OPTIMIZING MULTIDISCIPLINARY CONTRIBUTIONS FOR THE SMART CLOTHING DEVELOPMENT PROCESS

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ABSTRACT

This research aims to introduce a strategic approach to overcome the creative boundaries and optimize multidisciplinary contributions in Smart Clothing development, since the former research results revealed that these issues are key to achieving fully integrated Smart Clothes. Therefore, this paper examines collaborative projects that are shown to break through the creative boundary and integrate multidisciplinary contributions, and identifies how individual designers overcome their creative constraints and collaborate with others, in order to identify a practical method. The research result indicates that a clear description of Smart Clothing's context will provide a new framework for the developers to work on.

INTRODUCTION

Electronic and fashion experts agree that 'Smart Clothing' represents the future of the two areas (Marzano, 2000; Baurley, 2003). Through the use of advanced technologies, e.g. conductive textiles, ordinary clothes can incorporate electronic functions and become 'smart' (Meoli and May-Plumlee, 2002; Gould 2003; Van Langenhove and Hertleer, 2003). Due to the hybrid nature of Smart Clothing, multidisciplinary teams and cross-industrial collaboration are required. As the major inputs come from electronic and apparel sectors, the research focuses on how to achieve a greater integration of electronic technology and fashion design.

BACKGROUND RESEARCH

Background research is presented in three parts: 1) results of the literature review, which summarize the developments in the Smart Clothing field and the collaborative NPD processes, and explain the definition of the creative boundary, 2) a brief summary of the lessons learned from the previous Smart Clothing projects, and 3) a series of interviews that expands the problems and possible solutions suggested by key developers.

SUMMARY OF THE LITERATURE REVIEW

Smart Clothing Developments: Although Smart Clothes was originally perceived as an alternative way to develop wearable electronic or computing devices (Forman 2001; Stang 2004), the current projects indicate

that participants and outcomes are no longer restricted to the computing field (Ward, 2001; Marculescu *et al*, 2003). Recently, the developers involve governmental organizations, academic institutes, laboratories, design consultancies, and electronic and clothing companies. Since most projects have been carried out as collaborative ventures, the teams become very complex. Mattila (2001) describes his team as follows: *'a network of four university departments and four industrial companies were formed. The Institute of Electronics and the Institute of Textiles from Tampere University of Technology, the Institute of Industrial Arts and the Institute of Textile Design from University of Lapland, the snowmobile suit manufacturer Reima Tutta Oy, compass and navigating systems producer Suunto Oyi, heart rate monitor producer Polar-Electro Oy, and Dupont Advance Fibre Systems were the participants. In addition, Siemens and Nokia Mobile Phones assisted with GSM communications.'* At present, the contributions from electronic and clothing industries are imbalanced, as fashion thinking and techniques have not been successfully utilized. Fashion experts comment that Smart Clothes are still about portability rather than electronics being fully integrated (Lee and Stead, 2001). Currently, most products are offered in limited numbers in a niche market. Contrasting large investment with small benefits indicates a pressing need to improve profitability to cover the development cost. To gain a social acceptance, a new design strategy is required (Edwards, 2003).

The Collaborative NPD Process: As Smart Clothing development requires a high level of collaboration, it is important to investigate the existing collaborative NPD processes. Kahn (1996) defines 'collaboration' as a state of high degree of shared goal and mutual understanding among participants. Sethi and Nicholson (2000) indicate that it also includes team commitment, collaborative behaviours, interdependent outcomes and departmental relationships. Littler, Leverick, and Bruce (1995) note that certain factors affecting the process of collaborative product development are relevant to all NPD processes, e.g. having a product or collaboration champion and frequent communication. Nevertheless, some factors are only relevant to the collaborative NPD process, e.g. ensuring partners contribute as expected, building trust between partners, and the perception of even benefits between partners. Johnson and Evans (1999) propose a method to aid the management of co-development or joint-product development called *'transparency'*, which allows all participants to see through the development process and make the management systems comprehensible. Since Smart Clothing development expects integrated outcomes, it requires a 'synergy', which Jassawalla and Sashittal (1998) describe as *'the accomplishment as a result of cross-functional linkages of NPD outcomes that reflect capabilities significantly beyond those participants individually bring to the process.'*

To gain this high level of collaboration, Sonnenwald (1996) suggests that all participants need to explore new knowledge and integrate the differences in terms of 'pre-existing patterns' of work activities, perception of quality and success, specialized work language and organizational constraints and priorities.

The Creative Boundary: The 'pre-existing pattern' or 'creative boundary' is best described by De Bono (2000), as he explains that all information is perceived, recognized, analyzed and organized due to the 'routine perception track', which was set up by previous experiences. He stresses '*the brain can only see what it is prepared to see.'* In this manner, all information, no matter how new or old, is explained by the known theory and fashioned to support that theory. In order to breakthrough the existing boundary, a new perspective is required. According to Sutton (2004), seeing the same old things in new ways is an ability to keep shifting opinion and perception. He explains *'it means shifting our focus from objects or patterns that are in the foreground to those in the background.'* Therefore, the ability to shift the perception and break from the past is crucial for a radical innovation. Hargadon (2003) defines 'breakthrough' or 'innovation' as a process of forming a new relationship between people, ideas and technologies. Creative boundary can be expanded by introducing new constraints, as Walker, Dagger and Roy (1991) suggest that every design is limited by certain constraints, e.g. cost. Since each constraint does not operate independently, the change of one constraint leads to subsequent changes of the others. As a result, a solution once regarded as impossible becomes possible. In this case, Smart Clothing developers viewed applications as electronic or fashion items but rarely as 'Smart Clothes'. Thus, they tried to make the applications fit into their conventional NPD processes. To solve this problem, the researcher hypothesizes that the experts in the electronic area need to overcome their constraints and expand their creative boundaries into fashion field and vice versa.

SUMMARY OF THE LESSONS FROM PREVIOUS PROJECT

To emphasize the importance of overcoming the creative boundary, a brief summary of the lessons learned from the previous projects is provided. The researcher first developed a Smart Clothing application. To ensure that the outcome equally addressed key elements from product and fashion design, the researcher worked with two supervisors, one from each field. The final result was far from an integrated solution (see figure 1), as it was difficult to maintain the focus, which often shifted between fashion expression (see figure 2) and functional approach (see figure 3). If it was difficult for one person to balance the inputs from the two areas, it must be harder for multidisciplinary teams. Instead of thinking outside the box, the

researcher thought inside two boxes, product and fashion design, at different times. This example shows that an ability to break though the creative boundary and integrate two different cultures does not come simply by learning certain aspects from the new area. A practical method to overcome the established pattern is required. The outcome was 'compromised' not 'optimized' due to the lack of strategic direction. The researcher made sure that the design fitted both product and fashion requirements by using 'intelligent' fabrics to perform 'smart' functions and maintaining 'ordinary-look' of the garment rather than using a design strategy to guide the design approach. It was noted that most developers share similar problems (Ariyatum and Holland, 2003). As a result, further research was conducted with the key developers.

Figure 1 Final design of the Smart Clothing project

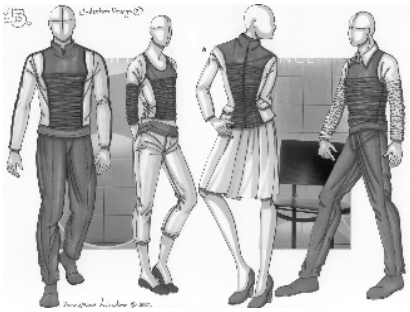

Figure 2 Fashion-led design focusing of styling

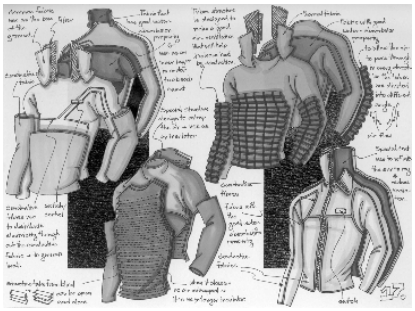

Figure 3 Product-led design concentrating on functions

SUMMARY OF THE INTERVIEWS

The in-depth interviews investigated the key aspects of identifying practical methods to achieve optimum balance between fashion design and electronic technology. The main focuses of the interviews are:

1. Current work procedures or NPD processes that Smart Clothing developers employ
2. The main problems that prevented the developers from achieving a fully integrated result
3. The personal opinions or suggestions of the developers on how to solve the identified problems.

To ensure a deep understanding of every discipline, ten interviewees were chosen based on their expertise. Six of the interviewees selected represented the key disciplines of Smart Clothing development. They were a design manager, a Smart Clothing designer, a product designer, a fashion designer, a textile scientist and an electronics engineer. Two more interviewees were potential developers; a technical textile designer and a trend researcher. A further two interviewees were professionals in related fields, sportswear and fashion accessory, as these areas are of particular interest to Smart Clothing developers. The key findings are:

1. The work procedure: 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 in linear order. All partners in a collaborative project met only three or four times a year to report the progress. Consequently, it was difficult to achieve a truly integrated and radical solution.
2. The main problems: Each discipline had a different approach to the design problem, and specific work procedure. Since the ways of thinking and working had been firmly established through education and work experience, it is difficult to change them entirely. Although the different approach and procedure caused no problems, most interviewees admitted that there was a language barrier between them. Thus, all participants needed to learn the language and in particular technical terms of others to some extent.
3. The suggestions: Most interviewees agreed that going beyond the existing creativity boundary and understanding user requirements was the key. For instance, the fashion designer stated *'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.'* Thus, each participant should take the partners' NPD process and manufacturing process into consideration. For example, the electronic engineer reported that he studied the apparel manufacturing process before developing the components. Interdisciplinary approach was introduced to ensure that every participant understands each other. Proximity plays an important role in collaborative NPD process, since having all required disciplines in one place allows quick response to any problem that might arise. Nevertheless, in most cases, the developers worked in separate locations, as Smart Clothing development was often a collaboration of different organisations.

SUMMARY OF THE BACKGROUND RESEARCH

The literature indicated that a fully integrated application was required to improve commercial potential. The extended study revealed that the current barrier was caused by established approaches and procedures.

AIM AND OBJECTIVES

Due to former research results, this paper focused on formulating a practical method to address three issues:

1. To achieve the optimum balanced contributions from all the participants.
2. To integrate the differences of fashion design and electronic technology.
3. To overcome the creative boundary and create an integrated outcome.

RESEARCH METHODS

There were two research methods employed in this research. Firstly, the case study was used to examine collaborative projects that were shown to break through the creative boundary, optimize multidisciplinary contributions and integrate the differences of high-tech and fashion sectors. This was because none of the existing Smart Clothing projects was considered successful because: 1) electronic engineering and garment design to date were still separate; 2) none of them were commercially successful in the mass market; and 3) the outcomes did not provide extra value from the user viewpoint. By investigating similar collaborative projects, the researcher sought possible solutions for the problems that Smart Clothing developers currently face. Secondly, focus groups were conducted to find out how individual designers overcome their creative constraints and integrate the differences when collaborating with other designers. Both research results were compared in order to draw practical measures, which are useful at both individual and project levels.

CASE STUDY

Aim: The case study aims to identify practical methods, which were employed in successful collaborative projects, to 1) achieve the optimum balance of contributions from all participants, 2) overcome the creative boundary and create an integrated result, and 3) integrate the differences of fashion and high-tech sectors.

Subjects: The investigation focused on successful 'integrated' projects, which were selected based on the similarity of their approach compared to Smart Clothing development. 'Successful' was defined largely in terms of commercial, market share and profit. Performance sportswear and Smart Car were chosen, as they met all criteria set out below. In this case, performance sportswear refers to apparel products designed to enhance the physical performance of the athletes and not the mainstream garments that adopt 'sport' style.

Criteria No. 1: The project is a collaboration of high technology and fashion design.

Performance Sportswear: Nyad and Hogan (1998) claim that female sportswear expresses the convergence of design and technology. Nike's female ranges result from the dedicated research of exercise physiologists, biomechanics experts, etc. Apparel design has also moved from a typical gimmick, e.g. pink colour, to a specifically engineering garment that addresses the female physique, as well as making a fashion statement.

Smart Car: Originally, a collaboration of the fashion watch company, SMH (producer of Swatch), and the car company with advanced technologies, Mercedes Benz AG. Although, Smart Car was 100 percent taken over by Mercedes Benz AG in 1998, the input from Swatch remains its chief influence.

Criteria No. 2: The outcome represents a synergy of fashion design and high technology. The output should be different from their parents' mainstream products in terms of physical appearance and product concept.
Performance Sportswear: O'Mahony (2002a) stresses that sportswear is one of the few successful multi-disciplinary design area. This may be due to the fact that many sportswear designers have been trained in related areas of design; thus, they are more open to other ways of thinking. Some companies, e.g. Reebok, deliberately employ designers from other field, e.g. car design. The author stresses that sportswear must be positioned independently from the apparel and high-tech product or it may lose its attraction as a fashion.
Smart Car: The design represents a new concept of vehicle, which is an environmentally friendly and mass-customization car. Van Hoek, and Weken (2000) comment that the innovative design, e.g. modular concept, and technologies, e.g. fully recyclable components, differentiate it from the small cars of other brands.

Criteria No. 3: The outcomes demonstrate equality of contributions. The contributions from each partner are clearly expressed. Furthermore, the differences of the participants are considered as the key benefit.
Performance Sportswear: Vanderbilt (1998) observes that the design curve in this sector has dramatically peaked. Fashion inputs, e.g. lifestyle marketing, are clearly presented. At the same time, the companies go to extremes to ensure that their elegant products provide high performance. For instance, Speedo hired an aircraft engineer to do Computational Fluid Dynamics (CFD) work for its goggles (McKee, 2004).
Smart Car: The design illustrates the equal contributions from both Mercedes Benz AG and SMH. For example, Corter (1995) describes *'the car's comfort, security and quality reflect Mercedes' traditional high-end values. Its originality and affordability, though, mirror the innovative splash and low cost of Swatch watches.'* Smart Car also represents the sharing of brand values of both partners (Lillford, 2003).

Criteria No. 4: The outcomes must be feasible and able to attract the mass market, since satisfying customers and making profits are the main reason for the collaboration and key factor to judge the success.
Performance Sportswear: Sportswear is successful commercially and attracts wide audiences, as O'Mahony (2002b) reports *' the sports industry in America was bigger than motion picture, radio, television and education service combined.'* Besides, it is of interest to Smart Clothing developers. For example, Adidas launched 'the world first intelligent shoes' that can adjust the cushion level automatically and continuously.
Smart Car: Smart Car has proved to be commercial and attracts a global target audience. The cars are sold in more than 20 countries and product lines continually extend. Brigley (2004) claims that its success may

be because of an ability to embrace many of the earliest microcar characteristics and its marketing strategy, which emphasizes a sense of fun, a design-conscious lifestyle, and a minimal environmental impact.

Procedures: The information was obtained through a literature research and supported by four interviews. Due to the design focus, visual, as well as verbal, evidence is analyzed. The literature research focused on performance sportswear covers design theories, strategies, NPD process and sportswear companies. The information about the Smart Car covers the developers, the design strategies employed, collaborative NPD process and Smart Car company. In-depth interviews are conducted with two sportswear design educators, one sportswear design researcher and one member of the Swatch Product Management Department. The interview with the manager from Swatch focused on its product development approach. The same set of questions was used for every interview to ensure consistency. The interview structure is shown below:

1. Role and responsibility of the interviewees within the company
2. Description of the product development team and the NPD process
3. Method employed to achieve the optimum balance contributions from all the participants involved
4. Method employed to overcome the creative boundary to generate a synergy or integrated solution
5. Method employed to integrate the differences between fashion design and high technology

FOCUS GROUP

Aim: As this research focused on overcoming the creative or design boundary; the purpose was to:

1. Identify practical methods that the major design contributors of Smart Clothing development, namely product and fashion designers, employ to break through their existing creative boundaries.
2. Identify how these major design contributors collaborate with each other in order to find out how to integrate their different approaches and optimize their contributions to create an integrated outcome.

Participants: One focus group was conducted with five product designers and another was carried out with five fashion designers. The samples of each group were a mixture of two professional designers and three design researchers. In this way, the researcher was able to gain both academic and industrial viewpoints. In order to gain a broad range of ideas on how different disciplines go beyond their creative boundary, the second focus group (see figure 4) was conducted with five participants, which were selected from varied areas and not restricted to the product and fashion design fields. These participants were selected as they

had an experience of working in a project that was entirely different from their established professional backgrounds, and they were able to discuss the methods they used to break through their creative boundary.

Education	Work experience	Current project
Graphic design	Graphic designer	Researching and developing a design policy for a fashion city
Industrial design	Product designer	Researching and developing a brand for craft products
Architecture	Photographer	Researching and developing a brand for furniture and home decorative items made from natural materials
Automation/Computing	-	Researching and developing an emotional brand experience for high-street fashion retailers' websites
Business/Marketing	-	Researching and developing new methods to enrich brand experience in food and beverage retails

Figure 4: Profiles of all the participants in the second focus group

Procedures: Before starting each focus group, the researcher briefly introduced the subject area, Smart Clothing, and explained the purpose of the focus group and discussion topics. The main topics were:

1. What do you generally contribute in a collaborative project?
2. How do you approach a project which is different from your background?
    a. Do you bring your own set of values and work procedure to this project? If so, how?
    b. Do you work differently? Does this project need a different set of values and process? If so, how?
3. How do you overcome the creative boundary?

Each focus group took one hour to complete. After the discussion, the researcher summarized all key issues and agreements made. Besides, the researcher ensured that each suggestion was clearly explained with an example of its implementation. All discussions were recorded and transcribed for analysis in the next stage.

DATA ANALYSIS METHOD

Grounded theory was employed to analyze the information collected from the case studies and focus groups. This method was selected due to its appropriateness for qualitative research analysis. The result of grounded theory analysis represents the *'Studied Phenomenon'*, which, in this case, included: 1) how to achieve the optimum balanced contributions from all the participants, 2) how to integrate the differences of fashion design and high technology, and 3) how to overcome the creative boundary and create an integrated outcome. The grounded theory method deconstructs the information into categories in order to extrapolate the key issues, which are then reconstructed to provide new meaning to the information. The main activity is coding procedure. In this research, two types of coding, open coding and axial coding, are employed.

OPEN CODING

Strauss and Corbin (1990) describe open coding as *'the process of breaking down, examining, comparing, conceptualizing, and categorizing data.'* The procedure used in this research can be divided into five steps.

1. Preparation: The transcripts from the case studies and focus groups were examined several times in order to familiarise and further comprehend the responses. Particular attention was made to distinguish the information that a respondent frequently repeated and emphasized (see figure 5).
2. Labelling phenomena: This step broke down the data into small incidents, gave each incident a name, and reviewed each incident to ensure that similar incidents have the same name (see figures 5-6).
3. Discovering categories: The incidents identified were grouped into categories (see figure 6). For instance, the incidents named *defining user requirement clearly*, *defining design approach clearly* and *defining product function clearly* were grouped together, as they all aimed to define a product context.
4. Naming a category: The name that represents the data in the group was chosen (see figure 6). The name 'defining product context clearly' was chosen for this example category. In this case, product context includes all contexts related to a particular product, e.g. context of use or environmental context.
5. Developing categories in terms of their properties and dimensions: This step identified the properties and dimensions of each category (see figure 7-8). Property is an attribute of a category that can be dimensionalized. The dimensionalizing procedure broke each property down into its dimension based on the interpretation of the description. For example, Lillford (2003) describes the state of shared risk and responsibility in the Smart Car project as '*Mercedes, although they have the history in automotive, did not want the responsibility for the project on their board level, but instead shared the decision on the board of the new organisation'* The statement was analyzed and given 'medium' as the dimensional range. Each dimension was compared with the data from other sources before the final one was drawn.

From the interview with the Sportswear Educator:

'We try not to have people that come just from fashion and textiles. We try to have product designers and industrial designers. One comes from sport science. Two are from sport marketing. People come from different backgrounds, but what holds them all together is a passion for designing things that have to function and part of function is to look good. Quite often these people coming from different backgrounds do have an opinion already about garments that work.'

Incident: mutual understanding of product context including function, appearance, materials, etc.

Figure 5: Example of labelling procedure based on Strauss and Corbin (1990)'s Grounded Theory

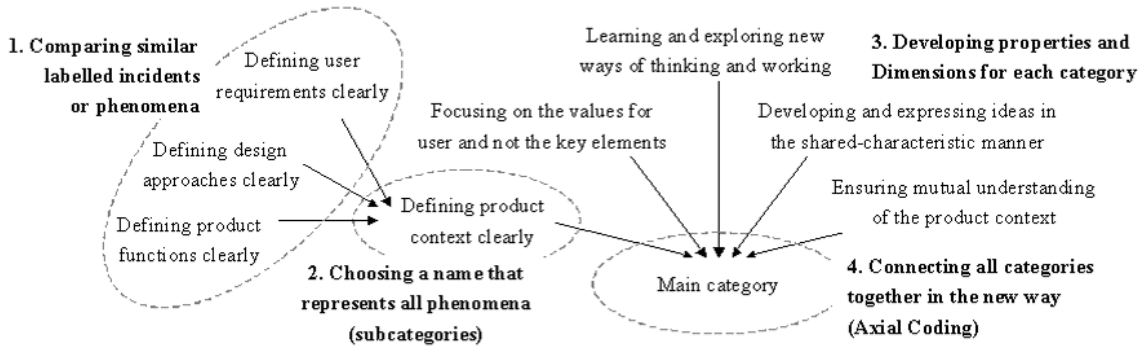

Figure 6 Example of discovering categories and naming categories based on Strauss and Corbin (1990)'s Grounded Theory

Phenomenon	**Properties**	**Dimension**
Balancing	1. Sharing goal and motivation among all participants	High
Multidisciplinary	(For example, Mercedes Benz and SMH shared the same vision of the car.)	
Contributions	2. Understanding other disciplines' approaches and working procedures	High
	3. Embracing characteristics of all partners into an outcome equally	High
	(For example, Smart Car design embraced the characteristics of both SMH and Mercedes Benz designs; therefore it had advantages of both partners.)	
Overcoming	1. Defining context of the new product clearly	High
the Creative	2. Ensuring mutual understanding of the new product's context	High
Boundaries	3. Defining expected contributions from all participants	High
	4. Learning and exploring new way of thinking and working	High
	5. Learning and incorporating other disciplines' approaches and processes	High
	6. Developing and presenting ideas in the shared-characteristic manner	High
	(For example, in sportswear design, high technology is expressed through fashion elements, such as pattern cutting and technical textile selecting.)	
	7. Focusing on the values for user and not the key elements of the product	High
	(For example, Swatch product development focuses on delivering its core value "emotion", rather than the key elements, such as fashion design.)	
	8. Obtaining ideas and inspirations from other disciplines or other fields	High
Integrating	1. Establishing a goal and basis for collaborative product development	High
the Differences	2. Sharing knowledge, resources and workspace	High
	(For example, SMH and Mercedes Benz formed a child organisation. In this way, the development team from both partners worked together.)	
	3. Embedding new cultures based on new product context into all parties	High
	(For example, the performance sportswear educators state that their courses embed the *'functional and practical approach'* into their students.)	

Figure 7 Properties and dimensions of the subcategories discovered from the case studies

Phenomenon	Properties	Dimension
Overcoming the Creative Boundaries	1. Defining the context of the new product clearly	High
	2. Approaching the new project differently within the established design principles if the new project is slightly different from the previous ones (All respondents agreed that they approached every project differently due to the specific requirements. However, this new approach was based on the principles which were established through education and experience.)	High
	3. Overlooking certain principles that do not fit in the new project's context (Most respondents reported that they tried to forget their old procedure if it prevented them from achieving the new goal. This could be overcome by familiarization with the new context, e.g. new users, characteristics, etc.)	High
	4. Replacing established principles with the new ones (Most respondents adopted new principles through education. However, they suggested this could be achieved through an establishment of a clear goal, a working basis or a guideline that explains the design approach and so on.)	High
Collaborating with Other Designers (Integrating the Differences)	1. Establishing a goal and design theme or key concept (All respondents reported that in every project that involved more than one designer, firstly the design theme or key concept must be developed and voted upon to ensure that all designers develop designs under the same theme.)	High
	2. Separating design tasks according to each participant's expertise (Most designers stressed that working separately could avoid unnecessary arguments. Moreover, it was easier to discuss when ideas became visible and concrete. In most cases, they separated specifications and work alone.)	High
	3. Pairing up or teaming up with another designer (In some cases, pairing up with another designer proved to be useful and productive. These two designers must share some similarities in terms of working style. However, they did not necessarily have similar ideas.)	High
	4. Contributing at different stages of the project due to the expertise (Many respondents suggested that different designers could contribute in different stages due to their expertise. For example, fashion designers contribute at concept stage, as they were good at creating radical ideas, whilst product designers contribute in later stages, as their approaches were seen as practical.)	

Figure 8: Properties and dimensions of the subcategories discovered from the focus groups

AXIAL CODING

Axial Coding is a procedure to put data back together in new way by making connections between categories (Strauss and Corbin, 1990). As a result, the subcategories are related to the main categories. The relationships are presented in the 'Paradigm Model' (see figure 9), which includes six factors:

1. Casual condition: Incidents leading to occurrence or development of a phenomenon
2. Phenomenon: The central idea or incident with which a set of actions or interactions are related
3. Context: The specific set of properties that belong to a phenomenon. Context represents the particular set of conditions within which the action/interactional strategies are taken
4. Intervening Condition: The conditions that facilitate or constrain the strategies taken
5. Action/Interactional Strategies: Strategies to manage or respond to a phenomenon
6. Consequences: Outcomes or results of action and interaction

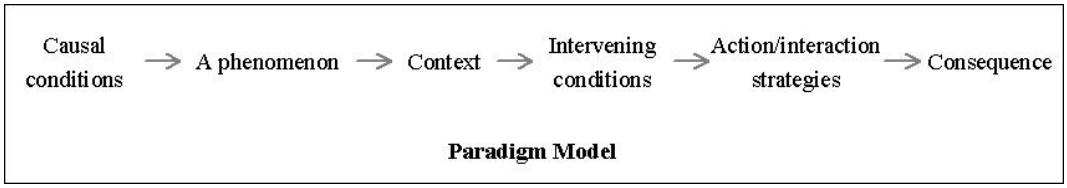

Figure 9: Paradigm model presenting relationship of subcategories and main category or phenomenon based on Strauss and Corbin (1990)'s Grounded Theory

The categories, properties and dimensions identified through open coding were examined in order to find out the relationship between them. The proposed relationships were examined and checked back several times to ensure that they were fully supported by the data. Finally, the proposed relationships are deduced.

PRINCIPAL FINDINGS

Practical methods drawn from the research and analysis to fulfil the three aims are presented respectively.

METHODS TO ACHIEVE THE OPTIMUM BALANCE CONTRIBUTIONS

1. Casual Condition: The current situation was caused by the lack of strategic approach to keep all the participants focused in the same design direction. Separating the tasks and workplaces multiplies the chances of misdirection. A consensus direction that incorporates multiple views and skills is required.
2. Phenomenon: To ensure that multidisciplinary expertise, perspectives and experiences of all participants are addressed evenly, a method to pick the 'winners' from varied contributions is needed.
3. Context and Intervening Conditions: Literature review indicates that intervening conditions of the Smart Car project were similar to those of Smart Clothing development, as the consumer latent needs were not recognized by the existing market at the time the product was developed. As a result, it is

difficult to develop criteria to pick the winners. Based on the interviews with two sportswear educators, the framework for sportswear design has been established; therefore, it is clearer how functions should be expressed, etc. As a result, it is necessary to complete the picture of product context first.

4. Strategies: The literature review explains that Smart Car achieved the consensus direction by sourcing partners that share the same goal and inspiration. SMH's proposal, was turned down by several car companies, e.g. Volkswagen, until it approached Mercedes, which shared the same product idea and motivation in terms of extending their product lines. As both partners had developed their own works up to the prototype, they were well aware of what the other could contribute (Lillford, 2003). To combine their characteristics, they established the basis for collaboration and a child organisation where both teams worked together (Weernink, 1997). This case study suggests three solutions: 1) sourcing out the participants that share goal and motivation, 2) making sure that every member is aware of what other disciplines can bring to the collaboration, and 3) creating a basis to ensure that multiple characteristics of all disciplines are identified and integrated into an outcome. These suggestions are similar to those of the sportswear case. Sportswear developers are selected based on their interests in sports and the understanding of sport culture. Many of them were professional athletes (Weaver, 2004).
5. Consequences: Although both projects were able to balance multidisciplinary contributions, sportswear design has better achievement in terms of integrating characteristics, as every technology and function is achieved through fashion elements. This is because all developers are aware of the product context.

METHODS TO BREAK THE CREATIVE BOUNDARY

1. Causal Condition: Currently, the developers have no alternative way to think about Smart Clothes. Because of the lack of a clear product context, the developers view Smart Clothes as a combination of separate pieces, e.g. intelligent fabrics and electronic components, instead of one 'integrated' object.
2. Phenomenon: An ability to perceive and use information in new ways means going beyond existing constraints and incorporating new possibilities. Firstly, the conventional boundaries must be identified.
3. Context and Intervening Conditions: As fashion and product designs are established fields, it is difficult to overcome conventional procedures and adopt a new method. Many participants found it difficult to use their expertise, ideas, etc in the different areas. However, this ability is crucial for the breakthrough.
4. Strategies: The results from both researches reveal that a new framework for thinking and working, which is based on the product context and the values perceived by the end user, is required at both

individual and project level. The new framework can be divided into three different levels as follows:

- Most designers agreed that every project had a different approach. Nevertheless, their personal principles based on their education background, e.g. user-centre design, influence their thinking.
- When they faced the projects that were very different from their backgrounds/experiences, many designers tended to keep certain principles, which they believed still relevant, and ignored others.
- When they encounter an entirely new project, they were likely to discard the old way of thinking. One focus group respondent realized that her linear thinking process prevented her from thinking in the required way. Consequently, she tried to forget her conventional procedure and absorb new methods by getting accustom with the new area. In sportswear case, the new framework is adopted through education. Since education is time consuming, it may not be suitable for every case. The clear description of the product context is the key, as demonstrated in the Smart Car project.

The ability to contribute in the other area is equally important to the boundary expansion. For example, Holtmann (2001) describes that Nike research team was struggling to find an appropriate design for the shock-absorption sole (Nike Shox) until the new head of Research Department, who formerly worked in Ford Development, provided the required inspiration – the spring elements from car shock absorbers.

5. Consequences: Both product context and a new framework can enhance the mutual understanding of the design direction among participants and provide a clear description of expected contributions.

METHODS TO INTEGRATE THE DIFFERENCES

1. Causal Condition: The focus group results revealed that both product and fashion designers rarely work with other designers either from the same field or others. All respondents found it easier to collaborate with technicians or marketeers than designers. One designer commented: *'six designers got together. We tried to get a solution, but we just argued all the time. Everybody wanted to have opinions about materials and so on. Design was easy, but dealing with people was difficult.'* To avoid argument, most designers separated the brief, developed individual designs, and met after the works were completed. All respondents agreed that it was easier to communicate after their ideas were visualised. As designers developed the 'main theme' together, all designs could go together well, but are not integrated.
2. Phenomenon: As most disciplines prefer to work on their own and dislike designing together, creating an integrating theme that reflects user needs and all expertises at the start of the process is the key.
3. Context and Intervening Conditions: Selecting the 'winning' and 'integrating' theme for the team to

work with matches the nature of Smart Clothing project – a collaboration of different organisations.

4. Strategies: At the project level, the case study results proposed three strategies: 1) establishing a basis for collaborative product development, 2) sharing knowledge, resources and workspace, 3) embedding new cultures based on the basis into all participants. The basis involves a clear goal, criteria, expected contributions, milestones, and business plans. Moreover, it addresses a 'winning' concept, which is perceived as equal benefits to each partner. For instance, Smart Car helps Mercedes expand its product line into the new area, which requires characteristics that it does not possess. At the same time, it also promotes the 'modular' concept of Swatch. In addition, this approach must reflect the partners' multiple expertise. This basis allows the team to discuss, exchange ideas, measure the progress and evaluate the outcome. According to the focus group, these methods are also practical at personal level.
5. Consequence: Creating the 'integrated' design theme can reconcile the differences to a certain extent. However, incorporating key elements from other areas requires personal commitment and willingness.

CONCLUSION

To break through the creative boundary and optimize multidisciplinary contributions, which can lead to an integrated outcome and high level of collaboration, the developers should adopt the following strategies:

1. Develop a clear goal and describe how multiple perspectives are evenly incorporated.
2. Identify user requirements and clarify how multidisciplinary expertises can satisfy these needs.
3. Develop a context of the new product accordingly and ensure that every participant understands.
4. Define expected contributions of all participants and establish a basis for a collaborative project
5. Create a new framework based on the product context to encourage the developers to think and express their ideas in an integrated manner. In this way, fashion elements and technologies cannot be separated.
6. The new framework can be adopted by working closely with the others. However, it is important that all disciplines challenge their established procedure and explore the new direction identified.

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