area, in order to gain a broad ranges of ideas. The responses from the first round are collected and summarised to form a basis for the second questionnaires, which aim to clarify or expand the issues, identify areas of agreement and disagreement, etc. In most cases, the participants are asked to vote on a specific proposal. The feedbacks from the second round are summarised and sent back in the form of the third questionnaires. In this way, the results of the third round are regarded as a consensus opinion of the participants.

This research aimed to identify areas of agreement of all stakeholders, including, not only existing Smart Clothing developers, but also potential users and potential developers. Thus, firstly, the literature review and interviews with the key developers were employed to explore a broad range of possibilities for the Smart Clothing design direction. The responses from the interviews were collected and analysed to form a questionnaire, which clarifies whether the end users agreed with the key developers and establishes a user profile and purchasing criteria. As a result, this questionnaire survey investigated the user's personality, consumer's requirements, perception of related products and their visions of future lifestyle and test certain ideas suggested by the interviewees and literature. Lastly, the results from the focus groups identified precise design directions and their implementations. Different perspectives from three groups of stakeholders were analysed in order to find out the consensus of opinions (see figure 4.9). Similar recommendations were drawn as a potential design direction. The ideas that are different are also useful. However, it is probably easier for the developers to start with a vision that is shared by all stakeholders. In this section, a summary of Smart Clothing's design directions suggested by the focus groups and interviews are presented (see table 4.9-10).

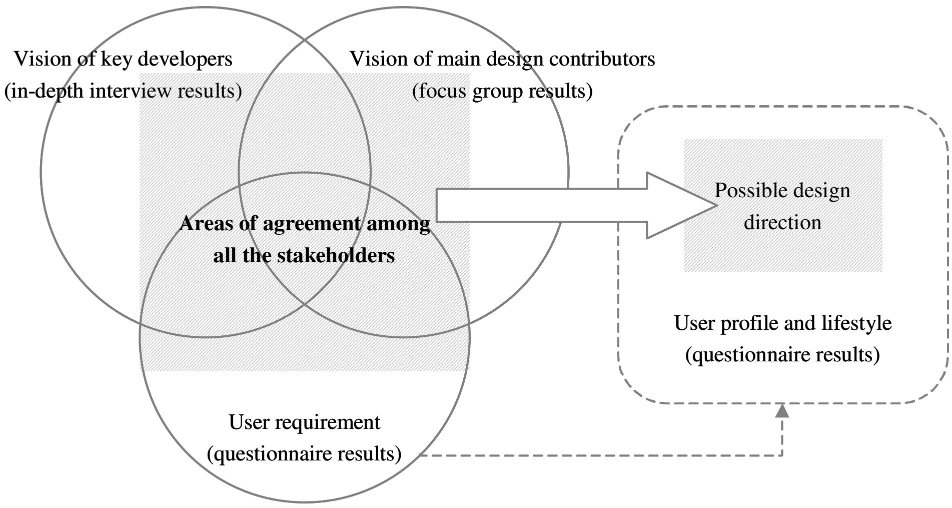

Figure 4.9: Diagram demonstrating a consensus agreement from all the stakeholders

Table 4.9: Smart Clothing's design directions deduced from the interviews

Discipline	**Smart Clothing's Design Direction**
Design manager	Technology should be developed from the user perspectives. Therefore, the focus should be values for users. The cultural impacts, consumer lifestyle, social acceptance, product lifecycle and sustainability issues must be addressed. The challenge was to change people's perception of fashion and electronic goods. Purchasing criteria of both products should be examined.
Intelligent textile designer	In the next five to ten years, every piece of clothing would have some electronics. The fastest growing sector was medical products, due to the development in the nanotechnology. Pressure sensor, temperature control and entertainment applications also represented an interesting area.

Discipline	Smart Clothing's Design Direction
Product designer	The current applications were not realistic due to the technological limitation and the lack of practical functions. The developers should adopt a functional approach and pay more attention to social acceptance. Smart Clothes could be a wearable item, which might be more suitable.
Smart Clothing designer	Technological achievement provided a plenty of opportunities. His team continued to develop simple body-worn devices. The unpractical gadgets made the users did not take Smart Clothes seriously; therefore, the developers should thoroughly develop a useful and functional design.
Fashion designer	Future lay in collaboration between different disciplines to create a product where technology was invisible and clothing performed the functions as always with a few discrete extra features.
Electronic engineer	Integrating electronics into clothes required a functional reason, as it led to many technical problems. One solution was to use a modular system and a universal interface, which allowed any device to be plugged into the garment. However, this idea limited the functionality of the devices, as the system could not keep up with the new function. The other way was that the devices must be produced cheaply; thus, they could be fitted into every garment. Currently, the trends for the mass market moved toward physical monitoring and healthcare. Sportswear products represented a suitable choice due to its experimental and innovative nature.
Textile Technician	Many products available on the market were not useful, complicated and expensive. Some prototypes for elderly people and those in healthcare and sport area seemed to be useful and had a potential market. The future lay on consumer latent needs, which had not been realised.
Trend researcher	There were many issues to be explored, such as fashion versus function, the reason behind people's purchasing and using electronic devices and fashion clothes, and user requirements.

Table 4.10: Smart Clothing's design directions deduced from the focus groups

Discipline	Smart Clothing's Design Directions
Focus group with five product designers	Due to their user-centre approach, the group preferred practical applications, such as those for the military, monitoring and medical because these products had a potential market and fit the current trend, i.e., a healthy and well-being lifestyle. Since product designers are always concerned about business benefits, some respondents were interested in the ideas that could be achieved with today's technologies, e.g. child monitoring applications. The group challenged the word 'Smart' and later agreed that it meant technology was invisible and function was provided only when it was needed without the user's conscious thought, which was similar to the Smart Clothing developers' idea. However, the user must control the technology. Moreover, social acceptance and user lifestyle must be addressed. Many respondents expressed their concerns about environmental issues, as new legislation requiring the producers to take back all their electronic components at the end of the -

Discipline	Smart Clothing's Design Directions
Focus group with five product designers	products' life. However, integrating electronics into clothing makes disassembly difficult and costly. Until every part was made of fabric, electronic components must not be permanently fixed within the clothes. In this way, electronic functions could be customised. Customisation could ensure that the products are useful for the user and could be used for longer. They believed that the clothes would be adopted by the military and law enforcers long before it would become a commodity product for the general consumers.
Focus group with five fashion designers	Since marketing was important for the fashion system, many respondents suggested that Smart Clothes needed to be more commercial. As a result, its design direction must be reconsidered. They believed that the poor acceptance from the consumers was caused by the lack of fashionable appearance. Because the final outcome is an apparel product, Smart Clothes must be designed with fashion consideration. This meant that the product must match user requirements functionally and emotionally. Many of them agreed that technology could add values to the clothes, but it was not the main reason that made people want the garment. The group stressed that emotional values, such as providing a pleasurable feeling, were more crucial for apparel products. Technology must be simplified. If technology was not invisible, it should have an attractive appearance and become 'accessories' of the clothes, such as a button or zip. In this way, electronic function could be added or removed easily due to the user's functional and emotional requirement. Being accessories allows electronic functions to be used for longer, as the style of the clothes can be changed due to fashion trends whilst basic parts, like a button or zip, can remain the same. However, the electronic function must be complete in itself, as it is impossible to have a 'supported system' embedded in every garment. In their opinion, an appropriate function was physical monitoring for sport practitioners. However, the product could be sold purely by its aesthetics. For example, decorating with lighting.
Focus group with mixed disciplines	The term 'Smart' was redefined. For them, 'Smart' applications should be able to relate, communicate or connect with other artefacts in order to provide the user a full control of the environment. For example, a 'Smart' jacket should be able to connect to the intelligent system in the house. In this way, room temperature, lighting and so on could be operated through the Smart Clothes. There was no point to put existing electronic functions into the clothes. The application must have a good reason why it had to be worn, e.g. control body temperature, detect health problems, etc. Communication field had a potential if the technology was cheap enough to be embedded into every garment. Furthermore, the gadgets had an opportunity if the functions and features were new or radical, and not repeated of the existing ones, such as an MP3 player. Smart Clothes needed to overcome the conflict between long development time and fast pace of fashion. One way was personalisation. Another way was that the product had a mechanism to change its -

Discipline	Smart Clothing's Design Directions
	appearance or it could be upgraded. For instance, the mechanism allowed the user to change colours, printing patterns or styles of the garment according to fashion trends.

These results highlight that several interviewees and focus group respondents correctly surmised what the popular applications and subsequent needs would be. For example, many of them stated that sportswear and medical applications would be an appropriate direction for the mass market in the future. These suggestions match the user profile and their visions of future lifestyle. Although some implementations suggested by these three groups are different, all disciplines had concerns about commercialisation and current technological achievement. The electronic features should not be limited to only technical function. They should also provide emotional value to the user. Most respondents stressed that electronic functions should be separated from the garment due to the benefits in terms of product lifecycle, customisation and disassembly. Nonetheless, this direction can be changed when all electronics are made of fabric and do not cause environmental problems.

To conclude, the new design directions based on the interviews and focus groups are:

1. Many participants suggested that Smart Clothing applications should take the design approach of Functional Clothing because its nature is similar to that of Smart Clothing's. For instance, Functional Clothing has a long lifecycle. Long lifecycle is crucial for Smart Clothing applications, as technologies take a long time to develop and test. In this case, Functional Clothing is a garment designed to serve specific purposes, e.g. garments for extreme conditions and military uniforms. Moreover, the excessive cost of developing and manufacturing intelligent textiles makes them far too expensive to be used in the mainstream fashion products (Gould, 2003).

2. Most interviewees pointed out that the design direction for mass market had moved towards the area of physical monitoring, sportswear and personal healthcare. This change not only helps expand the market to the new target groups, children and the elderly, but also focuses the design approach. Moreover, these new areas were more innovative and experimental which matched the nature of Smart Clothing.
3. All participants agreed that social acceptance was an important factor. Although Smart Clothes need not be fashionable, they should perform all the basic functions that ordinary garments do. Some interviewees stressed that the electronic function should be discrete and invisible. Further, it should be a wearable item rather than clothes, as it is easier for the users to accept. Most experts expressed that changing the user's perception was the biggest challenge. Smart Clothes should have a simple design. This way, the products have a long lifecycle regardless of any changes in fashion trends.
4. Many respondents commented that 'customisation' or 'personalisation' was probably an appropriate way to overcome the conflict between long development time and fast changing fashion. Since it allowed the user to choose the styles and functions, this could reconcile the differences between the way people perceive, purchase and use electronic device and clothes. Besides, the product should have mechanisms to restyle or upgrade itself. Thereby, allowing the user to keep the product for longer. This idea is feasible, as the 'micro-encapsulation' technology allows millions of microcapsules to be built into clothing. In this way, the pattern and colour of the clothes can be changed, and the camouflage can adapt to the surroundings dynamically (Cummings, 2004).
5. There must be a practical reason why particular technologies were embedded in garments and why the product needed to be worn on the body. Noticeably, most respondents were interested in sports and healthcare applications. Some agreed that

the technologies should be invisible and only work when it is needed without user's conscious thought. However, the control must not be overtaken by the technology.

6. To overcome washing problems, many people suggested that electronic component should be a separate item that could be attached and detached from the clothes easily. As a result, it should be considered an accessory of the clothes, such as a button or a badge. Being 'accessories' allows electronic functions to be attached into every garment. While the clothes could be changed due to the user's preference and fashion trends, the button could remain the same. However, the electronic function must be complete in itself, as it is impossible to have a 'supported system' embedded in every garment. This idea supports the modular concept explained by the electronic engineer, as the functionality is broken down into small modules, which can be connected and assembled with each other, and used according to the user requirements.

It can be assumed that the sportswear product represents a favourite choice for Smart Clothing applications, as it matches personality and lifestyle of the targets (see figure 4.10). Moreover, this idea is supported by key disciplines involved in Smart Clothing development and most respondents of the focus groups. Many respondents suggested that electronic functions and clothing styles should be *'personalised'* in order to ensure that the technologies are useful and match consumer's lifestyle. Furthermore, personalisation encourages people to keep products for longer. This idea helps solve the conflict between long development time and fast movement in fashion. Nevertheless, this concept can be changed after Smart Clothes can be produced and sold cheaply like normal clothes. Smart Clothes should look like ordinary garments and work well without technology. Besides, the electronic function should be discrete and not interrupt any activity performed by the user.

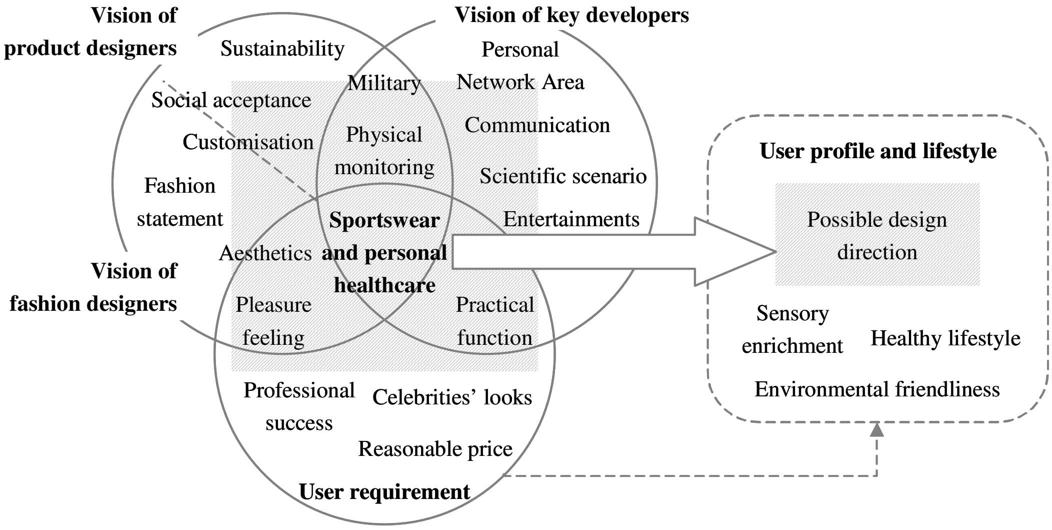

Figure 4.10: New design directions based on the consensus views of three stakeholders

4.4.4 Context of Smart Clothing

To improve a design process, Krose (2002) emphasises that it is unavoidable to be concerned about the nature of the product being designed. Based on the theory of Herbert Simon (1996 cited in Krose, 2002), Krose proposes that the nature of the product comprises of three aspects: 1) function based on the product's goal/purpose, 2) character or physical structure, and 3) context of human interaction, which is how a product is used in a particular environment. Jenlert (1997) notes that 'character' does not include only physical appearance, but also every type of attribute, such as the way products perform.

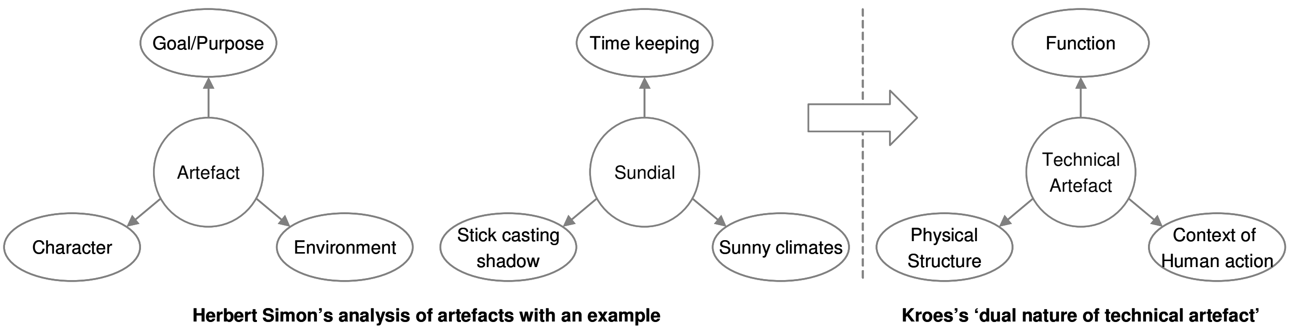

Figure 4.11: Diagram illustrating Simon and Krose's theories

To create characters never seen or experienced before, Jenlert suggests that a developer needs to start with a known character and then expand or change that character into something new and different. Subsequently, the diagram describing Smart Clothing's context is developed based on Krose and Jenlert's theories. Firstly, a diagram presenting a context of well-established product is created (see figure 4.12).

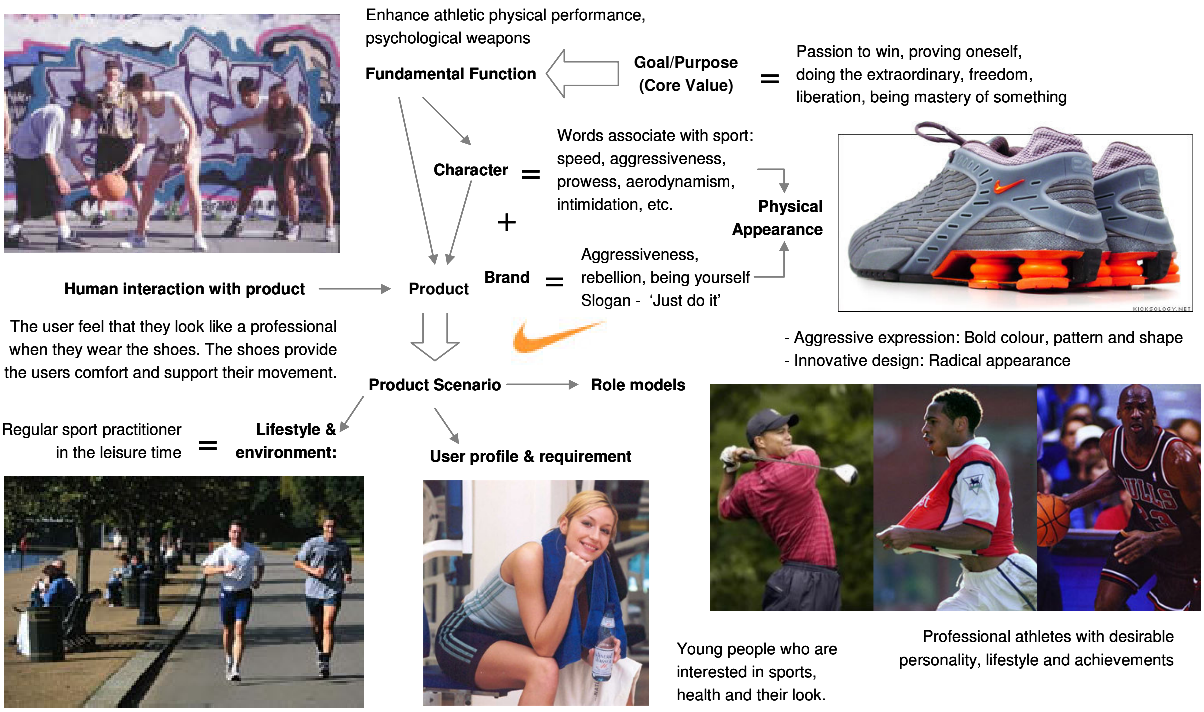

Figure 4.12: Diagram demonstrating product context of sportswear products

Next, the Smart Clothing's context (figure 4.13) is developed based on the first diagram (figure 4.12). The functions of Smart Clothes are varied due to the type of applications. However, the function must be specified in order to construct the context. Therefore, in this case, the application in the sportswear field is used as an example. For sportswear applications, many focus group respondents and interviewees believed that the main function should be monitoring, measuring and recording, rather than actually enhancing the user's physical performance. This was because most sport practitioners preferred to gain better performance from their own practices, not by some electronic function.

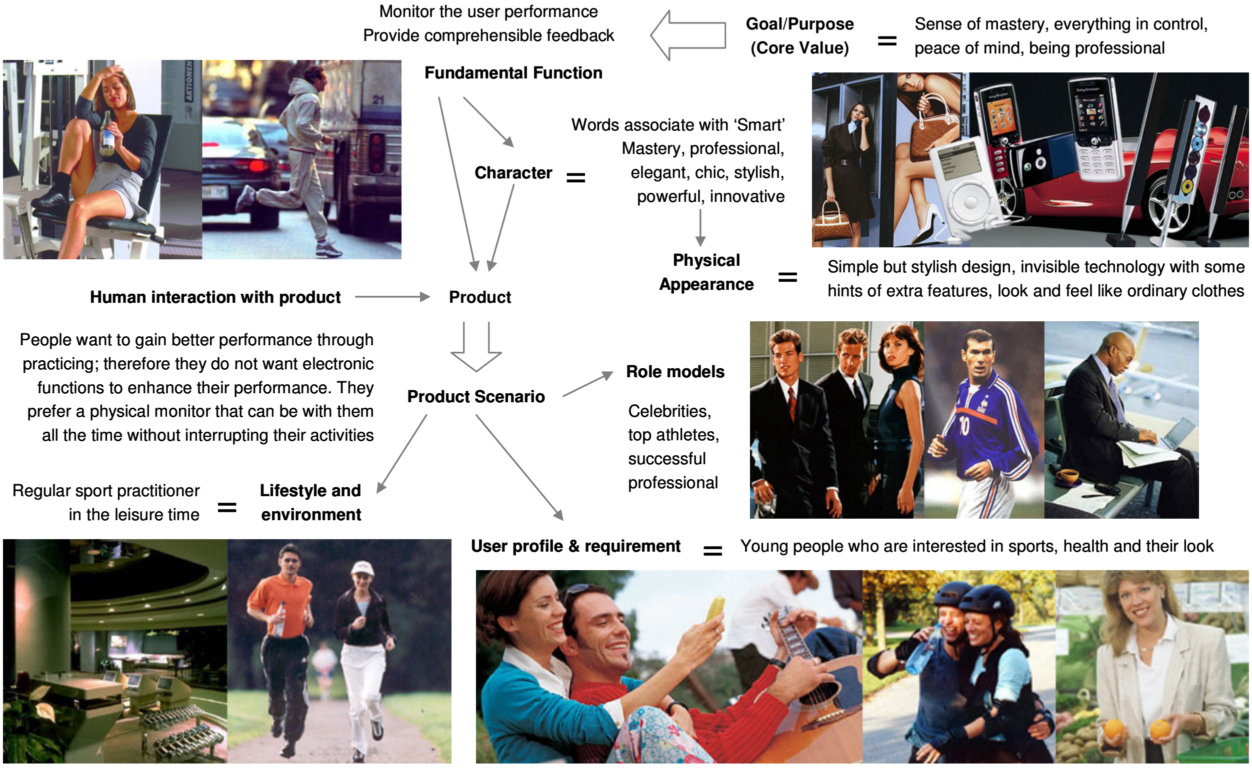

Figure 4.13: Diagram describing context of sportswear application of Smart Clothing

Although every application can have different functions and perform differently, all Smart Clothes should share a number of basic or fundamental functions, which are based on the core values and its purpose. According to respondents' definition of *'Smart'*, the product should operate when it is needed without the user's conscious though. It can be assumed that Smart Clothes make sure that **everything is under control**. Moreover, certain participants define its function as the abilities to control, adjust and change an undesirable environment into a pleasant one. As a result, *'Smart'* can refer to a **sense of absolute mastery**. The examples of applications that support this idea are protective clothes, self-heating garments and communicating devices allowing information access wherever and whenever the user wants. Since *'Smart'* means better performance, the products should give a **sense of professional and perfect operation**. To conclude, the core value of Smart Clothing is *'a sense of absolute mastery achieved through a product's perfect control of surrounding environment.'* Nevertheless, different target audiences might define the term *'Smart'* differently which can lead to a different set of values and fundamental functions.

To clarify a context of Smart Clothing applications, the researcher explores various words associate with its functions and values. These words describe the performance as well as appearance, for instance: mastery, professional, efficient, stylish, powerful and elegant. This appearance was supported by many respondents, as they described *'a simple design with some hints of the invisible technologies*.' Thus, the hidden value of the technology is expressed though *'Smart'* design (see figure 4.14). This idea fits consumer requirements, as they desire for the look, lifestyle and expertise of celebrities and successful professionals.

Figure 4.14: Sample of physical appearance regarded as *'Smart'* design

4.5 Conclusion of the Findings

In this section, principal findings and practical methods to solve current problems of Smart Clothing development identified through the research and analysis are combined to create a basis for a conceptual model, which will be developed later (see figure 4.15).

Smart Clothing Context

Core value : a sense of absolute mastery and professionalism achieved through the perfect control of surrounding environment.

Character: a simple design with some hints of the invisible electronic technologies
Words associated: mastery, professional, innovative, stylish, powerful and elegant

Method to balance the contributions from all disciplines
Crucial factor: Product must be developed from the multiple perspectives of all participants

Method to overcome the existing creative constrains
Crucial factor: A new framework of thinking and working must be employed to develop the ideas

Method to achieve a fully integrated outcomes
Crucial factor: An outcome shares characteristics with its major design contributors: fashion and product

Basic requirements of a new conceptual model

Figure 4.15: Diagram showing how all results are combined (see figure 4.1 for comparison)

1. Create a clear statement of a goal, product context and project requirements

   Identify user requirements and visions of all participants involved

   Establish and visualise the goal, product context and project requirements accordingly to make sure that every important aspect is clearly described

   Make sure that the goal and requirements are fully understood by all participants

2. Specify desirable characteristics and contributions expected from all disciplines

   2.1 Encourage every participant to learn from each other, such as try to understand different procedures, contributions and technical terms used by other disciplines

   2.2 In this way, important aspects, characteristics and core values of the major contributors, namely fashion design and electronic product development are identified and taken into consideration when developing a new product.

   2.3 Core values, characteristics and important issues of both areas are selected according to the goal/purpose of the product, context, and user requirements.

2.4 The team must make sure that the core values, characteristics and important aspects chosen from both areas are balanced in order to prevent the problems caused by too much electronic input, lack of fashion appearance, and so on.

2.5 After core values, characteristics and key aspects are selected, the specification describing which contribution is expected from which discipline can be created accordingly. This specification must be clearly explained to every participant.

3. Develop the new framework for Smart Clothing development

   Clarify the needs for a new framework of thinking and working, for example, why there is a need for the cultural change and new work procedure.

   Make sure every participant realises the need for a new framework and culture. In other words, all participants must understand why they need to change their ways of working and thinking and prepare for new methods, activities and cultures.

   After the needs are recognised, a specification for a new framework of working and thinking is developed. This specification describes aspects such as which existing activities must be changed, which new activities must be addressed, etc.

   Develop and ensure that this framework can be adopted by all disciplines. For instance, certain existing procedures might be incorporated in the new method. In this way, it is not too difficult for the participants to understand and employ it.

4. Embed new cultures and new framework into all participants

4.1 Expand existing creative boundary of each discipline by taking important aspects of other areas into consideration when carrying out design and development work.

4.2 Develop ideas based on multiple perspectives of all participants and shared characteristics of major contributors – fashion and electronic product design

4.3 Focus on final outcomes, not its key elements or contributions of a particular area.

Obviously, many of these tasks are dependent on the participants of Smart Clothing development teams, for example, setting up the goal and learning different procedures and technical terms used by other disciplines. This research only aims to develop and provide a new framework for all participants to think and work in the way that is suitable for Smart Clothing development. This framework will be addressed in a NPD model to ensure that the new ways of working and NPD process are synchronised. As a result, the basis for the new conceptual model of the NPD process for Smart Clothing includes:

1. In order to embed the new culture, develop a design from multiple views and shared characteristics and expand the creative boundary, the new conceptual model must **challenge the participants** to go beyond the existing creative boundary.
2. The new model must **clarify the roles and responsibilities** of every participant in order to make sure that all participants deliver the outcomes as expected based on the context and goal that the team established, and different contributions are balanced.
3. In order to visualise the project requirements, emphasise the multiple perspectives, ensure that the needs of collaborative framework are clearly understood, and the new framework are employed as intended, the new conceptual model should **incorporate the context of Smart Clothing development**, such as a multidisciplinary approach.

There are certain interim constraints that are difficult to solve currently due to the nature of this collaborative project and its participants at this moment. These conditions are: 1) development works are carried out separately in different locations; 2) the design task is regarded as individual works under one selected concept or theme; and 3) people want a framework or method that can be adopted easily and effortlessly as much as possible. In this research, these constraints will be treated as fixed conditions of the new NPD model.