Chapter 6 Feedbacks and Modification

This chapter is divided into four parts. Firstly, a validation process of the proposed conceptual model is described. Secondly, results of the validation are demonstrated. Thirdly, a modification procedure employed to strengthen the conceptual model, due to the validation results, is explained. Lastly, a conclusion of the final model is drawn.

6.1 Validation Process

This research used experts' opinions to validate the proposed model because of two main reasons. Firstly, an acceptance/approval of the pioneers in the Smart Clothing field could convince other developers to adopt the model. Secondly, whilst experiments with development teams in practice could only prove the practicalities of the certain parts of the model and raise potential problems, the experts could provide solutions to identified problems and suggest appropriate means to improve the conceptual model.

Aim: Personal opinions of the experts in the Smart Clothing field were used to assess:

1. Relative importance of the key issues addressed in the conceptual model including 1) a holistic view of Smart Clothing development, 2) roles of all the participants involved in Smart Clothing development, 3) responsibilities of all the participants, 4) working relationships of all the participants, and 5) creative boundary extension.
2. Relative practicality of the implementations of five key issues within the model.

Hypotheses: In this validation test, there were two experimental predictions. Firstly, it was predicted (two-tailed prediction) that there would be a difference between the scores measuring the importance of the key issues. Secondly, it was predicted (two-tailed prediction) that there would be a difference between the scores measuring the practicality of the implementation of the key issues within the conceptual model.

Subjects: Since opinions of the experienced experts were crucial to validate and improve the proposed model, they were carefully selected according to the criteria set out below:

1. The experts must represent all the key disciplines currently involved in the Smart Clothing development project, including a project manager, a Smart Clothing designer, a Smart Clothing engineer, a scientist or technician from the electronic field, a scientist or technician from an intelligent textile area, and a business developer.
2. Insightful knowledge of practical Smart Clothing research and development was significant to justify the appropriateness of the conceptual model; therefore, all the selected experts must have sufficient experience of developing Smart Clothing applications. As a result, potential developers, such as a future trend researcher and a conventional fashion designer, were not included in this validation process.
3. In order to ensure varied opinions, these experts were chosen from different educational backgrounds and worked in different organisations. Moreover, the same number of the experts was derived from the academic field and the private sector. Three experts came from academia (a Smart Clothing engineer, a conductive textile developer, and a research scientist) and three experts had experience of working in industry (a project manager, a concept designer, and a business developer).
4. Their research team or organisations were regarded as a major influence in the Smart Clothing area. Hence, their acceptance of the conceptual model could convince and persuade other developers to explore and employ this model.

Six experts were selected, as they met all the criteria set out above. The profiles of all the experts and some examples of their works are presented in Appendix E.

Materials: A questionnaire was constructed according to the aims and hypotheses described earlier. The questionnaire was divided into five sections as follows:

1. **Introduction**: This part explained aims and purposes of the questionnaire.
2. **Explanation of the key issues**: Five key issues addressed in the conceptual model and their brief descriptions were summarised.
3. **Presentation of the conceptual model**: In this part, the implementations of five key issues in the conceptual model were demonstrated visually and verbally.
4. **Validation of the key issues**: The first set of questions was designed to examine the relative importance of five key issues in order to find out their relationships.
5. **Validation of the implementation**: In this part, relative practicality of implementations of the key issues in the conceptual model was measured.
6. **Further suggestion**: This part was an open question, which allowed the experts to give comments and suggestions that may not have been included in the questions.

All the questions were constructed in a form of attitude scaling (see Appendix D) because they specialised in measuring non-factual topics (such as, opinions, attitudes, and values) and discovering the way in which an attitude related to other variables (Oppenhiem, 1992), which, in this case, were the importance of the key issues identified, and the practicality of the implementation. All the questionnaires were delivered via the Internet in an electronic format in order to reduce time consumption, and maximise the ease of response. All the responses were collected and prepared for statistical analyses (see Appendix F).

6.2 Results and Statistical Analyses

A Friedman test was performed to assess the two-tailed prediction, that there would be a difference between the scores measuring the importance of five key issues. The results indicated that there was no significant difference between the scores given to five different issues ($X^2 = 3.6$, df = 4, p = NS). Nonetheless, the results could possibly be non-significant due to small sample size (six participants). A histogram illustrating which issue was more important for the participants was constructed (see figure 6.1).

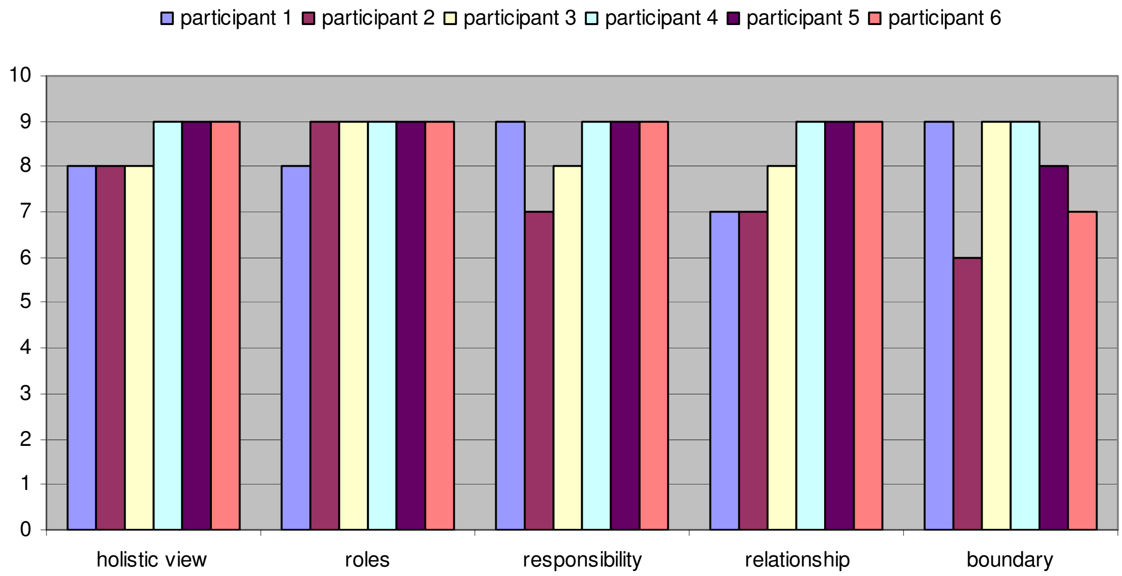

Figure 6.1: A histogram illustrating the scores measuring importance of five key issues

* 9 = Totally agree, 8 = Mostly agree, 7 = Partially agree, 6 = Fairly agree, 5 = Neither agree or disagree, 4 = Fairly disagree, 3 = Partially disagree, 2 = Mostly disagree, and 1 = Totally disagree

According to the histogram, *'clarifying the roles of all participants'* received the highest score. In contrast, *'describing the related areas, to which the creative boundary can be extended'* was given the lowest score. Noticeably, most participants had positive attitudes to these key issues, as 70% of the total scores were equal or higher than 'mostly agree.' Besides, 50% of the scores in each category reached 'totally agree'. Therefore, it can be assumed that most experts considered all key issues to be essential factors for Smart Clothing development. Moreover, some factors have already been confirmed in their significance by other practical research (Dunne, 2004). However, the experts paid attention to the practical issues of the NPD process, such as *'clarifying the roles of all participants'*, more than the aspects that relate to strategic thinking, such as boundary extensions.

A Friedman test was carried out to assess the two-tailed prediction, that there would be a difference between the scores measuring the practicality of the implementations of five key issues within the conceptual model. The results denoted that there was no significant difference between the scores measuring the practicality of the implementation of five key issues within the conceptual model ($X^2 = 6.2$, df = 4, p =NS). However, the results could possibly be non-significant because of small sample size (six participants). Histogram in figure 6.2 illustrates which issue was more important for the participants.

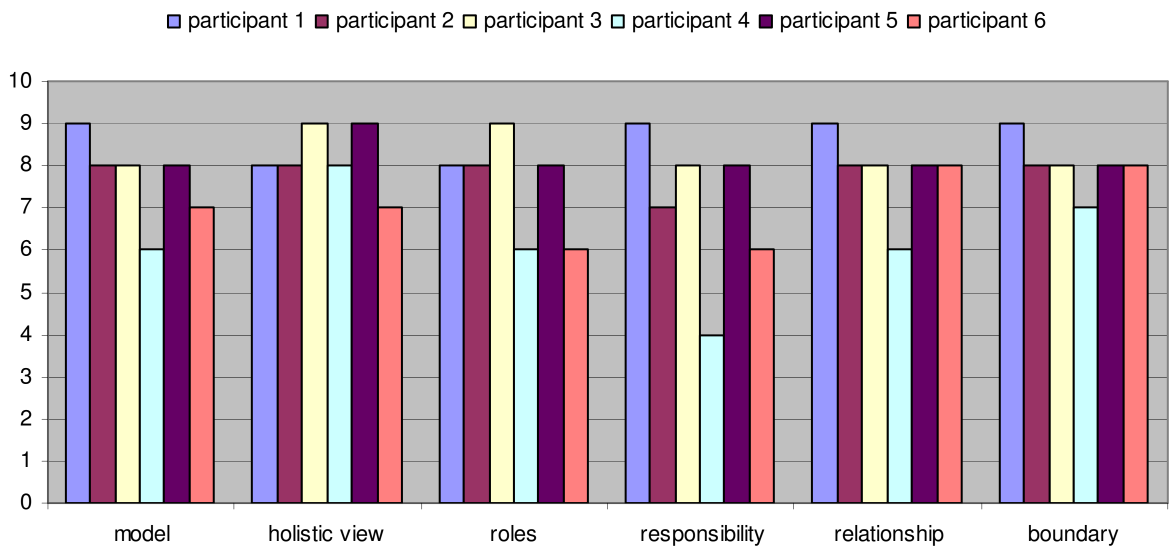

Figure 6.2: A histogram demonstrating the scores measuring practicality of implementation

* 9 = Totally agree, 8 = Mostly agree, 7 = Partially agree, 6 = Fairly agree, 5 = Neither agree or disagree, 4 = Fairly disagree, 3 = Partially disagree, 2 = Mostly disagree, and 1 = Totally disagree

Based on the histogram, 80% of the experts reported that they mostly or totally agreed with the way in which a holistic view of the Smart Clothing development process was implemented. In contrast, the model needed an improvement in terms of explaining the roles and responsibilities of all the participants, since 40% of the scores were equal or less than ‘fairly agree’. The ways, that the relationships of all participants and boundary extension were implemented, presented no problem, as more than 80% of the expert declared that they mostly or totally agreed with their implementations in the conceptual model. Nevertheless, the ways that relationships of all participants, and boundary extension were presented could be strengthened based on the suggestions of the experts in order to make the model more practical. At this stage, the model was considered rather practical, as approximately 70% of the scores were equal or higher than ‘mostly agree.’

6.3 Model Modification

Considering the results, the part that needs an improvement the most is how to describe **roles** and **responsibilities** of all the participants. To bring about clearer understanding of what each person has to do in relation to others, one expert suggested that new technical terms should be established. Subsequently, the misunderstanding due to language problems can be avoided. As a result, all the words that have more than one implication must be replaced. For example, people associate the word ‘fashion design’ not only with *‘garment design’* but also with *‘arts’*, *‘aesthetics’* or *‘fast changing trends.’* Therefore, the conceptual model should entitle an individual who designs and develops concepts and prototype garments as an *‘apparel designer* or *engineer’* in order to emphasise that Smart Clothes are different from conventional garments. This change matches the suggestion of the expert: *‘Wearable technology would probably be best designed by a clothing engineer* *than by a clothing artist. Using the term "fashion" when communicating to engineers implies that the individual performing certain tasks is more of an artist than an engineer, a common misconception that can prevent the investigation of key wearability issues.'*

One respondent confused and misunderstood the term 'research' used in the conceptual model, as she commented: *'Is this meant to be contained in the "research" group? What disciplines do the members of the "research" group belong to?'* Actually, the term 'research' was used to describe 'research activities' not 'researchers.' This confusion expresses a need for a clear distinction between the 'disciplines' and their 'tasks.' In addition, it was recommended that the conceptual model should provide more details, as one expert pointed out: *'One of the major obstacles in inter-disciplinary collaboration is lack of any real understanding between disciplines of the other's expertise, value, and process. A more detailed model, which outlined the actual processes involved might be more informative, and allow participants to appreciate the complexities of their partner's work.'* Nevertheless, details should not be added to the conceptual model at the strategic level (or the highest level) because it might lead to complications that make the model difficult to understand and employ. As a result, the details are added at the more practical levels (or the lower levels) and dialogue boxes provided in an electronic version. In this way, further details can be offered without over-complicating the conceptual model. The conceptual model was modified due to the comments of the experts as follows.

1. All the terms used in the conceptual model were revised and, in some cases, replaced to ensure that each name clearly explains the element it represents (see figure 6.3). For instance, the name *'research'* was changed to *'user research'*, since the research

activities that are included in this part mainly focus on the user (e.g. user requirements lifestyle, and social trends), and aim to identify the advantages or benefits over the competitors. It must be stressed that the key elements in the conceptual model at the highest level represent the activities that must be accomplished, not the participant. Thus, the researcher chose the names that signify *'action'* as much as possible in order to reduce confusion between persons and tasks. For example, *'Textile Technical Research and Development'* is replaced the previous title *'Textile Research and Technology Support*, which could lead to a misunderstanding that there must be a 'technical support' group within in a team. In fact, user and technical research, and design and development tasks can be carried out by the same person. Although technical research and development activities in electronic and textile fields could be called *'R&D'* (Research and Development), this abbreviation often associates with '*R&D Department*' that may lead to misinterpretation. Hence, the abbreviation, R&D, was not used in this conceptual model. In addition, the *'strategy planning'* was enclosed by a circle instead of an ellipse in order to indicate that a strategy covers every aspect, not only design and development as it was presented in previous one.

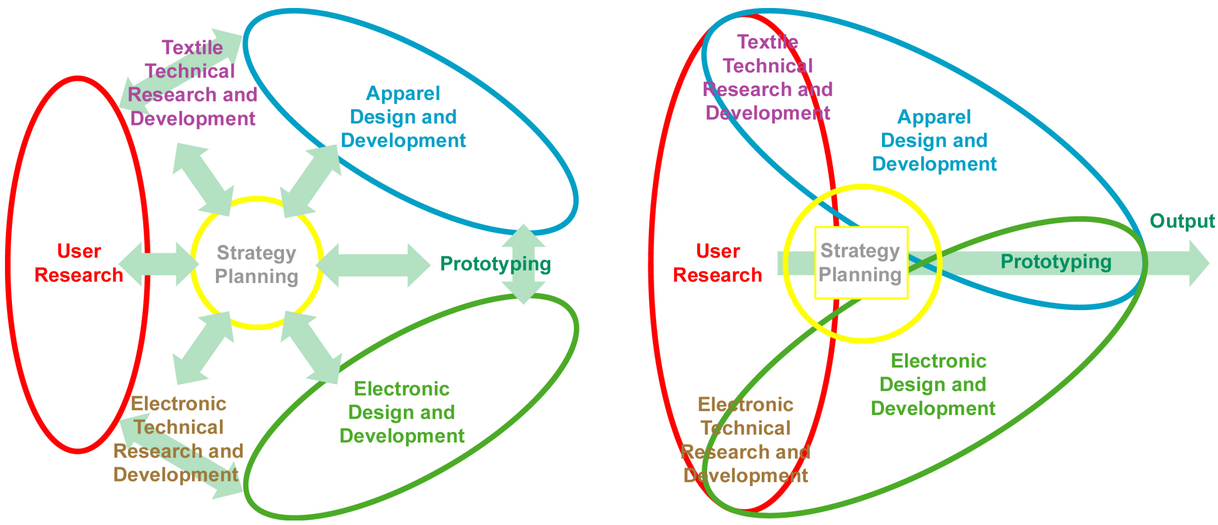

Figure 6.3: The conceptual model at the highest level after the first modification

2. All the names that were used in the detailed models (at the lower levels) were also reviewed and, in some cases, replaced (see figure 6.4). The main focus was to clarify all tasks and reduce misunderstanding as much as possible. For example, the terms *'textile research and development planning'* and *'textile planning'* replaced the previous title, *'planning about suitable textiles'* (see figure 5.13 for comparison) in order to emphasis that there are two main activities involved in '**textile technical research and development**' at the '**planning**' stage. Firstly, development teams hypothesise which technical or intelligent textiles they possibly require in order to focus their research (**textile planning**). Secondly, they plan how to conduct the research and development (**textile research and development planning**). Moreover, scattered tasks were grouped together in order to reduce confusion.

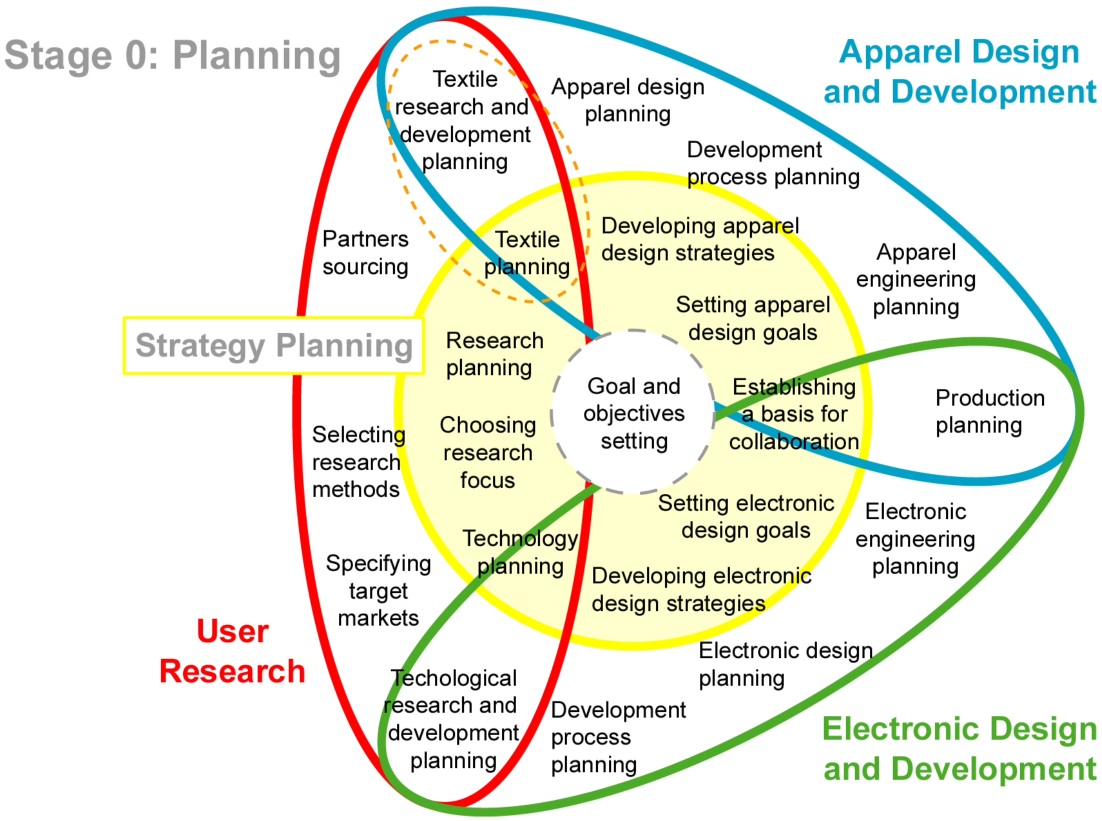

Figure 6.4: All the terms used in detailed model was revised and replaced

For instance, a number of tasks in the '**apparel design and development**' area at the **planning** stage were grouped into three main activities: 1) apparel design planning, 2) apparel engineering planning, and 3) apparel development process planning. Whilst **design planning** is concerned about functions and appearance, **engineering planning** deals with how to achieve required functions and appearance. The **process planning** clarifies how apparel design and engineering are carried out. The details of all the main activities that are not displayed can be accessed via the dialogue boxes. These main activities were rearranged to distinguish between the tasks at strategic level and those of practical level. For example, choosing a research focus and establishing a basis for collaboration, were placed in the **strategy planning** area. It is unavoidable that there are still some words that have more than one implication (figure 6.5).

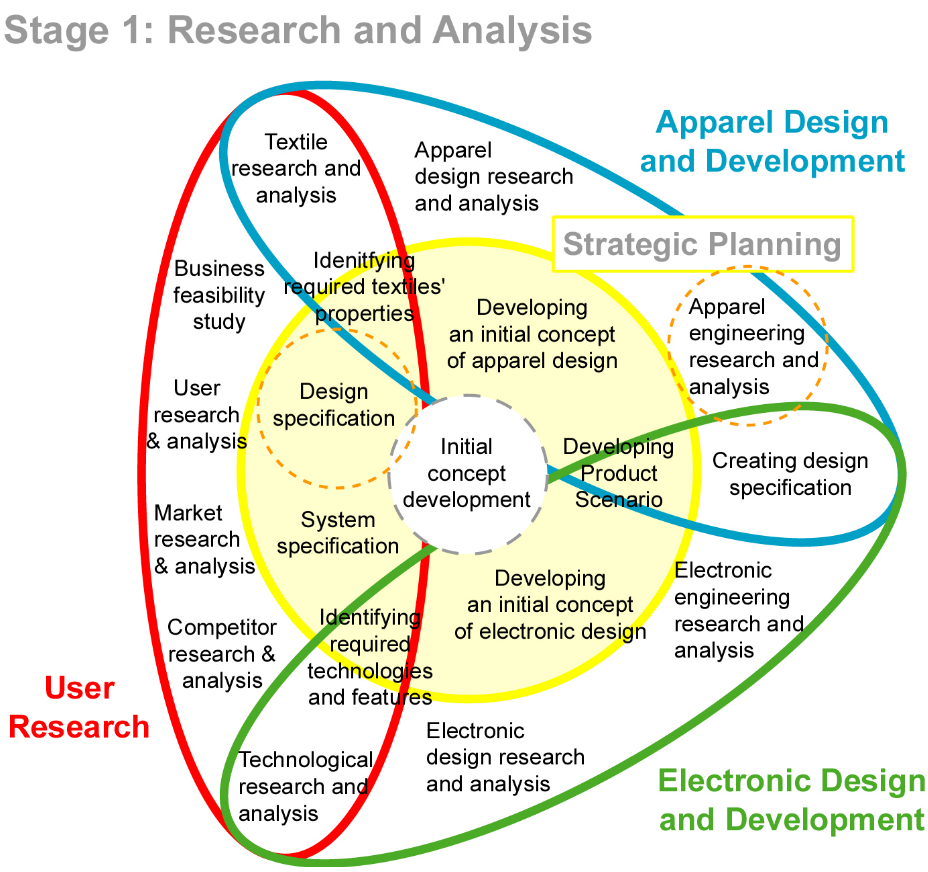

Figure 6.5: Certain terms which could lead to misinterpretation or confusion

For instance, the term *'design specification'* is widely used with varied implication. In this case, it refers to a description in terms of physical appearance and functions. Nevertheless, a description explaining how to achieve each function is excluded, since this explanation is expressed in *'system specification.'* Moreover, there are certain titles that can cause confusion. For example *'apparel engineering research and analysis'*, in this case, refers to a research and analysis in terms of garment techniques and technologies, which will be used to engineer Smart garments according to design concepts. In order to overcome misinterpretation and confusion, a dictionary of the new terms is given. When a particular task is selected, its meaning or detailed description, and, in some cases, images, are displayed automatically (see figure 6.6).

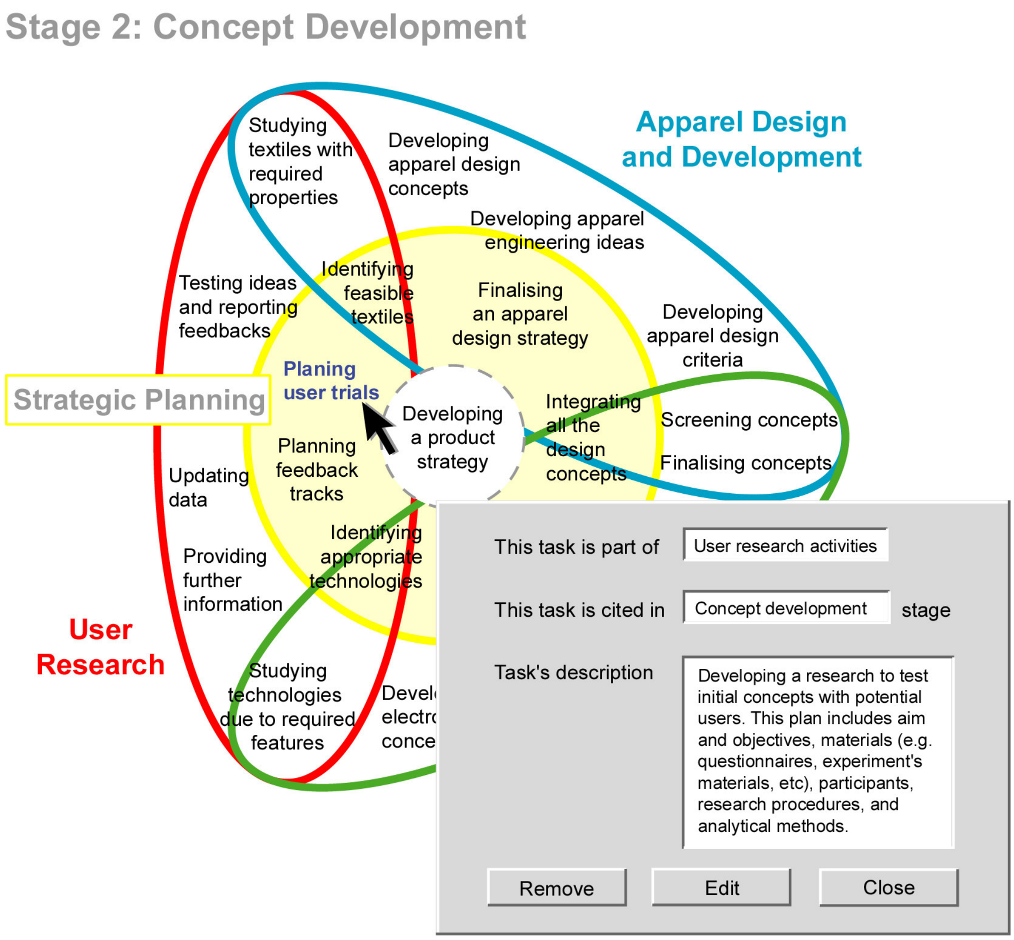

Figure 6.6: Detail is presented in dialogue box when a particular task is selected

Nevertheless, the meanings or detailed descriptions could be altered by the developers to match their requirements. In this way, detailed information of each task can be provided and customised without adding complications to the model at the higher level.

3. The way to locate the participants in the conceptual model is revised based on the previous principles (see figure 5.15). Firstly, each participant decides what his/her area of expertise is. For example, participant A's expertise is apparel concept design. Thus, he selects '**apparel design and development**', as his expertise belongs to this area. Responding to his selection, all the possible tasks required in the apparel design and development area are shown (see figure 6.7). Subsequently, participant A can specify his contributions, which are *'apparel concept design'* and *'2D presentation'*.

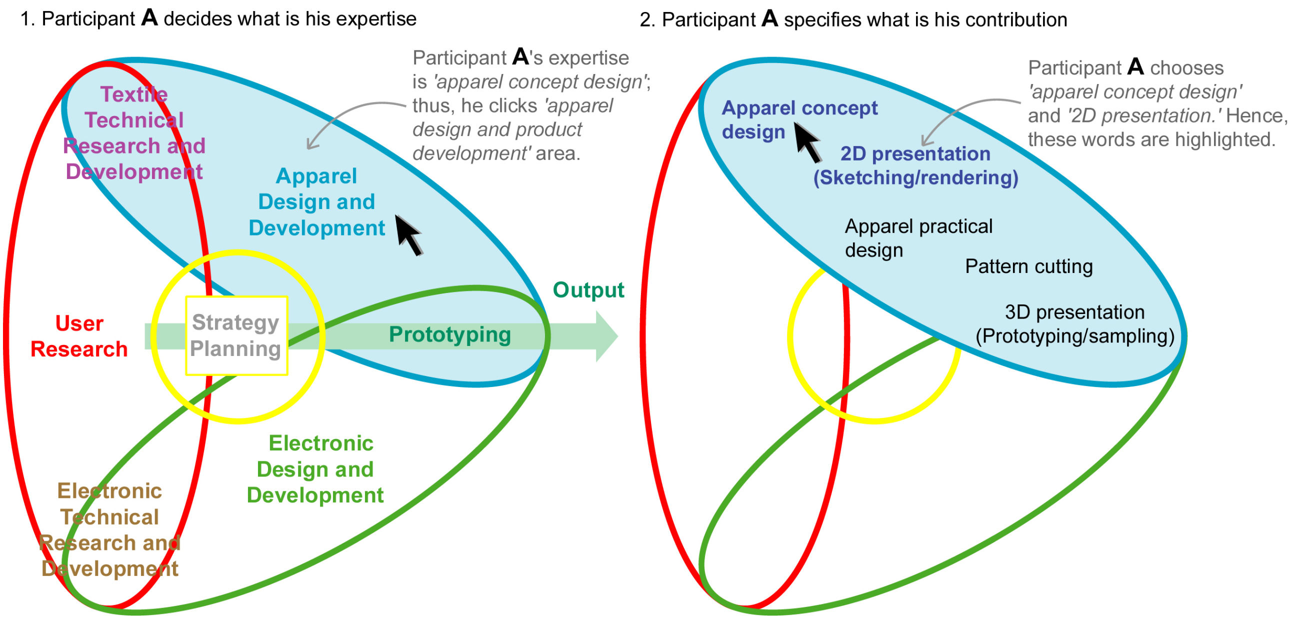

Figure 6.7: First step – the participants specify their expertise and main contributions.

According to this example, it can be seen that a development team needs further participants to work in *'apparel design and development'* in order to convert design concepts from participant A into a practical design and prototype garments. In this way, the conceptual model can be used as a checklist to make sure all the development tasks are allocated, and all the required expertise is obtained. If there are certain tasks remained unselected at the end of the task allocating procedure, a development team must decide whether these tasks are relevant, which participants should be responsible for them, and whether they need to find more partners or participants.

Next, the participants specify the areas that they also can contribute, but not considered their area of expertise. For instance, participant A is able to develop a strategic plan and carry out some user research. Therefore, at a command prompt (in electronic version) saying: *'specifying related areas'* he chooses '**strategy planning**' and '**user research**.' Consequently, all the possible tasks in relation to the apparel design and product development area are demonstrated (see figure 6.8). As a result, participant A is able to select the tasks he can contribute to in related areas that are not his expertise.

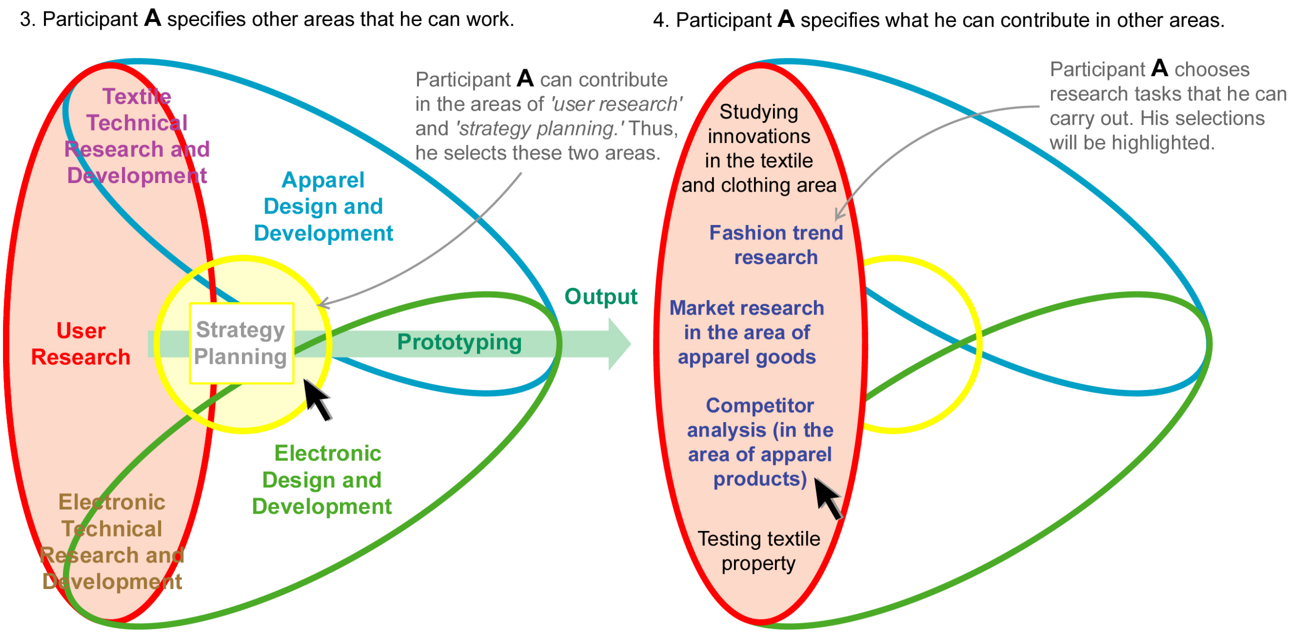

Figure 6.8: Second step – the participants specify their contributions in related areas.

An outline of the human body was used to explain the roles and responsibilities of all the participants. The outline is used emphasise the area of expertise. Using participant A as an example, the body part is located in the *'apparel design and development'* area, which is his area of expertise and covers '**embodying concepts into apparel design**', which is his main contribution (see figure 6.9). The limbs are used to indicate further contributions in related areas. For example, in participant A's case, the limbs cover certain tasks in the *strategy planning* area, such as **making sure that a design fits a strategy** and **making sure that apparel and electronic design are integrated**, and *user research* area, namely '**monitoring and quality controlling** (see figure 6.9). A human-shape outline is provided automatically after a participant enters his/her expertise, main contributions and further contributions in related areas (see figure 6.7 - 6.8). One outline represents a role of an individual in the process at a particular stage.

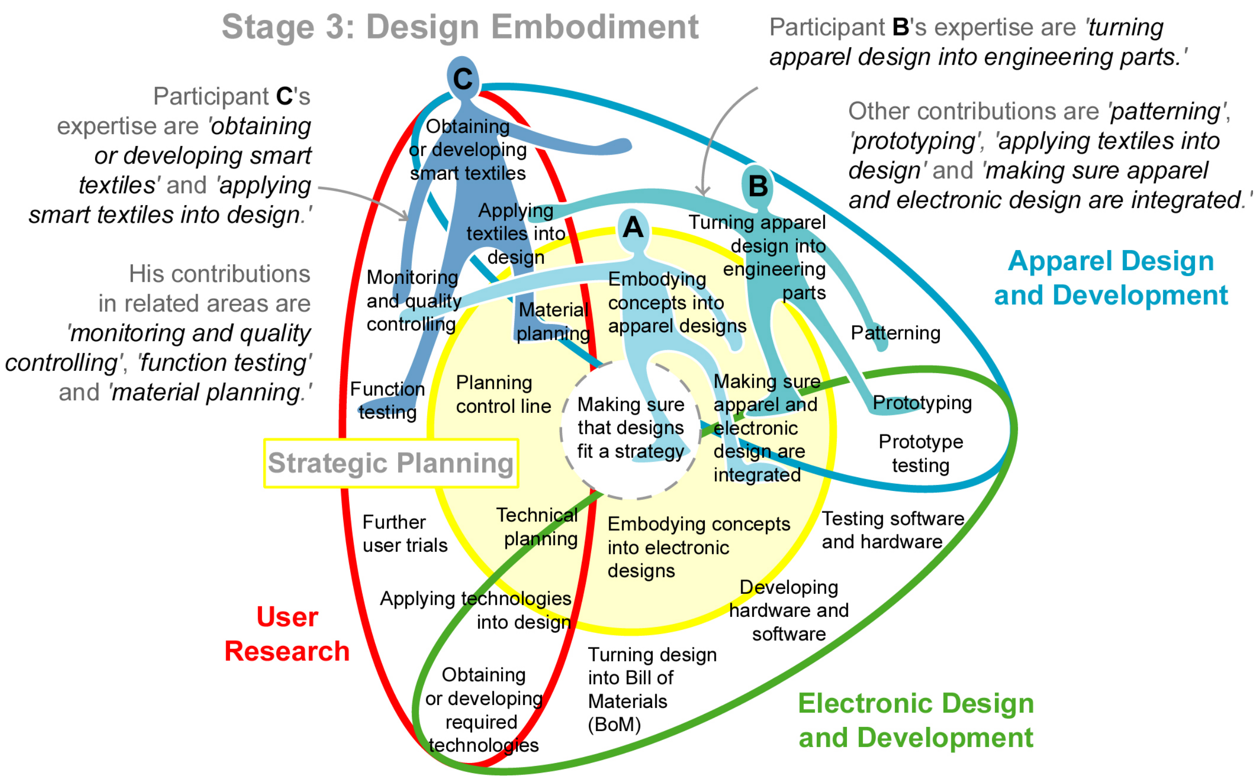

Figure 6.9: Human shape is used to present working boundaries and relationships

By providing a clear boundary of each participant's contribution, these outlines can explain the working relationships and show where roles and responsibilities overlap. For instance, figure 6.8 reveals that participants A and B are dependent on each other. While participant A works on conceptual level, participant B turns all concepts into practical apparel design, and produces prototype garments. The only work that they share is making sure that apparel design and electronic design integrate. All the boundaries are constantly changed through out the development process, since the contributions of each participant can be different from one stage to another. These boundaries support the idea of boundary extension. Boundary can be extended or changed by updating the contributions in both main and related areas. The programme responds by dragging the limbs to encompass the new tasks entered (see figure 6.10).

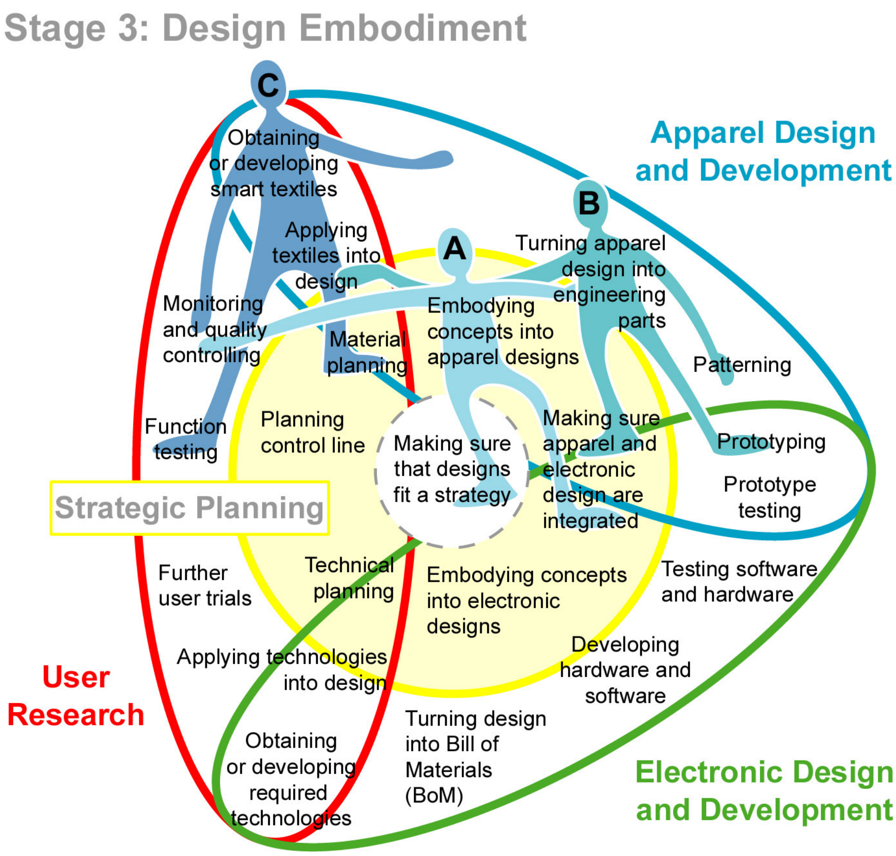

Figure 6.10: Boundaries can be updated in order to improve the working relationship

For example, participants A and B are dependent, but they rarely share responsibilities and tasks. Their relationships can be improved by increasing the overlaps of their responsibilities. In this way, the outcomes become possibly more integrated.

4. Noticeably, most experts who have educational background or work experience of conceptual designing or strategic planning, namely a Smart Clothing concept designer (respondent no. 1), a project manager (respondent no. 3), and conductive textile developer (respondent no. 5), gave higher scores for the practicality of the implementation. According to figure 6.2, the scores they offered were 'mostly agree' or higher. It was possibly because they were able to understand '**conceptual**' model and '**strategic thinking**' better than other disciplines. Certain experts, especially those who worked on the technical side of Smart Clothing development, such as technical textile developers and electronic engineers, refused to evaluate the conceptual model, as they were unfamiliar with the '**conceptual**' models and strategic approaches. For example, one expert replied: *'I am sorry that I am not so familiar with your kind of research and that I cannot help you by answering your questionnaire.*' These responses suggest that the conceptual model at the highest level should be employed only by the participants who are familiar with strategic thinking, such as, a project manager. The conceptual models at the practical level, which is accessible to all the participants, must accompany with sufficient text explanation in order to enhance the understanding of all the participants who are unfamiliar with conceptual model.

To conclude, at the highest level (see upper-left corner of figure 6.11), the conceptual model presents only basic elements in order to keep the NPD model simple and easy to understand by the project manager or other participants that deal with strategic planning. Detailed models of different development stages (see upper-right corner of figure 6.11) can be accessed by zooming or selecting a specific word that requires more explanation. The strategic planners have a full authority to customise the conceptual model according to the requirements of their projects. For the participants who work at the practical level, the only contacts they have with the conceptual model are as follows:

1. Specify their expertise by choosing one area from four key elements: user research, strategy planning, apparel design and development, and electronic design and development. They can select by clicking on the area or typing in the dialogue box (see middle-left model in figure 6.11).
2. Identify their main contributions by choosing the developments tasks provided in the area that they chose (see middle-right model in figure 6.11).
3. Describe further contributions that they can offer in the related areas that are not there areas of expertise (see lower-left corner of figure 6.11). After every participant enters his expertise, main contributions and further contributions, the roles and responsibilities of all the participants can be illustrated. The human shape is used to demonstrate the working boundary of each participant (see lower-right corner of figure 6.11). In this way, the working relationship can be expressed and adjusted (see figure 6.9-10). It must be stressed that the contributions in related areas, and are not their expertise may require only suggestion, discussion or idea exchange rather than hand-on works.
4. Use detailed models as a guideline or a checklist to make sure that they accomplish all tasks they are responsible. As detailed models provide a full explanation of all the tasks, they can help the participants understand other disciplines' works. As a result, the creative boundary can be overcome, and final outcomes can be more integrated.

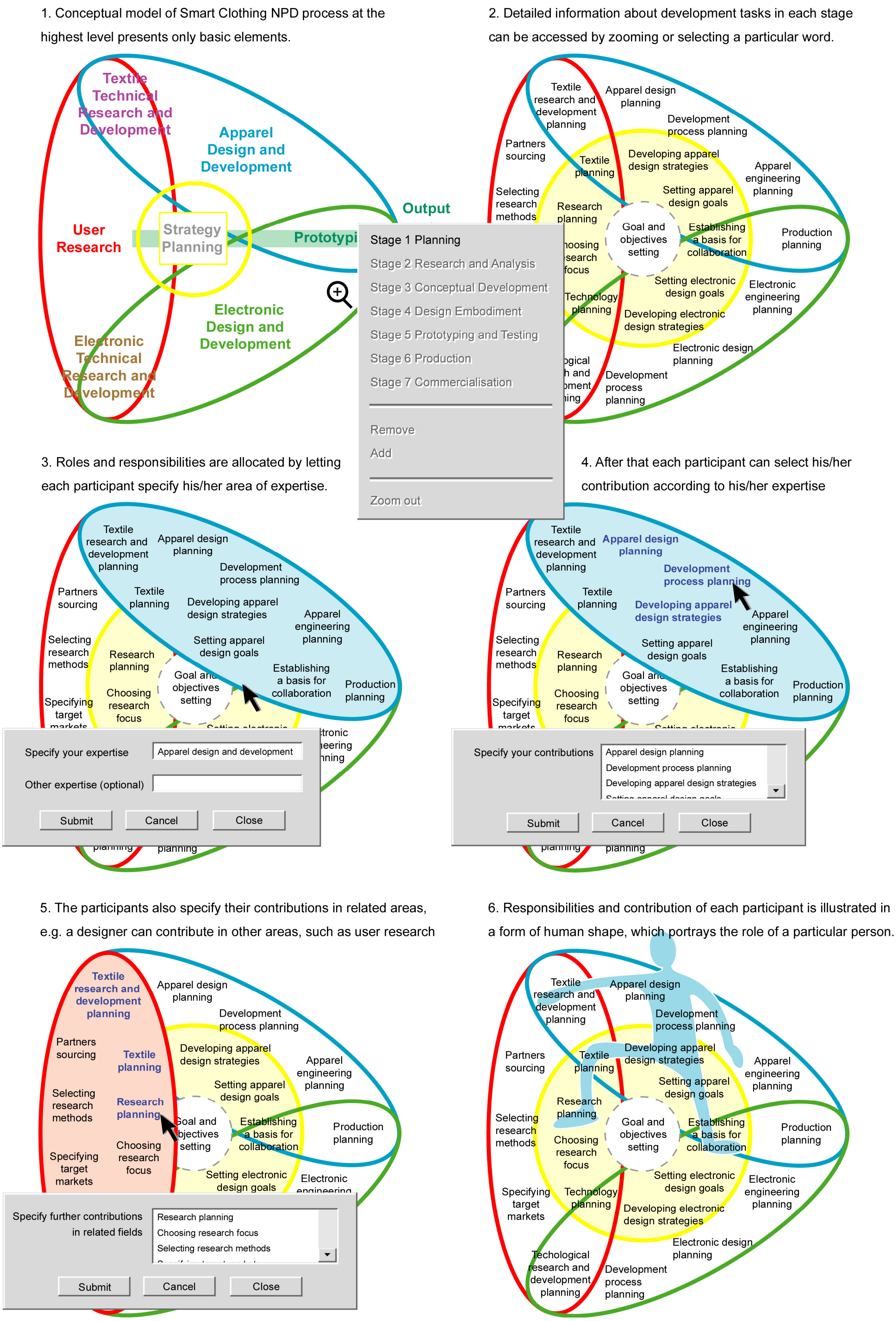

Figure 6.11: A summary of the final conceptual model and how it can be employed